JEPPIAAR
INSTITUTE OF TECHNOLOGY
"Self-Belief | Self Discipline | Self Respect"

QUESTION BANK

Regulation	:	2017
Year	:	II
Semester	:	04
Batch	:	2018-2022

DEPARTMENT OF
ELECTRONICS AND COMMUNICATION ENGINEERING

Vision of the Institution

Jeppiaar Institute of Technology aspires to provide technical education in futuristic technologies with the perspective of innovative, industrial and social application for the betterment of humanity.

Mission of the Institution

- To produce competent and disciplined high-quality professionals with the practical skills necessary to excel as innovative professionals and entrepreneurs for the benefit of the society.
- To improve the quality of education through excellence in teaching and learning, research, leadership and by promoting the principles of scientific analysis, and creative thinking.
- To provide excellent infrastructure, serene and stimulating environment that is most conducive to learning.
- To strive for productive partnership between the Industry and the Institute for research and development in the emerging fields and creating opportunities for employability.

To serve the global community by instilling ethics, values and life skills among the students needed to enrich their lives.

DEPARTMENTVISION

To enhance and impart futuristic and innovative technological education for the excellence of Electronics and Communication Engineering with new ideas and innovation to meet industrial expectation and social needs with ethical and global awareness reinforced by an efficiency through research platform for the advancement of humanity.

MISSION

M1: To produce competent and high quality professional Engineers in the field ofElectronics and Communication Engineering for the benefit of the society globally.

M2: To provide a conducive infrastructure and environment for faculty and students with enhanced laboratories, to create high quality professionals

M3: To provide Prerequisite Skills in multidisciplinary areas for the needs of Industries, higher education and research establishments and entrepreneurship

M4: To handle Socio Economic Challenges of Society by Imparting Human Values and Ethical Responsibilities.

Program Educational Objectives (PEOs)

PEO 1: Graduate Engineers will have knowledge and skills required for employment and an advantage platform for lifelong learning process.

PEO 2: Graduate Engineers willbe provided withfuturistic education along with the perspective research and application based on global requirements.

PEO 3: Graduate Engineers will have effective communication skills and work in multidisciplinary team.

PEO 4: Graduate Engineers will develop entrepreneurship skills and practice the profession with integrity, leadership, ethics and social responsibility.

Program Specific Outcomes (PSOs)

PSO 1 : Ability to develop and utilize novel, compact and power efficient coherent theoretical and practical methodologies in the field ofanalog and digital electronics.

PSO 2: Ability to implement analog, digital and hybrid communication Protocol to aspect the challenges in the field ofTelecommunication and Networking.

BLOOM’S TAXONOMY

Definition:

Bloom’s taxonomy is a classification system used to define and distinguish different levels of human cognition like thinking, learning and understanding.

Objectives:

- To classify educational learning objectives into levels of complexity and specification. The classification covers the learning objectives in cognitive, affective and sensory domains.
- To structure curriculum learning objectives, assessments and activities.

Levels in Bloom’s Taxonomy:

- **BTL 1 – Remember** - The learner recalls, restate and remember the learned information.

- **BTL 2 – Understand** - The learner embraces the meaning of the information by interpreting and translating what has been learned.

- **BTL 3 – Apply** - The learner makes use of the information in a context similar to the one in which it was learned.

- **BTL 4 – Analyze** - The learner breaks the learned information into its parts to understand the information better.

- **BTL 5 – Evaluate** - The learner makes decisions based on in-depth reflection, criticism and assessment.

- **BTL 6 – Create** - The learner creates new ideas and information using what has been previously learned.

TABLE OF CONTENT

MA8451 PROBABILITY AND RANDOM PROCESSES L T P C

4 0 0 4

OBJECTIVES :

- To provide necessary basic concepts in probability and random processes for applications

  such as random signals, linear systems in communication engineering.

- To understand the basic concepts of probability, one and two dimensional random variables and to introduce some standard distributions applicable to engineering which can describe real life phenomenon.
- To understand the basic concepts of random processes which are widely used in IT fields.
- To understand the concept of correlation and spectral densities.
- To understand the significance of linear systems with random inputs.

UNIT I PROBABILITY AND RANDOM VARIABLES 12

Probability – Axioms of probability – Conditional probability – Baye's theorem - Discrete and continuous random variables – Moments – Moment generating functions – Binomial, Poisson, Geometric, Uniform, Exponential and Normal distributions.

UNIT II TWO - DIMENSIONAL RANDOM VARIABLES 12

Joint distributions – Marginal and conditional distributions – Covariance – Correlation and linear regression – Transformation of random variables – Central limit theorem (for independent and identically distributed random variables).

UNIT III RANDOM PROCESSES 12

Classification – Stationary process – Markov process - Markov chain - Poisson process – Random telegraph process.

UNIT IV CORRELATION AND SPECTRAL DENSITIES 12

Auto correlation functions – Cross correlation functions – Properties – Power spectral density – Cross spectral density – Properties.

UNIT V LINEAR SYSTEMS WITH RANDOM INPUTS 12

Linear time invariant system – System transfer function – Linear systems with random inputs – Auto correlation and cross correlation functions of input and output.

TOTAL :60 PERIODS

OUTCOMES:

Upon successful completion of the course, students should be able to:

- Understand the fundamental knowledge of the concepts of probability and have knowledge of standard distributions which can describe real life phenomenon.
- Understand the basic concepts of one and two dimensional random variables and apply in engineering applications.
- Apply the concept random processes in engineering disciplines.
- Understand and apply the concept of correlation and spectral densities.
- The students will have an exposure of various distribution functions and help in acquiring skills in handling situations involving more than one variable. Able to analyze the response of random inputs to linear time invariant systems.

TEXT BOOKS:

1. Ibe, O.C.," Fundamentals of Applied Probability and Random Processes ", 1st Indian Reprint, Elsevier, 2007.

2. Peebles, P.Z., "Probability, Random Variables and Random Signal Principles ", Tata McGraw Hill, 4th Edition, New Delhi, 2002.

REFERENCES:

1. Cooper. G.R., McGillem. C.D., "Probabilistic Methods of Signal and System Analysis", Oxford University Press, New Delhi, 3rd Indian Edition, 2012.

2. Hwei Hsu, "Schaum‘s Outline of Theory and Problems of Probability, Random Variables and Random Processes ", Tata McGraw Hill Edition, New Delhi, 2004.

3. Miller. S.L. and Childers. D.G., ―Probability and Random Processes with Applications to Signal Processing and Communications ", Academic Press, 2004.

4. Stark. H. and Woods. J.W., ―Probability and Random Processes with Applications to Signal Processing ", Pearson Education, Asia, 3rd Edition, 2002.

5. Yates. R.D. and Goodman. D.J., ―Probability and Stochastic Processes", Wiley India Pvt. Ltd., Bangalore, 2nd Edition, 2012.

Subject Code:MA8451 **Year/Semester: II /04**
Subject Name: Probability & Random Processes **Subject Handler: Dr.S.Suresh**

UNIT I –PROBABILITY & RANDOM VARIABLES
Probability – Axioms of probability – Conditional probability – Baye‘s theorem - Discrete and continuous random variables – Moments – Moment generating functions – Binomial, Poisson, Geometric, Uniform, Exponential and Normal distributions.

PART *A

Q.No.	Questions
1.	**Find the probability of a card drawn at random form an ordinary pack, is a diamond.** BTL2 Total number of ways of getting 1 card = 52 Number of ways of getting 1 diamond card is 13 $\Pr obability = \frac{Number\ of\ \ favourable\ events}{Number\ of\ exhaustive\ events}$ $= \frac{13}{52} = \frac{1}{4}$
2	**A bag contains 7 white, 6 red and 5 black balls. Two balls are drawn at random. Find the probability that they both will be white.** BTL2 Total balls = 18 From these 18 balls 2 balls can be drawn in $18C_2$ ways Total number of ways of drawing 2 balls = 153 ---------------(1) 2 White balls can be drawn from 7 white balls in $7C_2$ ways. Therefore number of favourable cases = 21 Probability of drawing white balls $= \frac{No., of\ \ favourable\ events}{Total\ \ no., \ of\ cases}$ $= \frac{21}{153} = \frac{7}{51}$
3	**Write the axioms of probability**. BTL1 Let S be a sample space. To each event A, there is a real number P(A) satisfying the following axioms. (i) For any event A, $P(A) \geq 0$ (ii) P(S) = 1 (iii) If $A_1, A_2, ..., A_n$ are finite number of disjoint events of S then

	$P(A_1 \cup A_2 \cup A_3 \cup ...) = P(A_1) + P(A_2) + P(A_3) + ...$
4	**A and B are events such that** $P(A \cup B) = \frac{3}{4}$; $P(A \cap B) = \frac{1}{4}, P(\overline{A}) = \frac{2}{3}$, *Find* $P(\overline{A}/B)$.**(Nov/Dec-2019)** BTL2 $P(A \cup B) = P(A) + P(B) - P(A \cap B)$ $\frac{3}{4} = \frac{1}{3} + P(B) - \frac{1}{4}$ $P(B) = \frac{2}{3}$ $P(\overline{A}/B) = \frac{P(\overline{A} \cap B)}{P(B)} = \frac{P(B) - P(A \cap B)}{P(B)} = \frac{\frac{2}{3} - \frac{1}{4}}{\frac{2}{3}} = \frac{5}{8}$
5	**Define Baye's theorem.** BTL1 Let $A_1, A_2, ..., A_n$ be 'n' mutually exclusive and exhaustive events with $P(A_i) \neq 0$ for I = 1,2,…n. Let 'B' be an event such that $B \subset \bigcup_{I=1}^{N} A_i$, $P(B) \neq 0$ then $P(A_i / B) = \frac{P(A_i).P(B/A_i)}{\sum_{i=1}^{n} P(A_i).P(B/A_i)}$
6	**Define Random variable. (Nov/Dec2013, Apr/May 2017)** BTL1 A random variable is a function that assigns a real number X(S) to every element $s \in S$ where 'S' is the sample space corresponding to a random experiment E.
7	**Prove that the function P(x) is a legitimate probability mass function of a discrete random variable X, where** $p(x) = \begin{cases} \frac{2}{3}\left(\frac{1}{3}\right)^x, & x = 0,1,2... \\ 0, & otherwise \end{cases}$ **(Apr/May 2017)** BTL5

$$\sum p(x) = \sum_{x=0}^{\infty} \frac{2}{3}\left(\frac{1}{3}\right)^x = \frac{2}{3}\left(\frac{1}{3}\right)^0 + \frac{2}{3}\left(\frac{1}{3}\right)^1 + \frac{2}{3}\left(\frac{1}{3}\right)^2 + \dots$$

$$= \frac{2}{3}\left[1+\frac{1}{3}+\left(\frac{1}{3}\right)^2 + \dots\right]$$

$$= \frac{2}{3}\left[1-\frac{1}{3}\right]^{-1} = \frac{2}{3}\left[\frac{2}{3}\right]^{-1}$$

$$= \frac{2}{3}\left[\frac{3}{2}\right] \quad = 1$$

Since $\sum p(x) = 1$, the given function P(x) is a legitimate probability mass function of a discrete random variable 'X'.

8

A random variable X has the following probability function.

X=x	0	1	2	3	4	5	6	7	8
P(x)	a	3a	5a	7a	9a	11a	13a	15a	17a

Find the value of 'a'. BTL5

$$\sum P(x)=1$$

$$a+3a+5a+7a+9a+11a+13a+15a+17a=1$$

$$81a = 1$$

$$a = \frac{1}{81}$$

9

If the random variable X takes the values 1, 2, 3 and 4 such that 2P[X=1] = 3P[X=2] = P[X=3] = 5P[X=4]. Find the probability distribution (Nov/Dec 2016) BTL3

Let P[X=3] = k

2P[X=1] = k $\Rightarrow$ $p[X=1] = \frac{k}{2}$

3P[X=2] = k $\Rightarrow$ $p[X=2] = \frac{k}{3}$

5P[X=4] = k $\Rightarrow$ $p[X=4] = \frac{k}{5}$

We know that $\sum P(x)=1$

$$\frac{k}{2}+\frac{k}{3}+k+\frac{k}{5}=1 \Rightarrow \frac{61}{30}k=1 \Rightarrow k=\frac{30}{61}$$

The probability distribution of X is given by

X	1	2	3	4
P(x)	$\frac{15}{61}$	$\frac{10}{61}$	$\frac{30}{61}$	$\frac{6}{61}$

10

Find the variance of the discrete random variable X with the probability mass function $P_x(X)=\begin{cases}\frac{1}{3}; x=0\\ \frac{2}{3}; x=2\end{cases}$

(Nov/Dec 2015 , Nov/Dec 2015) BTL3

The probability distribution of X given by

X	0	2
P(x)	$\frac{1}{3}$	$\frac{2}{3}$

$$E[X]=\sum x\,P(x)=(0)\left(\frac{1}{3}\right)+(2)\left(\frac{2}{3}\right)=0+\frac{4}{3}=\frac{4}{3}$$

$$E[X^2]=\sum x^2P(x)=(0)^2\left(\frac{1}{3}\right)+(2)^2\left(\frac{2}{3}\right)=\frac{8}{3}$$

$$Var X=E[X^2]-\left(E[X]\right)^2=\frac{8}{3}-\left(\frac{4}{3}\right)^2=\frac{8}{3}-\frac{16}{9}$$

11

Test whether the function defined as follows a density function ? $f(x)=\begin{cases}0 & x<2\\ \frac{1}{18}(3+2x) & 2\le x\le 4\\ 0 & x>4\end{cases}$ BTL4

$$\int_2^4 f(x)\,dx=\int_2^4\frac{1}{18}(3+2x)dx=\frac{1}{18}\left[3(x)_2^4+2\left(\frac{x^2}{2}\right)_2^4\right]$$

$$=\frac{1}{18}\left[3(4-2)+(16-4)\right]=\frac{1}{18}(18)=1$$

Hence the given function is a density function.

12	**Show that the function** $f(x)=\begin{cases} e^{-x} & x\ge 0 \\ 0 & x<0 \end{cases}$ **is a probability density function of a random variable X.** BTL5 $\int f(x)\,dx = \int_0^\infty e^{-x}\,dx = \left[-e^{-x}\right]_0^\infty = -[0-1] = 1$ Hence the given function is a density function.
13	**Assume that X is a continuous random variable with the probability density function** $f(x)=\begin{cases} \frac{3}{4}\left(2x-x^2\right) & 0<x<2 \\ 0 & otherwise \end{cases}$ **. Find P(X>1).** BTL3 $P[X>1]=\int_1^2 \frac{3}{4}\left(2x-x^2\right)dx = \frac{3}{4}\left[2\left(\frac{x^2}{2}\right)_1^2 - \left(\frac{x^3}{3}\right)_1^2\right]$ $= \frac{3}{4}\left[(4-1)-\left(\frac{8}{3}-\frac{1}{3}\right)\right] = \frac{1}{2}$
14	**A random variable X is known to have a distributive function** $F(x)=u(x)\left[1-e^{-x^2/b}\right], b>0$ **is a constant. Determine density function.** BTL 3 $f(x)=F_x(x)=\frac{d}{dx}\left[u(x)\left(1-e^{-x^2/b}\right)\right]$ $=u(x)\left(e^{-x^2/b}\left(-\frac{2x}{b}\right)\right)+u'(x)\left(1-e^{-x\ \ /b}\right)$ $=\frac{2}{b}xu(x)e^{-x^2/b} + u'(x)\left(1-e^{-x^2/b}\right)$
15	**If** $f(x)=\frac{x^2}{3}, -1<x<2$ **is the PDF of the random variable X then find P[0<X<1]. (Apr/May 2018)** BTL3 $\int f(x)\,dx = \int_0^1 \frac{x^2}{3}dx = \frac{1}{3}\left[\frac{x^3}{3}\right]_0^1 = \frac{1}{9}[1-0] = \frac{1}{9}$
16	**A continuous random variable X has probability density function** $f(x)=\begin{cases} 3x^2 & 0\le x\le 1 \\ 0 & otherwise \end{cases}$ **Find 'k' such that P[X>k]=0.5** . BTL4

	P[X>k] = 0.5 $\Rightarrow\int_k^1 f(x)\,dx=0.5$ $\Rightarrow\int_k^1 3x^2dx=0.5$ $\Rightarrow 3\left[\frac{x^3}{3}\right]_k^1=0.5 \Rightarrow 1-k^3=0.5$ $\Rightarrow k^3=1-0.5=0.5\Rightarrow k=(0.5)^{\frac{1}{3}}=0.7937$
17	**The cumulative distribution function of the random variable X is given by** $F_x(X)=\begin{cases}0 & ;x<0\\ x+\frac{1}{2} & ;0\le x\le\frac{1}{2}\\ 1 & ;\ x>\frac{1}{2}\end{cases}$ **.** **Find** $P[X>\frac{1}{4}]$. BTL3 $P\left[X>\frac{1}{4}\right]=1-P\left[X\le\frac{1}{4}\right]=1-F\left[\frac{1}{4}\right]=1-\left[\frac{1}{4}+\frac{1}{2}\right]=\frac{1}{4}$
18	**Find the moment generating function of Binomial distribution. (May/June 2013)** BTL3 The P.M.F of Binomial distribution is $P[X=x]=nC_x p^x q^{n-x}$, $x=0,1,2,\dots,n$ $M_x(t)=\sum_{x=0}^{n}e^{tx}p(x)=\sum_{x=0}^{n}e^{tx}nC_x p^x q^{n-x}$ $=\sum_{x=0}^{n}nC_x q^{n-x}\left(pe^t\right)^x$ $=nC_0q^{n-0}\left(pe^t\right)^0+nC_1q^{n-1}\left(pe^t\right)^1+nC_2\ nC_0q^{n-0}\left(pe^t\right)^0q^{n-2}\left(pe^t\right)^2+\dots+nC_nq^{n-n}\left(pe^t\right)^n$ $=q^n+nC_1q^{n-1}\left(pe^t\right)+nC_2q^{n-2}\left(pe^t\right)^2+\dots+\left(pe^t\right)^n=\left(q+pe^t\right)^n$
19	**The mean & variance of Binomial distribution are 5 and 4. Determine the distribution.(Apr/May 2015)** BTL4 Given: Mean = np = 5, variance = npq =4

	$= 5q = 4 \Rightarrow q = \frac{4}{5}$ $p = 1 - q = 1 - \frac{4}{5} = \frac{1}{5}$ $np = n\left(\frac{1}{5}\right) = 5 \Rightarrow n = 25$ The P.M.F of the binomial distribution is $P[X = x] = nC_x p^x q^{n-x} \quad x = 0,1,2, \ldots n$ $P[X = x] = 25C_x \left(\frac{1}{5}\right)^x \left(\frac{4}{5}\right)^{n-x}, \; x = 0,1,2,\ldots,25$
20	**Balls are tossed at random into 50 boxes. Find the expected number of tosses required to get the first ball in the fourth box. (Apr/May 2017)** BTL3 Let probability of success be $p = \frac{1}{50}$ According to Geometric distribution, Expected number of tosses to get the first ball in the fourth box = $E[x] = \frac{1}{p} = 50$
21.	**A random variable is uniformly distributed between 3 and 15. Find the variance of X. (Nov/Dec 2015)** BTL3 $Var\ X = \frac{(b-a)^2}{12}$ $= \frac{(15-3)^2}{12} = \frac{144}{12} = 12$
22.	**Messages arrive at a switchboard in a poisson manner at an average rate of six per hour. Find the probability for exactly 2 messages arrive within one hour. (Apr/May 2018)** BTL3 $Mean = \lambda = 6 \; per\ hour$ $P[X = x] = \frac{e^{-\lambda}\lambda^x}{x!} = \frac{e^{-6}6^x}{x!}$ $P[X = 2] = \frac{e^{-6}6^2}{2!} = 0.0446$
23.	**Find the moment generating function of Poisson distribution. (Nov/Dec 2014, Apr/May 2015)** BTL2

The P.M.F of Poisson distribution is

$$P[X=x]=\frac{e^{-\lambda}\lambda^{x}}{x!},\ x=0,1,2,\ldots \qquad \lambda>0$$

$$M_x(t)=E[e^{tx}]=\sum e^{tx}p(x)$$

$$=\sum_{x=0}^{\infty}e^{tx}\frac{e^{-\lambda}\lambda^{x}}{x!} \quad =e^{-\lambda}\sum_{x=0}^{\infty}\frac{(\lambda e^{t})^{x}}{x!}$$

$$=e^{-\lambda}\left[1+\frac{(\lambda e^{t})^{1}}{1!}+\frac{(\lambda e^{t})^{2}}{2!}+\ldots\right]$$

$$=e^{-\lambda}e^{\lambda e^{t}}$$

24. **Let X be a random variable with M.G.F** $M_x(t)=\dfrac{(2e^{t}+1)^{4}}{81}$**. Find its mean and variance. (May/June 2016)** BTL3

$$M_x(t)=\frac{\left(1+2e^{t}\right)^{4}}{81}=\left(\frac{1+2e^{t}}{3}\right)^{4}=\left(\frac{1}{3}+\frac{2e^{t}}{3}\right)^{4}$$

Comparing the M.G.F of Binomial distribution , $M_x(t)=\left(q+pe^{t}\right)^{n}$, we have $p=\frac{2}{3},q=\frac{1}{3},n=4$

Hence

$$Mean=np=4\left(\frac{2}{3}\right)=\frac{8}{3}$$

$$Variance=npq=4\left(\frac{2}{3}\right)\left(\frac{1}{3}\right)=\frac{8}{9}$$

25. If **X and Y are independent random variables with variance 2 and 3. Find the variance of 3X+4Y. (May/June 2014)** BTL3

Given : *Var(x)= 2 and Var(y) = 3*

$Var(aX+bY)=a^{2}Var(X)+b^{2}Var(Y)$

$Var(3X+4Y)=9(2)+16(3)=66$

26. **If** $f(x)=\begin{cases}cxe^{-x} & x>0\\ 0 & elsewhere\end{cases}$ **is the p.d.f of a random variable X. Find 'c'. (NovDec-2019)**BTL5

$$\int_0^\infty cxe^{-x}\,dx = 1$$

W.K.T $c\left[x\left(\frac{e^{-x}}{-1}\right)-(1)\left(e^{-x}\right)\right]_0^\infty = 1$

$$c[(0)-(0-1)] = 1$$

$$c = 1$$

27. **Find the second moment about the origin of the Geometric distribution with parameter p.(Apr/May-2019)BTL-3**

Soln.

Wkt Geometric distribution with parameter p is $P[X = x] = pq^{n-1}\quad n = 0,1,2, ...$

Therefore the second moment about the origin is $M_X''(0) = \frac{1+q}{p^2}$

PART * B

1 **A random variable X has the following probability distribution**

X=x	-2	-1	0	1	2	3
P(X=x)	0.1	K	0.2	2k	0.3	3k

Find (i) The value of 'k'

(ii) Evaluate P(X>2) and P(-2<X<2)

(iii)Find the cumulative distribution of X

(iv) Evaluate the mean of X (8M)(May/June 2010, Nov/Dec 2011, Nov/Dec 2017) BTL5**.**

Answer:Page: 1.80-Dr.A. Singaravelu

- Total Probability $\sum P(x) = 1$
- C.D. F $F(x) = P(X \le x) = \sum_{t \le x} p(t)$
- Mean $E(x) = \sum xP(x)$
- $E(x^2) = \sum x^2 P(x)$
- $VarX = E(X^2) - [E(x)]^2$

- Using $\sum P(x) = 1$, we have $k = \frac{1}{15}$. (1M)
- P(X<2)=0.5, $P(-2 < X < 2) = \frac{2}{5}$. (2M)
- C.D. F , F(-2)=0.1, F(-1)= 0.17, F(0)= 0.37, F(1)=0.5, F(2)= 0.8, F(3)=1. (3M)
- Mean E(x) = $\frac{16}{15}$. (2M)

2

A random variable X has the following probability function

X	0	1	2	3	4	5	6	7
P(x)	0	K	2k	2k	3k	K^2	$2k^2$	$7k^2+k$

Find (i) the value of 'k'

(ii) Evaluate $P[1.5 < X < 4.5 / X > 2]$

(iii) **The smallest value of** λ **for which** $P[X \le \lambda] > \frac{1}{2}$ **(8M) (Nov/Dec 2012,May/June 2012, May/June 2014, A/M 2015)** BTL5

Answer: Page: 1.74-Dr.A.Singaravelu

- Total Probability $\sum P(x) = 1$
- C.D. F $F(x) = P(X \le x) = \sum_{t \le x} p(t)$
- Mean $E(x) = \sum xP(x)$
- $E(x^2) = \sum x^2 P(x)$
- $VarX = E(X^2) - [E(x)]^2$

- Value of $k = \frac{1}{10}$. (2M)
- $P[1.5 < X < 4.5 / X > 2] = \frac{P[1.5 < X < 4.5 \cap X > 2]}{P(X > 2)} = \frac{5}{7}$. (3M)
- The minimum value of $\lambda = 4$. (3M)

3

If the probability mass function of a random variable X is given by $P(X = r) = kr^3$ ***r=1,2,3,4*** **Find the value of 'k',** $P\left(\frac{1}{2} < X < \frac{5}{2} / X > 1\right)$**, mean and variance of X. (8M)(Apr/May 2015)** BTL5

Answer: Page: 1.24- Dr.G. Balaji

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- Total Probability $\sum P(x) = 1$
- C.D. F $F(x) = P(X \le x) = \sum_{t \le x} p(t)$
- Mean $E(x) = \sum xP(x)$
- $E(x^2) = \sum x^2 P(x)$
- $VarX = E(X^2) - [E(x)]^2$
- Value of $k = \frac{1}{100}$. (2M)
- $P\left(\frac{1}{2} < X < \frac{5}{2} / X > 1\right) = \frac{P\left(\frac{1}{2} < X < \frac{5}{2} \cap X > 1\right)}{P(X > 1)} = \frac{8}{99}$. (3M)
- Mean $E(X) = 3.54$, Var(X)= 0.4684. (3M)

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If the moments of a random variable 'X' are defined by E(X^r) =0.6; r=1,2,3,… Show that P(X=0)=0.4, P(X=1)=0.6, $P(X \ge 2) = 0$ BTL5

Answer: Page: 1.70-Dr.G. Balaji

- $M_x(t) = E(e^{tx}) = \sum_{x=0}^{\infty} e^{tx} p(x)$
- $M_x(t) = \sum_{x=0}^{\infty} \frac{t^r}{r!} \mu_r'$
- $M_x(t) = \sum_{x=0}^{\infty} \frac{t^r}{r!} \mu_r' = 0.4 + (0.6)e^t$
- But $M_x(t) = E(e^{tx}) = \sum_{x=0}^{\infty} e^{tx} p(x) = p(0) + e^t p(1) + e^{2t} p(2)$. (3M)
- Comparing P(X=0) = 0.4, P(X=1)=0.6. (3M)
- $P(X \ge 2) = 0$. (2M)

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A continuous random variable X that can assume any value between x=2 and x=5 has a density function f(x) = k(1+x). Find P[X<4]. (8M) (Nov/Dec 2012, Apr/May 2015) BTL5

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</table>

	Answer: Page: 1.88- Dr.A.Singaravelu • Total probability $\int_{-\infty}^{\infty} f(x)dx = 1 \Rightarrow \int_{2}^{5} k(1+x)dx = 1$. (2M) • The value of $k = \frac{2}{27}$. (3M) • $P[X < 4] = \int_{2}^{4} f(x)dx = \frac{16}{27}$. (3M)
6	**If the density function of a continuous random variable X is given by** $f(x) = \begin{cases} ax & ,0 \le x \le 1 \\ a & ,1 \le x \le 2 \\ 3a - ax, & 2 \le x \le 3 \\ 0 & ,otherwise \end{cases}$ **.Find the value of 'a, and find the c.d.f of X. (8M) (Apr/May 2015)**BTL5 **Answer : Page: 1.118- Dr. A. Singaravelu** • $\int_{-\infty}^{\infty} f(x)dx = 1 \Rightarrow \int_{0}^{1} ax\,dx + \int_{1}^{2} a\,dx + \int_{2}^{3} (3a - ax)\,dx = 1$ (1M) • Value of a=0.5. (1M) • For c.d.f , If x<0, F(x)=0. (1M) • If $0 \le x \le 1, F(x) = \frac{x^2}{4}$. (1M) • $1 \le x \le 2, F(x) = \frac{x}{2} - \frac{1}{4}$. (2M) • $2 \le x \le 3, F(x) = -\frac{x^2}{4} + \frac{3}{2}x - \frac{5}{4}$, For x>3, F(x)=1. (2M)
7	**A continuous random variable 'X' has the density function f(x) given by .** $f(x) = \frac{k}{1+x^2}, -\infty < x < \infty$ **Find the value of 'k' and the cumulative distribution of 'X'.(8M) (Nov/Dec 2014, Apr/May 2018)** BTL5 **Answer: Page: 1.123- Dr. A. Singaravelu** • $\int_{-\infty}^{\infty} f(x)dx = 1 \Rightarrow \int_{0}^{1} \frac{k}{1+x^2} dx = 1$. (2M) • The value of $k = \frac{1}{\pi}$. (2M) • The c.d.f is $F(x) = \int_{-\infty}^{x} f(x)dx = \int_{-\infty}^{x} \frac{1}{\pi}\left(\frac{1}{1+x^2}\right)dx = \frac{1}{\pi}\left[\tan^{-1} x + \frac{\pi}{2}\right]$. (4M)
8	**Let 'X' be the random variable that denotes the outcome of the roll of a fair die. Compute the mean and variance of 'X'.(8M)(Apr/May 2018)** BTL4

	Answer : Page: 1.177- Dr. A. Singaravelu • $P(X=i)=\frac{1}{6}, i=1,2,\ldots,6$. (1M) • $M_x(t)=\sum_{i=1}^{6} e^{it}P(X=i)=\frac{1}{6}\left[e^t+e^{2t}+\ldots+e^{6t}\right]$. (2M) • $E(x)=\left[M_x'(t)\right]_{t=0}=\frac{7}{2}$. (2M) • $.E(x^2)=\left[M_x''(t)\right]_{t=0}=\frac{91}{6}$. (2M) • $Var(X)=E(X^2)-\left[E(X)\right]^2=\frac{35}{12}$. (1M)
9	**For the triangular distribution** $f(x)=\begin{cases} x & ,0<x\le 1 \\ 2-x, & 1\le x\le 2 \\ 0 & ,otherwise \end{cases}$ **.Find the mean, variance, moment generating function. (8M) (Nov/Dec 2013)** BTL5 **Answer : Page: 1.180- Dr. A. Singaravelu** • $M_x(t)=E[e^{tx}]=\frac{\left[e^t-1\right]^2}{t^2}$. (3M) • Mean $E(X)=\int_{-\infty}^{\infty} x\, f(x)\,dx=1$. (2M) • $E(X^2)=\int_{-\infty}^{\infty} x^2\, f(x)\,dx=\frac{7}{6}$. (2M) • $Var(X)=E(X^2)-\left[E(X)\right]^2=\frac{1}{6}$ (1M)
10	**Find the M.G.F of the random variable X having the probability density function** $f(x)=\begin{cases} \frac{x}{4}e^{-x/2} & ,x>0 \\ 0 & ,elsewhere \end{cases}$ **(8M) (May/June2012, May/June 2014)** BTL5 **Answer: Page:1.74-Dr. G. Balaji** • $M_x(t)=E[e^{tx}]=\int_0^{\infty} e^{tx}\frac{x}{4}e^{-x/2}\,dx=\frac{1}{(1-2t)^2}$. (1M) • $M_x(t)=1+\frac{t}{1!}\mu_1'+\frac{t^2}{2!}\mu_2'+\frac{t^3}{3!}\mu_3'+\ldots$ (1M) • $M_x(t)=1+\frac{t}{1!}(4)+\frac{t^2}{2!}(24)+\frac{t^3}{3!}(192)+\ldots$ (2M)

	• $\mu_1' = coefficient\ of\ \frac{t}{1!} = 4$. (1M) • $\mu_2' = coefficient\ of\ \frac{t^2}{2!} = 24$. (1M) • $\mu_3' = coefficient\ of\ \frac{t^3}{3!} = 192$. (1M) • $\mu_4' = coefficient\ of\ \frac{t^4}{4!} = 1920$. (1M)
11	**Find the MGF of the Binomial distribution and hence find the mean and variance. (8M)(Apr/May 2011, May/June2019)**BTL2 **Answer : Page: 1.190- Dr. A. Singaravelu** • $P(x) = nC_x p^x q^{n-x}$, $x = 0,1,2,...,n$. (1M) • $M_x(t) = E[e^{tx}] = (q + pe^t)^n$. (2M) • Mean $E(X) = \left[M_x'(t)\right]_{t=0} = np$. (2M) • $E(X^2) = \left[M_x''(t)\right]_{t=0} = n^2p^2 + npq$. (2M) • Var(X)= npq. (1M)
12	**Derive Poisson distribution form Binomial distribution. (8M)(Nov/Dec 2014, Apr/May 2019)**BTL2 **Answer : Page: 1.219 – Dr. A. Singaravelu** The Binomial distribution becomes Poisson distribution under the following conditions (2M) • The number of trials is very large • The probability of success is very small • $np = \lambda$ • $P(X = x) = \lim_{n\to\infty} nC_x p^x q^{n-x} = \lim_{n\to\infty} \frac{(1-1/n)(1-2/n)...(1-(x-1)/n)}{x!} \lambda^x \frac{(1-\lambda/n)^n}{(1-\lambda/n)^x}$. (4M) • $P(X = x) = \frac{e^{-\lambda}\lambda^x}{x!}$. (2M)
13	**It is known that the probability of an item produced by a certain machine will be defective is 0.05. If the produced items are sent to the market in packets of 20, find the number of packets containing atleast, exactly and atmost 2 defective items in a consignment of 1000packets using binomial and Poisson distribution.(8M) (Nov/Dec 2017)** BTL5 **Answer : Page: 1.116 – Dr. GBalaji**

	Probability of Binomial Distribution $P(X=x)=nC_x p^x q^{n-x}$ Probability of Poisson Distribution $P(X=x)=\dfrac{e^{-\lambda}\lambda^x}{x!}$ Binomial Distribution • Number of packets containing atleast 2 defective items $= NP(X\geq 2)=264$. (2M) • Number of packets containing exactly 2 defective items $= NP(X=2)=189$. (1M) • Number of packets containing atmost 2 defective items $= NP(X\leq 2)=925$. (1M) Poisson Distribution • Number of packets containing atleast 2 defective items $= NP(X\geq 2)=264$. (2M) • Number of packets containing exactly 2 defective items $= NP(X=2)=184$. (1M) • Number of packets containing atmost 2 defective items $= NP(X\leq 2)=920$. (1M)
14	**The number of monthly breakdown of a computer is a random variable having a Poisson distribution with mean equal to 1.8. Find the probability that this computer will function for a month (1)without a breakdown, (2)with only one breakdown and (3)with atleast one breakdown(8M) (Nov/Dec 2017)** BTL5 **Answer : Page: 1.227- Dr. A. Singaravelu** Probability of Poisson Distribution $P(X=x)=\dfrac{e^{-\lambda}\lambda^x}{x!}$ • P(without a breakdown) = P(X=0) = 0.1653. (2M) • P(with only one breakdown) = P(X=1)=0.2975. (2M) • P(with atleast 1 breakdown)= $P(X\geq 1)=1-P(X<1)=0.8347$. (4M)
15	**State and prove the Memoryless property of Geometric distribution.(8M)(Nov/Dec2015, May/June 2016)** BTL1 **Answer : Page: 1.254- Dr. A. Singaravelu** Probability of Geometric distribution $P(X=x) = q^{x-1}p$, x=1,2,… • $P[X>m+n/X>m]=\dfrac{P[X>m+n\cap X>m]}{P[X>m]}$. (2M) • $P[X>k] = q^k$ (4M) • $P[X>m+n/X>m]=\dfrac{P[X>m+n]}{P[X>m]}=q^n$. (2M)
16	**If the probability that an applicant for a driver's license will pass the road test on any given trial is 0.8, what is the probability that he will finally pass the test (a) on the fourth trial, (b) in fewer than 4 trials. (8M) (May/June2015)** BTL5 **Answer : Page: 1.137- Dr. G. Balaji** Probability of Geometric distribution $P(X=x) = q^{x-1}p$, x=1,2,…

	• P(on the fourth trial) = P(X=4) = 0.0064. (4M) • P(fewer than 4 trials) = P(X<4) = 0.992. (4M)
17	**A coin is tossed until the first head occurs. Assuming that the tosses are independent and the probability of a head occurring is 'p', find the value of 'p' so that the probability that an odd number of tosses is required, is equal to 0.6. Can you find a value of 'p' so that the probability is 0.5 that an odd number of tosses is required? (8M)(Nov/Dec 2010, Nov/Dec 2016)** BTL4 **Answer : Page: 1.135- Dr. G. Balaji** Probability of Geometric distribution $P(X=x) = q^{x-1}p$, x=1,2,… • P[X= odd number of tosses] $=\frac{1}{1+q}=0.6$ (3M) • $q=\frac{2}{3}, p=1-q=\frac{1}{3}$. (1M) • P[X= odd number of tosses] $=\frac{1}{1+q}=0.5$ (3M) • q=1, p=0 . (1M)
18	**Determine the moment generating function of Uniform distribution in (a,b) and hence find the mean and variance. (8M) (Nov/Dec 2017, Apr/May 2018)** BTL2 **Answer : Page: 1.256- Dr. A. Singaravelu** The probability function of Uniform distribution is $f(x)=\begin{cases}\frac{1}{b-a}, a<x<b\\ 0 \quad ,otherwise\end{cases}$ • $M_x(t)=E[e^{tx}]=\int_a^b e^{tx} f(x)dx=\frac{\left(e^{bt}-e^{at}\right)}{t(b-a)}$. (3M) • Mean $E(X)=\int_a^b x\, f(x)\, dx=\frac{b+a}{2}$. (2M) • $E(X^2)=\int_a^b x^2\, f(x)\, dx=\frac{b^2+ab+a^2}{3}$. (2M) • $Var(X)=\frac{(b-a)^2}{12}$. (1M)
19	**Suppose 'X' has an exponential distribution with mean=10, Determine the value of 'x' such that P(X<x)=0.95. (8M) (Nov/Dec 2015, Apr/May 2017)** BTL5 **Answer : Page: 1.143- P. Sivaramakrishna Dass**

<table>
<tr><td></td><td>The probability function of exponential distribution is $f(x)=\begin{cases}\lambda e^{-\lambda x}, x\geq 0\\ 0 \quad ,otherwise\end{cases}$

• $Mean=\frac{1}{\lambda}=10 \Rightarrow \lambda=\frac{1}{10}$. (2M)
• P(X<x)= 1-P(X>x) =0.95. (2M)
• $1-e^{-\frac{x}{10}}=0.95 \Rightarrow x=29.96$. (4M)</td></tr>
<tr><td>20</td><td>The time in hours required to repair a machine is exponentially distributed with perimeter $\lambda=\frac{1}{2}$.

(i) What is the probability that the repair time exceeds 2h
(ii) What is the conditional probability that a repair takes atleast 10h given that its duration exceeds 9h? (8M) (May/June 2012, Nov/Dec 2016, Nov/Dec 2017) BTL3

Answer : Page: 1.274- Dr. A. Singaravelu

The probability function of exponential distribution is $f(x)=\begin{cases}\lambda e^{-\lambda x}, x\geq 0\\ 0 \quad ,otherwise\end{cases}$

• P(the repair time exceeds 2h) $P(X>2)=\int_2^\infty \frac{1}{2}e^{-x/2}dx$ (2M)
• $P(X>2)=0.3679$. (2M)
• $P(X\geq 10/X>9)=P(X>1)=\int_1^\infty \frac{1}{2}e^{-x/2}dx$. (2M)
• $P(X\geq 10/X>9)=0.6065$. (2M)</td></tr>
<tr><td>21</td><td>In a test 2000 electric bulbs, it was found that the life of a particular make, was normally distributed with an average life of 2040 hours and S.D. of 60 hours. Estimate the number of bulbs likely to burn for (i)more than 2150 hours, (ii)less than 1950 hours and (iii) more than 1920 hours but less than 2160 hours. (8M) (Nov/Dec 2017) BTL5

Answer: Page:1.293 -A. Singaravelu

• $z=\frac{X-\mu}{\sigma}$
• P(more than 2150 hrs) = P(X>2150) =P(z > 1.833) = 0.5-P(0 < z < 1.833) = 0.0336. (2M)
• The number of bulbs expected to burn for more than 2150hrs = 2000 x 0.0336 = 67. (1M)
• P(Less than 1950 hrs) = P(X< 1950) = P(z< -1.5) = 0.5 – P(0< z< 1.5) = 0.0668. (2M)
• The number of bulbs expected to burn for less than 1950hrs = 2000 x 0.0668 = 134. (1M)
• P(more than 1920 hrs but less than 2160 hrs) = P(1920 <X < 2160) = P(-2 < z < 2) = 0.9546.(1M)
• The number of bulbs = 2000 x 0.9546 = 1909. (1M)</td></tr>
<tr><td>22</td><td>In a normal distribution 31% of the items are under 45 and 8% are over 64. Find the mean and variance</td></tr>
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of the distribution. (8M) (Nov/Dec 2012, Nov/Dec 2015) BTL5

Answer: Page: 1.295- A. Singaravelu

- $z = \dfrac{X-\mu}{\sigma}$
- $45-\mu = -0.49\sigma$. (2M)
- P(Z > Z_1) = 0.8 or P(0 < Z < Z_2)= 0.42. (1M)
- From tables , Z_2 = 1.40. (1M)
- $64-\mu = 1.40\sigma$. (2M)
- Solving, $\sigma = 10, \mu = 50$. (2M)

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<tr>
<td>23</td>
<td>

The contents of urns I, II, III are as follows:

1 white, 2 red and 3 black balls

2 white, 3 red and 1 black balls and

3 white, 1 red and 2 black balls.

One urn is chosen at random and 2 balls are drawn. They happen to be white and red. What is the probability that they came from urns I, II, III. (Nov/Dec 2019) BTL5

Answer: Page: 1.60-Dr. A. Singaravelu

Let $A_1, A_2, ..., A_n$ be 'n' mutually exclusive and exhaustive events with $P(A_i) \neq 0$ for I = 1,2,…n. Let 'B' be an event such that $B \subset \bigcup_{I=1}^{N} A_i$, $P(B) \neq 0$ then $P(A_i/B) = \dfrac{P(A_i).P(B/A_i)}{\sum_{i=1}^{n} P(A_i).P(B/A_i)}$

- P(E_1)= P(E_2)= P(E_3) = $\frac{1}{3}$ (1M)
- $P(A/E_1) = \dfrac{1C_1 \times 2C_1}{6C_2} = \dfrac{2}{15}$, $P(A/E_2) = \dfrac{2C_1 \times 3C_1}{6C_2} = \dfrac{6}{15}$, $P(A/E_3) = \dfrac{3C_1 \times 1C_1}{6C_2} = \dfrac{3}{15}$ (2M)
- $P(E_2/A) = \dfrac{P(E_2).P(A/E_2)}{\sum_{i=1}^{3} P(E_i).P(A/E_i)} = \dfrac{6}{11}$ (2M)
- $P(E_3/A) = \dfrac{P(E_3).P(A/E_3)}{\sum_{i=1}^{3} P(E_i).P(A/E_i)} = \dfrac{3}{11}$ (2M)
- P(E_1/A) = 1- P(E_2/A) - P(E_3/A) = $\frac{2}{11}$ (1M)

</td>
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</table>

UNIT II – TWO - DIMENSIONAL RANDOM VARIABLES

Joint distributions – Marginal and conditional distributions – Covariance – Correlation and linear regression – Transformation of random variables – Central limit theorem (for independent and identically distributed random variables).

PART *A

<table>
<tr><th>Q.No.</th><th>Questions</th></tr>
<tr><td>1.</td><td>State the basic properties of joint distribution of (X,Y) where X and Y are random variables. (May/June 2014) BTL1
Properties of joint distribution of (X,Y) are
(i) $F[-\infty, y] = 0 = F[x, -\infty] \text{ and } F[-\infty,-\infty] = 0, F[\infty,\infty] = 0$
(ii) $P[a < X < b, Y \le y] = F(b, y) - F(a, y)$
(iii) $P[X \le x, c < Y < d] = F(x,d) - F(x,c)$
(iv) $P[a < X < b, c < Y < d] = F(b,d) - F(a,d) - F(b,c) + F(a,c)$
(v) At points of continuity of f(x,y), $\frac{\partial^2 F}{\partial x \partial y} = f(x, y)$</td></tr>
<tr><td>2</td><td>The joint probability mass function of a two dimensional random variable (X,Y) is given by p(x,y) = f(2x + y); x = 1,2 and y = 1,2 where ‘k’ is a constant. Find the value of ‘k’.(Nov/Dec 2015) BTL5
The joint pmf of (X,Y) is
<table><tr><td>x \ y</td><td>1</td><td>2</td></tr><tr><td>1</td><td>3k</td><td>4k</td></tr><tr><td>2</td><td>5k</td><td>6k</td></tr></table>We have $\sum\sum p(x, y) = 1$
Therefore, $3k + 4k + 5k + 6k = 1$
18 k=1 $k = \frac{1}{18}$.</td></tr>
<tr><td>3</td><td>The joint probability density function of the random variables (X,Y) is given by $f(x, y) = kxye^{-\left(x^2+y^2\right)}, \ x > 0, y > 0$. Find the value of ‘k’. (Apr/May 2015) BTL5</td></tr>
</table>

	$\iint f(x,y)\,dkx\,dy=1$ $\int_0^\infty\int_0^\infty kxy\,e^{-(x^2+y^2)}\,dx\,dy=1$ $k\int_0^\infty ye^{-y^2}dy\int_0^\infty x\,e^{-x^2}dx=1$ $\quad Put\ x^2=t$ $2xdx=dt$ $k\int_0^\infty ye^{-y^2}dy\int_0^\infty e^{-t}\frac{dt}{2}=1$ $\quad xdx=\frac{dt}{2}$ $\frac{k}{2}\int_0^\infty ye^{-y^2}\left[-e^{-t}\right]_0^\infty dy=1$ $\frac{k}{2}\int_0^\infty ye^{-y^2}[0+1]dy=1$ $\frac{k}{2}\int_0^\infty e^{-t}\frac{dt}{2}=1$ We have $\frac{k}{4}\left[-e^{-t}\right]_0^\infty=1$ $\frac{k}{4}[0+1]=1 \Rightarrow k=4$
4	**If the function f(x,y) = c(1-x)(1-y) , 0 < x < 1 , 0 < y < 1 is to be a density function, find the value of 'c'.(8M) (Nov/Dec 2017)** BTL5 $\iint f(x,y)\,dx\,dy=1$ $\int_0^1\int_0^1 c(1-x)(1-y)dx\,dy=1$ $c\int_0^1(1-y)dy\int_0^1(1-x)dx=1$ $c\left[y-\frac{y^2}{2}\right]_0^1\left[x-\frac{x^2}{2}\right]_0^1=1$ $c\left[1-\frac{1}{2}\right]\left[1-\frac{1}{2}\right]=1$ $c\left[\frac{1}{2}\right]\left[\frac{1}{2}\right]=1$ $c\left[\frac{1}{4}\right]=1 \Rightarrow c=4$

5	**The joint pdf of (X,Y) is** $f_{xy}(x,y)=xy^2+\frac{x^2}{8}, 0\le x\le 2, 0\le y\le 1$**. Find P(X<Y). (May/June 2013, Apr/May 2019)**BTL5 $P(X<Y)=\int_0^1\int_0^y\left(xy^2+\frac{x^2}{8}\right)dx\,dy$ $=\int_0^1\left[y^2\left(\frac{x^2}{2}\right)_0^y+\frac{1}{8}\left(\frac{x^3}{3}\right)_0^y\right]dy$ $=\int_0^1\left[\frac{y^2}{2}(y^2)+\frac{1}{24}(y^3)\right]dy=\int_0^1\left[\frac{y^4}{2}+\frac{y^3}{24}\right]dy$ $=\frac{1}{2}\left(\frac{y^5}{5}\right)_0^1+\frac{1}{24}\left(\frac{y^4}{4}\right)_0^1=\frac{1}{10}(1-0)+\frac{1}{96}(1-0)=\frac{53}{480}$
6	**If the joint pdf of (X,Y) is** $f(x,y)=\begin{cases}\frac{1}{4} & ,0<x,y<2\\ 0 & ,otherwise\end{cases}$ **. Find** $P[X+Y\le 1]$BTL5 $P[X+Y\le 1]=\int_0^1\int_0^{1-y}\left(\frac{1}{4}\right)dx\,dy=\frac{1}{4}\int_0^1(x)_0^{1-y}dy$ $=\frac{1}{4}\int_0^1(1-y)dy=\frac{1}{4}\left[y-\frac{y^2}{2}\right]_0^1$ $=\frac{1}{4}\left[1-\frac{1}{2}\right]=\frac{1}{8}$
7	**Find the marginal density function of X and Y if** $f(x,y)=\begin{cases}\frac{6}{5}(x+y^2) & ,0\le x,y\le 1\\ 0 & ,otherwise\end{cases}$ **(Nov/Dec 2012)** BTL5 Marginal density function of X is $f_x(x)=\int f(x,y)\,dy=\int_0^1\frac{6}{5}(x+y^2)dy=\frac{6}{5}\left[xy+\frac{y^3}{3}\right]_0^1=\frac{6}{5}\left[x+\frac{1}{3}\right]\ 0\le x\le 1$ Marginal density function of Y is

	$f_y(y)=\int f(x,y)\,dx=\int_0^1 \frac{6}{5}\left(x+y^2\right)dy=\frac{6}{5}\left[\frac{x^2}{2}+y^2x\right]_0^1=\frac{6}{5}\left[\frac{1}{2}+y^2\right]\ 0\le y\le 1$
8	**The joint probability density function of the random variable X and Y is** $f(x,y)=\begin{cases}25e^{-5y} & ,0<x<0.2, y>0\\ 0 & ,otherwise\end{cases}$ **.Find the marginal PDF of X and Y. (Nov/Dec 2016)** BTL5 Marginal density function of X is $f_x(x)=\int f(x,y)\,dy=\int_0^\infty 25e^{-5y}dy=25\left[\frac{e^{-5y}}{-5}\right]_0^\infty=-5[0-1]=5\ \ 0\le x\le 0.2$ Marginal density function of Y is $f_y(y)=\int f(x,y)\,dx=\int_0^{0.2} 25e^{-5y}dx=25e^{-5y}[x]_0^{0.2}=2e^{-5y}[0.2-0]=5e^{-5y}\quad y>0$
9	**If X and Y are independent random variables having the joint density function** $f(x,y)=\frac{1}{8}(6-x-y), 0<x<2,\ 2<y<4$ **. Find P[X+Y<3]**. BTL5 $P[X+Y<3]=\frac{1}{8}\int_2^3\int_0^{3-y}(6-x-y)dx\,dy$ $=\frac{1}{8}\int_2^3\left[(6-y)(x)-\frac{x^2}{2}\right]_0^{3-y}dy=\frac{1}{8}\int_2^3\left[(6-y)(3-y)-\frac{(3-y)^2}{2}\right]dy$ $=\frac{1}{8}\int_2^3\left[18-9y+y^2-\frac{1}{2}(3-y)^2\right]dy$ $=\left[18y-9\frac{y^2}{2}+\frac{y^3}{3}-\frac{1}{2}\frac{(3-y)^3}{-3}\right]_2^3$ $=\left[18(3)-\frac{9}{2}(9)+\frac{27}{3}+\frac{1}{6}(0)\right]-\left[18(2)-\frac{9}{2}(4)+\frac{8}{3}+\frac{1}{6}(1)\right]$ $=\left[18-\frac{45}{2}+\frac{19}{3}-\frac{1}{6}\right]=\frac{5}{24}$
10	**Let X and Y be random variables with joint density function** $f(x,y)=\begin{cases}4xy & ,0\le x\le 1,\ 0\le y\le 1\\ 0 & ,otherwise\end{cases}$ **Find E[XY].** BTL5

	$E[XY]=\iint xy\, f(x,y)\,dx\,dy=\int_0^1\int_0^1 xy(4xy)\,dx\,dy$ $=4\int_0^1 x^2dx\int_0^1 y^2dy$ $=4\left[\frac{x^3}{3}\right]_0^1\left[\frac{y^3}{3}\right]_0^1=\frac{4}{9}(1)(1)=\frac{4}{9}$
11	**Let X and Y be a two-dimensional random variable. Define covariance of (X,Y). If X and Y are independent, what will be the covariance of (X,Y)? (May/June 2016)** BTL2 Covariance of (X,Y) is defined as *Cov(X,Y) = E[XY] – E[x]E[Y]* If X and Y are independent, then *Cov(X,Y) =0.*
12	**Two random variables X and Y have the joint pdf** $f(x,y)=\begin{cases}\frac{xy}{96} & ;0<x<4,1<y<5\\ 0 & ;otherwise\end{cases}$**. Find *Cov(X,Y)*. (May/June 2016)** BTL5 *Cov(X,Y) = E[XY] – E[x]E[Y]* $E[X]=\iint x\, f(x,y)\,dx\,dy=\int_1^5\int_0^4 x\left(\frac{xy}{96}\right)dx\,dy=\frac{1}{96}\int_1^5 ydy\int_0^4 x^2\,dx$ $=\frac{1}{96}\left[\frac{y^2}{2}\right]_1^5\left[\frac{x^3}{3}\right]_0^4=\frac{1}{576}[25-1][64]=\frac{8}{3}$ $E[Y]=\iint y\, f(x,y)\,dx\,dy=\int_1^5\int_0^4 y\left(\frac{xy}{96}\right)dx\,dy=\frac{1}{96}\int_1^5 y^2dy\int_0^4 x\,dx$ $==\frac{1}{96}\left[\frac{y^3}{3}\right]_1^5\left[\frac{x^2}{2}\right]_0^4=\frac{1}{576}[125-1][16]=\frac{31}{9}$ $E[XY]=\iint xy\, f(x,y)\,dx\,dy=\int_1^5\int_0^4 xy\left(\frac{xy}{96}\right)dx\,dy=\frac{1}{96}\int_1^5 y^2dy\int_0^4 x^2\,dx$ $=\frac{1}{96}\left[\frac{y^3}{3}\right]_1^5\left[\frac{x^3}{3}\right]_0^4=\frac{1}{864}[125-1][64]=\frac{248}{27}$ $\therefore\ Cov(X,Y)=\left[\frac{248}{27}\right]-\left[\frac{8}{3}\right]\left[\frac{31}{9}\right]=0$
13	**Let X and Y be any two random variables a,b be constants. Prove that**

	Cov(aX,bY)=abCov(X,Y). BTL5 $Cov(X,Y) = E[XY] - E[X]E[Y]$ $Cov(aX,bY) = E[aX\ bY] - E[aX]\ E[bY]$ $= ab\ E[XY] - ab\ E[X]E[Y]$ $= ab[E[XY] - E[X]E[Y]]$ $= ab\ Cov(X,Y)$
14	**If Y = - 2X + 3, Find Cov(X,Y).** BTL3 $Cov(X,Y) = E[XY] - E[X]E[Y]$ $= E[X(-2X+3)] - E[X]E[-2X+3]$ $= E[-2X^2+3X] - E[X][-2E[X]+3]$ $= -2E[X^2]+3E[X]+2(E[X])^2-3E[x]$ $= -2(E[X^2]-(E[X])^2) = -2Var\ X$
15	**If X_1 has mean 4 and variance 9 while X_2 has mean -2 and variance 5 and the two are independent , find $Var(2X_1+X_2-5)$.** BTL3 $E[X_1]=4$, $E[X_2] = -2$ $Var[X_1] = 9$, $Var[X_2] = 5$ $Var(2X_1+X_2-5) = 4\ VarX_1 + VarX_2$ $= 4(9) + 5 = 41.$
16	**If X and Y are independent random variables then show that E[Y/X] = E[Y] , E[X/Y] = E[X]. (Nov/Dec 2016)** BTL5 $E[Y/X] = \int y.\frac{f(x,y)}{f(x)}dy$ Since X and Y are independent, $E[Y/X] = \int y.\frac{f(x).f(y)}{f(x)}dy = \int y.\ f(y)\,dy = E[Y]$ $E[X/Y] = \int x.\frac{f(x,y)}{f(y)}dx$ Since X and Y are independent, $E[X/Y] = \int x.\frac{f(x).f(y)}{f(y)}dx = \int x.\ f(x)\,dx = E[X]$
17	**Find the acute angle between the two lines of regression. (Apr/May 2015, Apr/May 2019)** BTL3 The equations of the regression are

	$y-\bar{y}=r\frac{\sigma_y}{\sigma_x}(x-\bar{x})$ ------------(1) $x-\bar{x}=r\frac{\sigma_x}{\sigma_y}(y-\bar{y})$ ------------(2) Slope of line (1) is $m_1=r\frac{\sigma_y}{\sigma_x}$ Slope of line (2) is $m_2=\frac{1}{r}\frac{\sigma_y}{\sigma_x}$ If θ is the acute angle between the two lines, then $\tan\theta=\frac{\lvert m_1-m_2\rvert}{1+m_1m_2}$ $=\frac{\left\lvert r\frac{\sigma_y}{\sigma_x}-\frac{\sigma_y}{r\sigma_x}\right\rvert}{1+r\frac{\sigma_y}{\sigma_x}.\frac{\sigma_y}{r\sigma_x}}=\frac{\left\lvert\frac{(r^2-1)}{r}\frac{\sigma_y}{\sigma_x}\right\rvert}{1+\frac{\sigma_y^2}{\sigma_x^2}}$ $=\frac{\left\lvert\frac{-(1-r^2)}{r}\frac{\sigma_y}{\sigma_x}\right\rvert}{\frac{\sigma_x^2+\sigma_y^2}{\sigma_x^2}}=\frac{(1-r^2)\sigma_x\sigma_y}{\lvert r\rvert(\sigma_x^2+\sigma_y^2)}$
18	**The regression equations are 3x + 2y = 26 and 6x + y = 31. Find the correlation coefficient between X and Y.** BTL5 Let 3x + 2y = 26 be the regression equation of Y on X. Therefore, $2y=-3x+26 \Rightarrow y=-\frac{3}{2}x+\frac{26}{2}$. The regression coefficient $b_{yx}=-\frac{3}{2}$ Let 6x + y = 31 be the regression equation of X on Y. Therefore, $6x=-y+31 \Rightarrow x=-\frac{1}{6}y+\frac{31}{6}$ The regression coefficient $b_{xy}=-\frac{1}{6}$ Hence, correlation coefficient r_{xy} is given by $r_{xy}=\pm\sqrt{b_{yx}\times b_{xy}}=\pm\sqrt{\left(\frac{-3}{2}\right)\left(\frac{-1}{6}\right)}=\pm\sqrt{\frac{1}{4}}=\pm 0.5$ =-0.5, since both the regression coefficients are negative.
19	**The two regression equations of two random variables X and Y are 4x – 5y +33 = 0 and 20x – 9y =107. Find the mean values of X and Y. (Nov/Dec 2015)** BTL5 Replace x and y as $\bar{x}$ and $\bar{y}$, we have

	$4\bar{x}-5\bar{y}=-33 \quad ------(1)$ $20\bar{x}-9\bar{y}=107 \quad ------(2)$ Solving the equations (1) and (2), we have $\bar{x}=13$ and $\bar{y}=17$.
20	**Can y=5+2.8x and x=3-0.5y be the estimated regression equations of y on x and x on y respectively, explain your answer. (Nov/Dec 2016)** BTL4 Since the signs of regression co-effieients are not the same, the given equation is not estimated regression equation of y on x and x on y.
21	**If X has an exponential distribution with parameter 1. Find the pdf of $y=\sqrt{x}$.** BTL3 $y=\sqrt{x} \Rightarrow x=y^2$ Since $dx=2y\,dy \Rightarrow \frac{dx}{dy}=2y$ Since X has an exponential distribution with parameter 1, the pdf of X is given by, $f_x(x)=e^{-x}, x>0 \qquad [f(x)=\lambda e^{-\lambda x}, \lambda=1]$ $\therefore f_y(y)=f_x(x)\left\|\frac{dx}{dy}\right\|$ $=e^{-x}2y=2ye^{-y^2} \quad y>0$
22	**State Central limit theorem.** BTL1 If X_1, X_2, …,X_n,… be a sequence of independent identically distributed random variables with $E(X_i)=\mu$ and $Var(X_i)=\sigma^2$, i=1,2,… and if $S_n = X_1 + X_2 + … + X_n$, then under certain general conditions, S_n follows a normal distribution with mean $n\mu$ and variance $n\sigma^2$ as $n\to\infty$
23	**If X and Y have joint pdf of** $f(x,y)=\begin{cases} x+y, & 0<x,y<1 \\ 0 & ,elsewhere \end{cases}$**. Check whether X and Y are independent.** BTL4 The marginal function of X is $f(x)=\int_0^1 (x+y)dy=\left[xy+\frac{y^2}{2}\right]_0^1=x+\frac{1}{2}$, 0<x<1 The marginal function of Y is $f(y)=\int_0^1 (x+y)dx=\left[\frac{x^2}{2}+y\right]_0^1=y+\frac{1}{2}$, 0<y<1 Now, $f(x).f(y)=\left(x+\frac{1}{2}\right)\left(y+\frac{1}{2}\right)=xy+\frac{1}{2}(x+y)+\frac{1}{4}\neq x+y\neq f(x,y)$ Hence X and Y are not independent.
24	**Assume that the random variables X and Y have the probability density function f(x,y). What is E[E[X/Y]]? (Apr/May 2017)** BTL5

	$E[[X/Y]] = \int_{-\infty}^{\infty} E[X/Y] f(y)\,dy$ $= \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} x\, f(x/y)\,dx\, f(y)\,dy$ $= \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} x\, f(x/y)\; f(y)\,dx\,dy$ $= \int_{-\infty}^{\infty} x \int_{-\infty}^{\infty} f(x,y)\; dy\,dx$ $= \int_{-\infty}^{\infty} x\, f(x)\,dx = E(X)$
25	**Define the joint density function of two random variables X and Y.** BTL1 If (X,Y) is a two dimensional continuous random variables such that , a function f which assigns each (X,Y) a real number f(x,y) for all real x,y then f(x,y) is called the joint pdf of (X,Y), provided f(x,y) satisfies the following conditions (i) $f(x,y) \geq 0,\ for\ all\,(x,y) \in R$ (ii) $\iint_R f(x,y)\,dx\,dy = 1$
	Part*B
1	**The joint pmf of (X,Y) is given by P(x,y) = k(2x + 3y), x = 0,1,2 ; y = 1,2,3. Find all the marginal and conditional probability distributions. Also, find the probability distribution of (X+Y). (10M) (Nov/Dec 2014, Nov/Dec 2019)** BTL5 **Answer: Pg. 2.8 – Dr. A. Singaravelu** • $k = \frac{1}{72}$. (1M) • Marginal distribution of X: $P(X=0)=\frac{18}{72}, P(X=1)=\frac{24}{72}, P(X=2)=\frac{30}{72}$ (1M) • Marginal distribution of Y: $P(Y=1)=\frac{15}{72}, P(Y=2)=\frac{24}{72}, P(Y=3)=\frac{33}{72}$ (1M) • Conditional distribution of X given Y: $P[X=x_i/Y=y_1]=\frac{1}{5},\frac{1}{3},\frac{7}{15}$ (1M) • $P[X=x_i/Y=y_2]=\frac{1}{4},\frac{1}{3},\frac{5}{12}$. (1M) • $P[X=x_i/Y=y_3]=\frac{9}{33},\frac{1}{3},\frac{13}{33}$. (1M) • Conditional distribution of Y given X: $P[Y=y_i/X=x_0]=\frac{1}{6},\frac{1}{3},\frac{1}{2}$. (1M) • $P[Y=y_i/X=x_1]=\frac{5}{24},\frac{1}{3},\frac{11}{24}$. (1M) • $P[Y=y_i/X=x_2]=\frac{7}{30},\frac{1}{3},\frac{13}{30}$. (1M) • Total probability distribution of X+Y is 1. (1M)

2	**The two dimensional random variable (X,Y) has the joint pmf** $f(x,y)=\frac{x+2y}{27}, x=0,1,2; y=0,1,2$ **Find the conditional distribution of Y for X=x. (8M) (Nov/Dec 2017)** BTL5 **Answer : Pg. 2.13 – Dr. A. Singaravelu** • Marginal distribution of X: $P(X=0)=\frac{6}{27}, P(X=1)=\frac{9}{27}, P(X=2)=\frac{12}{27}$ (1M) • Marginal distribution of Y: $P(Y=0)=\frac{3}{27}, P(Y=1)=\frac{9}{27}, P(Y=2)=\frac{15}{27}$ (1M) • Conditional distribution of Y given X: $P[Y=y_i / X=x_0]=0,\frac{1}{3},\frac{2}{3}.$ (2M) • $P[Y=y_i / X=x_1]=\frac{1}{9},\frac{1}{3},\frac{5}{9}.$ (2M) • $P[Y=y_i / X=x_2]=\frac{1}{6},\frac{1}{3},\frac{1}{2}.$ (2M)
3	**Three balls are drawn at random without replacement from a box containing 2 white, 3 red and 4 black balls. If X denotes the number of white balls drawn and Y denote the number of red balls drawn, find the joint probability distribution of (X,Y). (8M)(Apr/May 2015, May/June 2016)** BTL5 **Answer: Page: 2.20- Dr. G. Balaji** • Let X denote number of white balls drawn and Y denote the number of red balls drawn. • $P(X=0,Y=0)=\frac{1}{21}, P(X=0,Y=1)=\frac{3}{14}, P(X=0,Y=2)=\frac{1}{7}, P(X=0,Y=3)=\frac{1}{84}$ (3M) • $P(X=1,Y=0)=\frac{1}{7}, P(X=1,Y=1)=\frac{2}{7}, P(X=1,Y=2)=\frac{1}{14}$ (3M) • $P(X=2,Y=0)=\frac{1}{21}, P(X=2,Y=1)=\frac{1}{28}$ (2M)
4	**The joint pdf of the random variable (X,Y) is given by** $f(x,y)=Kxye^{-(x^2+y^2)}, x>0, y>0$**. Find the value of 'K' and also prove that X and Y are independent. (8M) (Apr/May 2015)** BTL5 **Answer : Pg. 2.25 – Dr.A. Singaravelu** • Marginal density function of X : $f(x)=\int_{-\infty}^{\infty} f(x,y)dy$ • Marginal density function ofY: $f(y)=\int_{-\infty}^{\infty} f(x,y)dx$ • X and Y are independent if f(x,y) = f(x). f(y) • $\int_0^{\infty}\int_0^{\infty} Kxye^{=(x^2+y^2)}dx\,dy=1 \Rightarrow K=4.$ (2M) • Marginal density function of X : $f(x)=\int_0^{\infty} Kxye^{=(x^2+y^2)}dy=2xe^{-x^2}$. (2M)

	• Marginal density function of Y : $f(y)=\int_0^\infty Kxye^{-(x^2+y^2)}dx=2ye^{-y^2}$. (2M) • f(x). f(y) = $2xe^{-x^2}.2ye^{-y^2} = 4xye^{-(x^2+y^2)}=f(x,y)$. (2M)
5	**Given** $f_{XY}(x,y)=Cx(x-y), 0<x<2, -x<y<x$ **and 0 elsewhere. (a)Evaluate C; (b)Find $f_X(x)$; (c)** $f_{y/x}\left(\frac{y}{x}\right)$ **(d)**Find $f_y(y)$. **(8M) (May, June 2013May/June 2016)**BTL5 **Answer : Pg. 2.40 – Dr. A. Singaravelu** • $\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x,y)dx\,dy=1$ • Marginal density function of X : $f(x)=\int_{-\infty}^{\infty} f(x,y)dy$ • Marginal density function ofY: $f(y)=\int_{-\infty}^{\infty} f(x,y)dx$ • $\int_0^2\int_{-x}^{x} Cx(x-y)dy\,dx=1 \Rightarrow C=\frac{1}{8}$. (1M) • $f_x(x)=\int_{-x}^{x} Cx(x-y)dy=\frac{x^3}{4}, 0<x<2$. (2M) • $f\left(\frac{y}{x}\right)=\frac{f(x,y)}{f(x)}=\frac{x-y}{2x^2}, -x<y<x$. (2M) • $f_y(y)=\begin{cases}\int_{-y}^{2}\frac{1}{8}x(x-y)dx, if\ -2\le y\le 0 \ =\frac{1}{3}-\frac{y}{4}+\frac{5}{28}y^3\\ \int_{y}^{2}\frac{1}{8}x(x-y)dx, if\ 0\le y\le 2 \ =\frac{1}{3}-\frac{y}{4}+\frac{1}{28}y^3\end{cases}$ (3M)
6	**The joint pdf of (X,Y) is given by** $f(x,y)=e^{-(x+y)}, 0\le x,y\le\infty$ **. Are X and Y independent. (8M)(Nov/Dec 2015, Apr/May 2018)** BTL4 **Answer : Page:2.28 – Dr. A. Singaravelu** • Marginal density function of X : $f(x)=\int_{-\infty}^{\infty} f(x,y)dy$ • Marginal density function ofY: $f(y)=\int_{-\infty}^{\infty} f(x,y)dx$ • X and Y are independent if f(x,y) = f(x). f(y)

	• $f(x)=\int_0^\infty e^{-(x+y)}dy=e^{-x}$. (3M) • $f(y)=\int_0^\infty e^{-(x+y)}dx=e^{-y}$. (3M) • $f(x).f(y)=e^{-x}\,e^{-y}=e^{-(x+y)}=f(x,y)$. (2M)
7	**The joint p.d.f of a two dimensional random variable (X,Y) is given by** $f(x,y)=xy^2+\frac{x^2}{8}, 0\le x\le 2, 0\le y\le 1$ **. Compute (i)** $P\left(X>1/Y<\frac{1}{2}\right)$**, (ii)** $P\left(Y<\frac{1}{2}/X>1\right)$**,** **(iii) P(X<Y), (iv)** $P(X+Y\le 1)$**(8M) (Apr/May 2017)** BTL5 **Answer : Pg. 2.43 – Dr.A. Singaravelu** • $P\left(X>1/Y<\frac{1}{2}\right)=\frac{P\left(X>1,Y<\frac{1}{2}\right)}{P\left(Y<\frac{1}{2}\right)}=\frac{\frac{5}{24}}{\frac{1}{4}}=\frac{5}{6}$ (2M) • $P\left(Y<\frac{1}{2}/X>1\right)=\frac{P\left(X>1,Y<\frac{1}{2}\right)}{P(X>1)}=\frac{\frac{5}{24}}{\frac{19}{24}}=\frac{5}{19}$ (2M) • $P(X<Y)=\int_0^1\int_0^y\left(xy^2+\frac{x^2}{8}\right)dx\,dy=\frac{53}{480}$ (2M) • $P(X+Y\le 1)=\int_0^1\int_0^{1-y}\left(xy^2+\frac{x^2}{8}\right)dx\,dy=\frac{13}{480}$ (2M)
8	**Let X and Y have j.d.f f(x,y) = k , 0<x<y<2, Find the marginal pdf. Find the conditional density functions.(8M) (Nov/Dec 2016, Nov/Dec 2017)** BTL5 **Answer : Pg. 2.33 – Dr. A. Singaravelu** • $\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x,y)\,dx\,dy=1$ • Marginal density function of X : $f(x)=\int_{-\infty}^{\infty} f(x,y)dy$ • Marginal density function ofY: $f(y)=\int_{-\infty}^{\infty} f(x,y)dx$ • The conditional density function of X given Y: $f(X/Y)=\frac{f(x,y)}{f(y)}$ • The conditional density function of Y given X: $f(Y/X)=\frac{f(x,y)}{f(x)}$

- $\int_0^2 \int_0^y k\,dx\,dy = 1 \Rightarrow k = \frac{1}{2}$. (2M)
- $f(x) = \int_x^2 \frac{1}{2} dy = \frac{1}{2}(2-x), 0 < x < 1$ (2M)
- $f(y) = \int_0^y \frac{1}{2} dx = \frac{y}{2}, 0 < y < 2$ (2M)
- $f(X/Y) = \frac{1}{y}, 0 < x < y$ (1M)
- $f(Y/X) = \frac{1}{2-x}, x < y < 2$ (1M)

9

If the joint distribution function of X and Y is given by $F(x,y) = (1-e^{-x})(1-e^{-y}), x > 0, y > 0$**. Find the marginal density function of X and Y. Check if X and Y are independent. Also find P(1<X<3 / 1<Y<2). (8M) (Apr/May 2015, May/June 2016)** BTL5

Answer : Pg. 2.50 – Dr. A. Singaravelu

- $f(x,y) = \frac{\partial^2 F(x,y)}{\partial x \partial y} = e^{-(x+y)}$
- $f(x) = \int_0^\infty e^{-(x+y)} dy = e^{-x}$. (2M)
- $f(y) = \int_0^\infty e^{-(x+y)} dx = e^{-y}$. (2M)
- $f(x).f(y) = e^{-x} e^{-y} = e^{-(x+y)} = f(x,y)$. (2M)
- $P(1 < X < 3, 1 < Y < 2) = \left(\frac{1-e^2}{e^3}\right)\left(\frac{1-e}{e^2}\right)$. (2M)

10

Find the co-efficient of correlation between X and Y from the data given below.(8M) (May 2016) BTL5

X	65	66	67	67	68	69	70	72
Y	67	68	65	68	72	72	69	71

Answer : Page: 2.71- Dr. A. Singaravelu

- $\overline{X} = \frac{\sum X}{n} = \frac{544}{8} = 68$ (1M)
- $\overline{Y} = \frac{\sum Y}{n} = \frac{552}{8} = 69$ (1M)
- $\sigma_x = \sqrt{\frac{1}{n}\sum X^2 - \overline{X}^2} = 2.121$ (2M)
- $\sigma_y = \sqrt{\frac{1}{n}\sum Y^2 - Y^2} = 2.345$ (2M)

	• $r(X,Y)=\dfrac{Cov(X,Y)}{\sigma_x.\sigma_y}=0.6031$ (2M)
11	**Let X and Y be discrete random variables with pdf** $f(x,y)=\dfrac{x+y}{21}, x=1,2,3; y=1,2$ **. Find** $\rho(X,Y)$ **(8M) (Nov/Dec-2019)**BTL5 **Answer : Pg. 2.78- Dr. A. Singaravelu** • $E(X)=\sum x\, f(x)=\dfrac{46}{21}$ (1M) • $E(Y)=\sum y\, f(y)=\dfrac{33}{21}$ (1M) • $E(X^2)=\sum x^2\, f(x)=\dfrac{114}{21}$ (1M) • $E(Y^2)=\sum y^2\, f(y)=\dfrac{57}{21}$ (1M) • $Var\, X=\sigma_x^2=E(X^2)-[E(X)]^2=\dfrac{278}{441}$ (1M) • $Var\, Y=\sigma_y^2=E(Y^2)-[E(Y)]^2=\dfrac{108}{441}$ (1M) • $E(XY)=\sum xy\, f(x,y)=\dfrac{72}{21}$ (1M) • $r(X,Y)=\dfrac{Cov(X,Y)}{\sigma_x.\sigma_y}=\dfrac{-6}{173.20}=-0.035$ (1M)
12	**If the joint pdf of (X,Y) is given by** $f(x,y)=x+y, 0\le x,y\le 1$**. Find** ρ_{xy} **. (8 M) (May/June 2014)** BTL3 **Answer : Page : 2.99 – Dr. A. Singaravelu** • $f(x)=\int_0^1 (x+y)dy=x+\dfrac{1}{2}, 0<x<1$ (1M) • $f(y)=\int_0^1 (x+y)dx=y+\dfrac{1}{2}, 0<y<1$ (1M) • $E(X)=\int x\, f(x)dx=\int_0^1 x\left(x+\dfrac{1}{2}\right)dx=\dfrac{7}{12}$ (1M) • $E(Y)=\int y\, f(y)dy=\int_0^1 y\left(y+\dfrac{1}{2}\right)dy=\dfrac{7}{12}$ (1M) • $E(X^2)=\int x^2\, f(x)dx=\dfrac{5}{12},\ E(Y^2)=\int y^2\, f(y)dy=\dfrac{5}{12}$ (1M) • $Var\, X=\sigma_x^2=E(X^2)-[E(X)]^2=\dfrac{11}{144},\ Var\, Y=\sigma_y^2=E(Y^2)-[E(Y)]^2=\dfrac{11}{144}$ (1M)

	• Cov(X,Y) = E(XY) – E(X). E(Y) = $\frac{-1}{144}$ (1M) • $r(X,Y)=\frac{Cov(X,Y)}{\sigma_x.\sigma_y}=\frac{-1}{11}$ (1M)
13	**Two independent random variables X and Y are defined by,** $f(x)=\begin{cases}4ax, 0\le x\le 1\\ 0 \quad ,otherwise\end{cases}$ $f(y)=\begin{cases}4by, 0\le y\le 1\\ 0 \quad ,otherwise\end{cases}$ **. Show that U=X + Y and V=X – Y are uncorrelated. (8 M)(May/June 2013)** BTL4 **Answer : Page: 2.105 – Dr. A. Singaravelu** • $\int_0^1 f(x)\,dx=1\Rightarrow a=\frac{1}{2}$; $\int_0^1 f(y)\,dy=1\Rightarrow b=\frac{1}{2}$ (1M) • $E(U)=E(X)+E(Y)=\frac{2}{3}+\frac{2}{3}=\frac{4}{3}$. (2M) • $E(V)=E(X)-E(Y)=\frac{2}{3}-\frac{2}{3}=0$. (2M) • $E(UV)=E(X^2)-E(Y^2)=\frac{1}{2}-\frac{1}{2}=0$. (2M) • Cov(U,V) = E(UV) – E(U).E(V) =0. (1M)
14	**If X and Y are two random variables having joint pdf** $f(x,y)=\frac{1}{8}(6-x-y)$**, 0<x<2, 2<y<4. Find (i)** r_{xy} **(ii)P(X<1 /Y<3) (8 M)** BTL5 **Answer : Page : 2.109 – Dr. A. Singaravelu** • $f(x)=\int_2^4 \frac{1}{8}(6-x-y)\,dy=\frac{6-2x}{4}$ (1M) • $f(y)=\int_0^2 \frac{1}{8}(6-x-y)\,dy=\frac{10-2y}{8}$ (1M) • $E(X)=\int x\, f(x)dx=\frac{5}{6}$ (1M) • $E(Y)=\int y\, f(y)dy=\frac{17}{6}$ (1M) • $E(X^2)=\int x^2\, f(x)dx=1$ (1M) • $E(Y^2)=\int y^2\, f(y)dy=\frac{25}{3}$ (1M) • $E(XY)=\int\int x\, f(x)dx=\frac{7}{3}$ (1M)

	• $\sigma_x^2 = \frac{11}{36},\ \sigma_y^2 = \frac{11}{36}$ (1M) • $r_{xy} = \frac{Cov(X,Y)}{\sigma_x.\sigma_y} = -\frac{1}{11}$ (1M)
15	**The two lines of regression are *8x – 10y +66 = 0; 40x -18y -214 = 0.* The variance of 'x' is 9. Find th4e mean values of 'x' and 'y'. Also find the correlation coefficient between 'x' and 'y'.(8 M) (Apr/May 2015, May/June 2016)** BTL4 **Answer: Page : 2.129 – Dr.A. Singaravelu** • $\bar{x} = 13$, $\bar{y} = 17$ • From first equation $x = \frac{10}{8}y - \frac{66}{8} \Rightarrow b_{xy} = \frac{10}{8}$. (2M) • From the second equation $y = \frac{40}{18}x - \frac{214}{18} \Rightarrow b_{yx} = \frac{40}{18}$. (1M) • Correlation coefficient $r = 1.66$ which is not less than 1. (1M) • Now, From first equation $y = \frac{8}{10}x + \frac{66}{10} \Rightarrow b_{yx} = \frac{8}{10}$. (1M) • From the second equation $x = \frac{18}{40}y - +\frac{214}{40} \Rightarrow b_{yx} = \frac{18}{40}$. (1M) • Correlation coefficient $r = \pm 0.6$. (2M)
16	**If the pdf of a two dimensional random variable (X,Y) is given by** $f(x,y) = x + y,;0 \le (x,y) \le 1$**. Find the pdf of U=XY. (8 M) (Apr/May 2015, Nov/Dec 2019)** BTL4 **Answer : Page : 2.156 – Dr.A.Singaravelu** • Take $u=xy$ and $v=y$. • $J = \frac{\partial(x,y)}{\partial(u,v)} = \begin{vmatrix} \frac{\partial x}{\partial u} & \frac{\partial x}{\partial v} \\ \frac{\partial y}{\partial u} & \frac{\partial y}{\partial v} \end{vmatrix} = \frac{1}{v}$. (2M) • $f(u,v) = \lvert J \rvert f(x,y) = 1 + \frac{u}{v^2}$. (3M) • $f(u) = \int_u^1 \left(1 + \frac{u}{v^2}\right) dv = 2 - 2u$. (3M)
17	**Let (X,Y) be a two-dimensional non-negative continuous random variable having the joint density** $f(x,y) = \begin{cases} 4xy\, e^{-\left(x^2+y^2\right)} & , x, y \ge 0 \\ 0 & , elsewhere \end{cases}$**. Find the density function of** $U = \sqrt{X^2 + Y^2}$ **. (8 M) (May/June 2016, Apr/May 2018)** BTL5 **Answer : Page : 2.179 – Dr.A. Singaravelu** • Take $u^2 = x^2 + y^2$, $v = x$

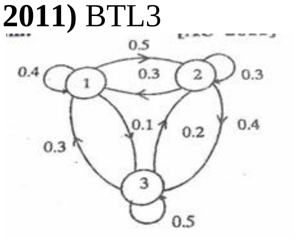
	• $J=\dfrac{\partial(x,y)}{\partial(u,v)}=\begin{vmatrix}\dfrac{\partial x}{\partial u} & \dfrac{\partial x}{\partial v}\\ \dfrac{\partial y}{\partial u} & \dfrac{\partial y}{\partial v}\end{vmatrix}=\dfrac{u}{\sqrt{u^2-v^2}}$. (2M) • $f(u,v)=\lvert J\rvert\, f(x,y)=4uv\,e^{-u^2}$. (3M) • $f(u)=\int_0^u\left(4uv\,e^{-u^2}\right)dv=2u^3\,e^{-u^2}$. (3M)
18	**If X and Y are independent random variables with pdf $e^{-x}, x\geq 0$; $e^{-y}, y\geq 0$ respectively. Find the density function of $U=\dfrac{X}{X+Y}$ and $V=X+Y$. Are X and Y independent? (8 M) (Nov/Dec 2013, Apr/May 2017, Nov/Dec 2017)** BTL5 **Answer : Page : 2.176- Dr. A. Singaravelu** • Take $U=\dfrac{X}{X+Y}$ and $V=X+Y$. • $J=\dfrac{\partial(x,y)}{\partial(u,v)}=\begin{vmatrix}\dfrac{\partial x}{\partial u} & \dfrac{\partial x}{\partial v}\\ \dfrac{\partial y}{\partial u} & \dfrac{\partial y}{\partial v}\end{vmatrix}=v$. (2M) • $f(u,v)=\lvert J\rvert\, f(x,y)=v\,e^{-v}$. (1M) • $f(u)=\int_0^\infty\left(v\,e^{-v}\right)dv=1$ (2M) • $f(v)=\int_0^\infty\left(v\,e^{-v}\right)du=ve^{-v}$. (2M) • $f(u).f(v)=1.\,ve^{-v}=ve^{-v}=f(u,v)$. (1M)
19	**If X_1, X_2, …, X_n are Poisson variables with parameter $\lambda=2$, use the central limit theorem to estimate P(120 < S_n < 160) where $S_n = X_1+ X_2+ \ldots+X_n$ and n=75. (8M) (Apr/May-2019)**BTL5 **Answer:Page: 2.187-Dr.A. Singaravelu** • $n\mu=150; n\sigma=\sqrt{150}$. (1M) • $z=\dfrac{S_n-n\mu}{\sigma\sqrt{n}}$; If $S_n=120, z=\dfrac{-30}{\sqrt{150}}$. (2M) • If $S_n=160, z=\dfrac{10}{\sqrt{150}}$. (2M) • $P(120<S_n<160)=P(-2.45\leq S_n\leq 0.85)=P(-2.45\leq S_n\leq 0)+P(0\leq S_n\leq 0.85)=0.7866$. (3M)

	UNIT III – Random Proccesses
	Classification – Stationary process – Markov process - Markov chain - Poisson process – Random telegraph process.
	PART *A
Q.No	**Questions**
1.	**Define a random process and give an example. (May/June 2016)** BTL1 A random process is a collection of random variables {X(s,t)} that are functions of a real variable, namely time 't' where $s \in S$ (Sample space) and $t \in T$ (Parameter set or index set). Example: $X(t) = A\cos(\omega t + \theta)$ where θ is uniformly distributed in $(0, 2\pi)$, where 'A' and 'ω' are constants.
2	**State the two types of stochastic processes.** BTL1 The four types of stochastic processes are Discrete random sequence, Continuous random sequence, Discrete random process and Continuous random process.
3	**Define Stationary process with an example.(May/June 2016)** BTL1 If certain probability distribution or averages do not depend on 't', then the random process {X(t)} is called stationary process. Example: A Bernoulli process is a stationary process as the joint probability distribution is independent of time.
4	**Define first Stationary process. (Nov/Dec 2015)** BTL1 A random process {X(t)} is said to be a first order stationary process if $E[X(t)] = \mu$ is a constant.
5	**Define strict sense and wide sense stationary process.(Nov/Dec 2015, Apr/May 2017, Nov/Dec 2017)** BTL1 A random process is called a strict sense stationary process or strongly stationary process if all its finite dimensional distributions are invariant under translation of time parameter. A random process is called wide sense stationary or covariance stationary process if its mean is a constant and auto correlation depends only on the time difference.
6	**In the fair coin experiment we define {X(t)} as follows** $X(t) = \begin{cases} \sin \pi t & ,if\ head\ shows \\ 2t & ,if\ tail\ shows \end{cases}$ **.Find E[X(t)] and find F(x,t) for t = 0.25. (Nov/Dec 2016)** BTL3 $P[X(t) = \sin \pi t] = \frac{1}{2}$, $P[X(t) = 2t] = \frac{1}{2}$ $E[X(t)] = \sum X(t) P[X(t)] = \sin \pi t\left(\frac{1}{2}\right) + 2t\left(\frac{1}{2}\right) = \frac{1}{2}\sin \pi t + t$ $When\ t = 0.25$, $P[X(0.25) = \sin \pi(0.25)] = P\left[X(0.25) = \frac{1}{\sqrt{2}}\right] = \frac{1}{2}$ $P[X(t) = 2(0.25)] = P\left[X(t) = \frac{1}{2}\right] = \frac{1}{2}$ Hence F(x,t) for t= 0.25 is given by

	$F(x,t)=\begin{cases}0 & ,x<0\\ \frac{1}{2} & ,\frac{1}{2}\le x<\frac{1}{\sqrt{2}}\\ 1 & ,x\ge\frac{1}{\sqrt{2}}\end{cases}$
7	**Prove that a first order stationary random process has a constant mean. (Apr/May 2011)** BTL3 f[X(t)] = f[X(t+h)] as the process is stationary. $E[X(t)]=\int X(t)\,f[X(t+h)]d(t+h)$ $t+h=u\Rightarrow d(t+h)=du$ Put $=\int X(u)\,f[X(u)]du$ $=E[X(u)]$ Therefore, E[X(t+h)] = E[X(t)] Therefore, E[X(t)] is independent of 't'. Therefore , E[X(t)] is a constant.
8	**What is a Markov process. Give an example.(Nov/Dec 2014, Apr/May 2015, May/June 2016,Apr/May 2019, Nov 2019)** BTL1 Markov process is one in which the future value is independent of the past values, given the present value. (i.e.,)A random process X(t) is said to be a Markov process if for every $t_0 < t_1 < t_2 < \ldots t_n$, $P\{X(t_n)\le x_n / X(t_{n-1})=x_{n-1}, X(t_{n-2})=x_{n-2},\ldots,X(t_0)=x_0\}\Rightarrow P\{X(t_n)\le x_n / X(t_{n-1})=x_{n-1}\}$. Example: Poisson process is a Markov process. Therefore, number of arrivals in (0,t) is a Poisson process and hence a Markov process.
9	**Define Markov chain. When it is called homogeneous? Also define one-step transition probability. (Apr/May 2010)** BTL1 • If $\forall n$, $P[X_n=a_n/X_{n-1}=a_{n-1},X_{n-2}=a_{n-2},\ldots,X_0=a_0]=P[X_n=a_n/X_{n-1}=a_{n-1}]$then the process $\{X_n\}$ n = 0,1,2,… is called a Markov chain. • In a Markov chain if the one-step transition probability $P[X_n=a_n/X_{n-1}=a_{n-1}]=P_{ij}(n-1,n)$ independent of the step 'n'. (i.e.,) $P_{ij}(n-1,n)=P_{ij}(m-1,m)$ for all m,n and I,j. Then the Markov chain is said to be homogeneous. • The conditional probability $P[X_n=a_j/X_{n-1}=a_j]$ is called the one step transition probability from state a_i to state a_j at the nth step.
10	**Define Poisson process.(Nov/Dec 2017)** BTL1 If X(t) represents the number of occurrences of a certain event in (0,t), then the discrete process {X(t)} is called the Poisson process provided the postulates are satisfied: $P[1\ occurrence\ in\ (t,t+\Delta t)]=\lambda\Delta t+0(\Delta t)$ $P[0\ occurrence\ in\ (t,t+\Delta t)]=1-\lambda\Delta t+0(\Delta t)$ $P[2\ occurrence\ in\ (t,t+\Delta t)]=0(\Delta t)$ X(t) is independent of the number of occurrences of the event in any interval prior and after the interval (0,t) The provability that the event occurs a specified number of times in (t_0, t_0+t) depends only on 't', but not on 't_0'.

11	**State any two properties of Poisson process. (Nov/Dec 2015, Apr/May 2018)** BTL1 • The Poisson process is a Markov process • Sum of two different Poisson process is a Poisson process • Difference of two different Poisson process is not a Poisson process
12	**If the customers arrive at a bank according to a Poisson process with mean rate 2 per minute, find the probability that during a 1-minute interval no customers arrive. (Apr/May 2017)** BTL3 Mean arrival rate = $\lambda = 2$ The probability of Poisson process is $P[X(t)=n]=\frac{e^{-\lambda t}(\lambda t)^n}{n!}$ $P[X(t)=0]=\frac{e^{-2}(2)^0}{0!}=e^{-2}=0.1353$.
13	**Prove that the sum of two independent Poisson process is a Poisson process.(Nov/Dec 2012, Apr/May 2015, Apr/May 2017)** BTL5 $Let\ \ X(t)=\left[X_1(t)+X_2(t)\right]$ $E[X(t)]=E\left[X_1(t)+X_2(t)\right]=E\left[X_1(t)\right]+E\left[X_2(t)\right]$ $=\lambda_1 t+\lambda_2 t=(\lambda_1+\lambda_2)t$ $E[X^2(t)]=E\left[X_1(t)+X_2(t)\right]^2=E\left[X_1^{\,2}(t)+2X_1(t)X_2(t)+X_2^{\,2}(t)\right]$ $=E\left[X_1^{\,2}(t)\right]+2E\left[X_1(t)\right]E\left[X_2(t)\right]+E\left[X_2^{\,2}(t)\right]$ $=\lambda_1^2t^2+\lambda_1 t+2(\lambda_1 t)(\lambda_2 t)+\lambda_2^2t^2+\lambda_2 t$ $=\left(\lambda_1+\lambda_2\right)^2t^2+\left(\lambda_1+\lambda_2\right)t$ Therefore $X(t)=\left[X_1(t)+X_2(t)\right]$ is a Poisson process.
14	**Prove that the sum of two independent Poisson process is a Poisson process.** BTL5 $Let\ \ X(t)=\left[X_1(t)-X_2(t)\right]$ $E[X(t)]=E\left[X_1(t)+-X_2(t)\right]=E\left[X_1(t)\right]-E\left[X_2(t)\right]$ $=\lambda_1 t-\lambda_2 t=(\lambda_1-\lambda_2)t$ $E[X^2(t)]=E\left[X_1(t)-X_2(t)\right]^2=E\left[X_1^{\,2}(t)-2X_1(t)X_2(t)+X_2^{\,2}(t)\right]$ $=E\left[X_1^{\,2}(t)\right]-2E\left[X_1(t)\right]E\left[X_2(t)\right]+E\left[X_2^{\,2}(t)\right]$ $=\lambda_1^2t^2+\lambda_1 t-2(\lambda_1 t)(\lambda_2 t)+\lambda_2^2t^2+\lambda_2 t$ $=\left(\lambda_1-\lambda_2\right)^2t^2+\left(\lambda_1+\lambda_2\right)t$ $\neq\left(\lambda_1-\lambda_2\right)^2t^2+\left(\lambda_1-\lambda_2\right)t$ Therefore $X(t)=\left[X_1(t)-X_2(t)\right]$ is not a Poisson process.
15	**Patients arrive randomly and independently at a doctor's consulting room form 8 A.M at an average rate of 1 for every 5 minutes. The waiting room can hold 12 persons. What is the probability that the room will be full when the doctor arrives at 9 A.M?. (Nov/Dec 2016)** BTL3

	Given $\lambda = \frac{1}{5}\ per\ \min = \frac{1}{5} \times 60 = 12\ per\ hour$ The probability law of Poisson process is $P[X(t) = n] = \frac{e^{-\lambda t}(\lambda t)^n}{n!}$ $$P[X(1) = 12] = \frac{e^{-12}(12)^{12}}{12!} = 0.1144$$
16	**Define Semi- Random telegram signal process. (Apr/May 2015)** BTL1 If N(t) represents the number of occurrences of a specified event in (0,t) and $X(t) = (-1)^{N(t)}$, then {X(t)} is called a semi-random telegraph signal process.
17	**Define Random telegraph process.** BTL1 A random telegraph process is a discrete random process X(t) satisfying the following conditions: • X(t) assumes only one of the two possible values 1 or -1 at any time 't', randomly • X(0) = 1 or -1 with equal probability ½. • The number of level transitions or flips, $N(\tau)$, from one value to another occurring in any interval of length τ is a Poisson process with rate λ so that the probability of exactly 'r' transitions is $P[N(\tau) = r] = \frac{e^{-\lambda\tau}(\lambda\tau)^r}{r!},\ r = 0,1,2,...$
18	**Write the properties of Random telegraph process.** BTL1 • $P[X(t)=1] = \frac{1}{2} = P[X(t)= -1]$ for any t >0 • E[X(t)] = 0 and Var[X(t)] = 1 • X(t) is a WSS process
19	**Consider the random process** $X(t) = \cos(t+\phi)$ **where** ϕ is a random variable with density function $f(\phi) = \frac{1}{\pi},\ -\frac{\pi}{2} < \phi < \frac{\pi}{2}$**. Check whether or not the process is stationary.** BTL3

	$E[X(t)]=\int_{-\infty}^{\infty} X(t)\, f(\phi)\, d\phi$ $= \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \cos(t+\phi)\, \frac{1}{\pi} d\phi$ $=\frac{1}{\pi}\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \cos(t+\phi)\; d\phi$ $=\frac{1}{\pi}\left[\sin(t+\phi)\right]_{-\frac{\pi}{2}}^{\frac{\pi}{2}}$ $=\frac{1}{\pi}\left[\sin(\frac{\pi}{2}+t)-\sin(-\frac{\pi}{2}+t)\right]$ $=\frac{1}{\pi}\left[\cos(t)+\cos(t)\right]= \frac{2}{\pi}\cos(t)$ Therefore E[X(t)] is not a constant. Hence X(t) is not stationary.
20	**Find the transition probability matrix of the process represented by the transition diagram. (Apr/May 2011)** BTL3  $\begin{array}{c} 1 \\ 2 \\ 3 \end{array}\begin{bmatrix} 0.4 & 0.5 & 0.1 \\ 0.3 & 0.3 & 0.4 \\ 0.3 & 0.2 & 0.5 \end{bmatrix}$
21	**If the tpm of the markov chain is** $\begin{bmatrix} 0 & 1 \\ \frac{1}{2} & \frac{1}{2} \end{bmatrix}$ **, find the steady-state distribution of the chain.** BTL5 Given : P= $\begin{bmatrix} 0 & 1 \\ \frac{1}{2} & \frac{1}{2} \end{bmatrix}$ Let the steady- state probability distribution be $\pi = \left(\pi_1 \quad \pi_2\right)$ we have

	$\pi P = \pi$ ....(1) $\pi_1 + \pi_2 = 1$...........(2) $(1) \Rightarrow (\pi_1 \quad \pi_2)\begin{bmatrix} 0 & 1 \\ \frac{1}{2} & \frac{1}{2} \end{bmatrix} = (\pi_1 \quad \pi_2)$ $\left[\pi_1(0) + \pi_2\left(\frac{1}{2}\right) \quad \pi_1(1) + \pi_2\left(\frac{1}{2}\right)\right] = (\pi_1 \quad \pi_2)$ $\Rightarrow \left[\pi_2\left(\frac{1}{2}\right) \quad \pi_1 + \pi_2\left(\frac{1}{2}\right)\right] = (\pi_1 \quad \pi_2)$ $\Rightarrow \frac{1}{2}\pi_2 = \pi_1$............(3) $\pi_1 + \pi_2\left(\frac{1}{2}\right) = \pi_2$..........(4) $Now\ (2) \Rightarrow \pi_1 + \pi_2 = 1$, *substitute* (3) *in* (2) $\Rightarrow \frac{1}{2}\pi_2 + \pi_2 = 1 \Rightarrow \frac{3}{2}\pi_2 = 1 \Rightarrow \pi_2 = \frac{2}{3}$ *Sub* π_2 *in* (3), $\frac{1}{2}.\frac{2}{3} = \pi_1 \Rightarrow \pi_1 = \frac{1}{3}$ The steady state distribution of the chain is $\pi = \begin{pmatrix} \frac{1}{3} & \frac{2}{3} \end{pmatrix}$
22	**Let $A = \begin{pmatrix} 0 & 1 \\ \frac{1}{2} & \frac{1}{2} \end{pmatrix}$ be a stochastic matrix. Check if it is regular. (Nov/Dec 2016)** BTL4 $A^2 = \begin{pmatrix} 0 & 1 \\ \frac{1}{2} & \frac{1}{2} \end{pmatrix}\begin{pmatrix} 0 & 1 \\ \frac{1}{2} & \frac{1}{2} \end{pmatrix} = \begin{pmatrix} \frac{1}{2} & \frac{1}{2} \\ \frac{1}{4} & \frac{3}{4} \end{pmatrix}$ Since all the entries of A^2 are positive , 'A' is regular.
23	**What is the autocorrelation function of the Poisson process. Is Poisson process stationary? (**Apr/May 2019) BTL2 Let X(t) be a Poisson process then $P[X(t) = n] = \frac{e^{-\lambda t}(\lambda t)^n}{n!}$ n=0,1,2,… Autocorrelation function $R_{xx}(t_1, t_2) = \lambda^2 t_1 t_2 + \lambda \min\{t_1, t_2\}$ Since $R_{xx}(t_1, t_2)$ is not a function of time difference t_1-t_2, Poisson process is not stationary.
24	**When is a Random process said to be evolutionary. Give an example. (Apr/May 2015)** (BTL1) A random process that is not stationary at any sense is called evolutionary process. Semi-random telegraph signal process is an example of evolutionary random process.
25	**Define irreducible Markov chain and state Chapman-Kolmogorov theorem.** BTL1 A Markov chain is said to be irreducible if every state can be reached from every other state, where $p_{ij}^{(n)} > 0$

for some 'n' and for all 'i' and 'j'.

If 'P' is the tpm of a homogeneous Markov chain, then the n-step tpm $P^{(n)}$ is equal to P^n.

(i.e.,) $\left[P_{ij}^{(n)}\right]=\left[P_{ij}\right]^n$.

Part*B

1

The process {X(t)} whose probability distribution under certain conditions is given by,

$$P\{X(t)=n\}=\frac{(at)^{n-1}}{(1+at)^{n+1}},\ n=1,2...$$

$$=\frac{at}{1+at},\ n=0$$

Show that it is not stationary(evolutionary). (8M)(Nov/Dec 2014, Nov/Dec 2016, Apr/May 2018) BTL5

Answer: Page: 3.33 –Dr. A. Singaravelu

- $E\left[X(t)\right]=\sum_{n=0}^{\infty} n\,p_n = 0+(1)\frac{1}{(1+at)^2}+(2)\frac{at}{(1+at)^3}+....\ =1.$ (3M)
- $E\left[X^2(t)\right]=\sum_{n=0}^{\infty} n^2\,P_n=\sum_{n=0}^{\infty}([n(n+1)-n]P_n=1+2at\,.$ (3M)
- $Var[X(t)]=E[X^2(t)]-E[X(t)]=2at\neq cons\tan t\,.$ (2M)

2

If the random process X(t) takes the value -1 with probability $\frac{1}{3}$ and takes the value 1 with probability $\frac{2}{3}$, find whether X(t) is a stationary process or not. (6M)(Apr/May 2019) BTL4

Answer:Page: 3.12 – Dr. G. Balaji

X(t)=n	-1	1
P_n	1/3	2/3

- $E[X(t)]=\sum_{n=-1}^{1} n\,P_n=\frac{1}{3}$ (2M)
- $E[X^2(t)]=\sum_{n=-1}^{1} n^2\,P_n=1$ (2M)
- $Var[X(t)]=E[X^2(t)]-E[X(t)]=\frac{8}{9}$ = constant. (2M)

3

Show that the process $X(t)=A\cos(\omega t+\theta)$ where A, ω are constants, θ is uniformly distributed in $(-\pi,\pi)$ is wide sense stationary. (8M) (May/June 2016, Nov/Dec 2016) BTL5

Answer:Page: 3.15-Dr. A. Singaravelu

- $E[X(t)]=\int_{-\infty}^{\infty} X(t)\ f(\theta)\,d\theta=\int_{-\pi}^{\pi} A\cos(\omega t+\theta)\frac{1}{2\pi}\,d\theta=0=cons\tan t$ (2M)
- $R_{XX}(t,t+\tau)=E\left[X(t)X(t+\tau)\right]=E\left[A\cos(\omega t+\theta).A\cos(\omega(t+\tau)+\theta)\right]$ (1M)
- $E\left[A\cos(\omega t+\theta).A\cos(\omega(t+\tau)+\theta)\right]=\frac{A^2}{2}\{E(\cos\omega\tau)+E\left[\cos(2\omega t+2\theta+\omega\tau)\right]\}$ (2M)
- $E\left[\cos(2\omega t+2\theta+\omega\tau)\right]=0$ (2M)

	• $R_{XX}(t,t+\tau)=\frac{A^2}{2}\cos\omega\tau$ =a function of τ. (1M)
4	**Show that the process $X(t)=A\cos(\omega t+\theta)$ where A, ω are constants, θ is uniformly distributed in $(0,2\pi)$ is WSS. (8M) (Nov/Dec 2017)** BTL5 **Answer:Page: 3.24-Dr. G. Balaji** • $E[X(t)]=\int_{-\infty}^{\infty}X(t)\,f(\theta)\,d\theta=\int_{0}^{2\pi}A\cos(\omega t+\theta)\frac{1}{2\pi}\,d\theta=0=cons\tan t$ (2M) • $R_{XX}(t,t+\tau)=E[X(t)X(t+\tau)]=E[A\cos(\omega t+\theta).A\cos(\omega(t+\tau)+\theta)]$ (1M) • $E[A\cos(\omega t+\theta).A\cos(\omega(t+\tau)+\theta)]=\frac{A^2}{2}\{E(\cos\omega\tau)+E[\cos(2\omega t+2\theta+\omega\tau)]\}$ (2M) • $E[\cos(2\omega t+2\theta+\omega\tau)]=0$ (2M) • $R_{XX}(t,t+\tau)=\frac{A^2}{2}\cos\omega\tau$ =a function of τ. (1M)
5	**Show that the process $X(t)=A\cos\lambda t+B\sin\lambda t$ is strict sense stationary of order 2. A and B are random variables if E[A] = E[B] = 0 ; E[A^2] = E[B^2]; E[AB] = 0.** **(OR)** **If $X(t)=A\cos\lambda t+B\sin\lambda t$, $t\geq 0$ is a random process where A and B are independent $N(0,\sigma^2)$ random variables. Examine the WSS process of X(t). (8M) (Apr/May 2015, Apr/May 2017)** BTL5 **Answer:Page: 3.13-Dr. A. Singaravelu** • $E\{X(t)\}=E\{A\cos\lambda t+B\sin\lambda t\}=0=cons\tan t$ (2M) • $R_{XX}(t,t+\tau)=E[X(t)X(t+\tau)]=E\{[A\cos\lambda t+B\sin\lambda t][A\cos\lambda(t+\tau)+B\sin\lambda(t+\tau)]\}$ (2M) • $R_{XX}(t,t+\tau)=K^2[\cos\lambda t\cos\lambda(t+\tau)+\sin\lambda t\sin\lambda(t+\tau)]=K^2\cos\lambda\tau$ (4M)
6	**A random variable {X(t)} is defined by $X(t)=A\cos t+B\sin t,-\infty<t<\infty$ where A and B are independent random variables each of which has a value -2 with probability $\frac{1}{3}$ and a value 1 with probability $\frac{2}{3}$. Show that X(t) is wide sense stationary. (8M) (Nov/Dec 2015, Apr/May 2017, Apr/May 2018)** BTL5 **Answer:Page: 3.44-Dr. G. Balaji** • $E[A]=\sum A_i\,P(A_i)=0$ (1M) • $E[B]=\sum B_i\,P(B_i)=0$ (1M) • $E[A^2]=\sum A_i^{\,2}\,P(A_i)=2$ (1M) • $E[B^2]=\sum B_i^{\,2}\,P(B_i)=2$ (1M) • $E[X(t)]=E[Y\cos t+Z\sin t]=0=cons\tan t$ (2M) • $R_{XX}(t,t+\tau)=E[X(t)X(t+\tau)]=E[(Y\cos t_1+Z\sin t_1)(Y\cos t_2+Z\sin t_2)]=2\cos\tau$ (2M)
7	**The transition probability matrix of a Markov chain {X_n}, n=1,2,… having 3 states 1,2 and 3 is** $P=\begin{bmatrix}0.1 & 0.5 & 0.4\\0.6 & 0.2 & 0.2\\0.3 & 0.4 & 0.3\end{bmatrix}$ **and the initial distribution is** $P^{(0)}=(0.7\quad 0.2\quad 0.1)$. **Find (i)** $P\{X_2=3\}$ **and (ii)**

$P\{X_3=2, X_2=3, X_1=3, X_0=2\}$.

Answer:Page: 3.60-Dr. A. Singaravelu

- $P^{(1)}=P^{(0)}P=\begin{bmatrix}0.7 & 0.2 & 0.1\end{bmatrix}\begin{bmatrix}0.1 & 0.5 & 0.4\\ 0.6 & 0.2 & 0.2\\ 0.3 & 0.4 & 0.3\end{bmatrix}=\begin{bmatrix}0.22 & 0.43 & 0.35\end{bmatrix}$ (2M)
- $P^{(2)}=P^{(1)}P=\begin{bmatrix}0.22 & 0.43 & 0.35\end{bmatrix}\begin{bmatrix}0.1 & 0.5 & 0.4\\ 0.6 & 0.2 & 0.2\\ 0.3 & 0.4 & 0.3\end{bmatrix}=\begin{bmatrix}0.385 & 0.336 & 0.279\end{bmatrix}$ (2M)
- $P\{X_2=3\}=0.279$ (1M)
- $P\{X_3=2, X_2=3, X_1=3, X_0=2\}=P_{32}^{1}\,P_{33}^{1}\,P_{23}^{1}\,P[X_0=2]=0.0048$ (3M)

8

A man either drives a car or catches a train to office each day. He never goes 2 days in a row by train but if he drives one day, then the next day he is just as likely to drive again as he is to travel by train. Now suppose that on the first day of the week, the man tossed a fair die and drive to work if and only if a 6 appeared. Find (i) The probability that he drives to work in the long run and (ii) The probability that he takes a train on the third day. (8M) (May/June 2016, Nov/Dec 2017) BTL4

Answer:Page: 3.71-Dr. A. Singaravelu

- $P=\begin{bmatrix}0 & 1\\ \frac{1}{2} & \frac{1}{2}\end{bmatrix}$ (2M)
- $\pi=(\pi_1 \quad \pi_2)=\begin{pmatrix}\frac{1}{3} & \frac{2}{3}\end{pmatrix}$ (3M)
- $P^{(2)}=P^{(1)}P=\begin{pmatrix}\frac{1}{12} & \frac{11}{12}\end{pmatrix}$ (1M)
- $P^{(3)}=P^{(2)}P=\begin{pmatrix}\frac{11}{24} & \frac{13}{22}\end{pmatrix}$ (2M)

9

If $\{X_n; n=1,2,3\ldots\}$ be a Markov chain on the space S={1,2,3} with one-step $\begin{bmatrix}0 & 1 & 0\\ \frac{1}{2} & 0 & \frac{1}{2}\\ 1 & 0 & 0\end{bmatrix}$.Sketch the transition diagram. Is the chain irreducible? Explain. Is the chain ergodic? Explain. (8M) (May/June 2013, Nov/Dec 2019) BTL4

Answer:Page:3.141-Dr. G. Balaji

- $P^4=P^3P=P.P=P^2$ (1M)
- $P^5=P^4P=P^2.P=P^3=P$ (1M)
- 1st state $P_{00}^{(2)}>0, P_{00}^{(4)}>0, P_{00}^{(6)}>0 \;\ldots.\Rightarrow d_i=GCD(2,4,6,\ldots)=2$ (1M)
- 2nd state $P_{11}^{(2)}>0, P_{11}^{(4)}>0, P_{11}^{(6)}>0 \;\ldots.\Rightarrow d_i=GCD(2,4,6,\ldots)=2$ (1M)
- 3rd state $P_{22}^{(2)}>0, P_{22}^{(4)}>0, P_{22}^{(6)}>0 \;\ldots.\Rightarrow d_i=GCD(2,4,6,\ldots)=2$ (1M)
- The states are aperiodic with period 2.

	• We find $P_{ij}^{(n)} > 0$. So the Markov chain is irreducible (2M) • The chain is finite and irreducible so it is non- null persistant. But not ergodic. (1M)
10	**Find the mean, variance and auto correlation of Poisson process. (8M) (May/June 2014, Apr/May 2015)** BTL2 **Answer: Page:3.93- Dr. A. Singaravelu** • The probability of Poisson distribution is $P\{X(t)=n\}=\frac{e^{-\lambda t}(\lambda t)^n}{n!}$, n=0,1,2,… (1M) • $E[X(t)]=\sum_{x=0}^{\infty} x\frac{e^{-\lambda t}(\lambda t)^n}{n!}=\lambda t$ (2M) • $E[X^2(t)]=\sum_{x=0}^{\infty} x^2\frac{e^{-\lambda t}(\lambda t)^n}{n!}=(\lambda t)^2+\lambda t$ (2M) • $Var[X(t)]=\lambda t$ (1M) • $R_{xx}(t_1,t_2)=E\left[X(t_1)X(t_2)\right]=\lambda^2 t_1 t_2+\lambda\min(t_1,t_2)$ (2M)
11	**(i) Prove that the interval between two successive occurrences of a Poisson process with parameter λ has an exponential distribution.** **(ii)Show that Poisson process is a Markov process. (8M) (Apr/May 2018)** BTL5 **Answer: Page:3.98- Dr. A. Singaravelu** (i) • P(T > t) = P(E_{i+1} did not occur in (t_i, t_{i+1}) = P(X(t)=0) = $e^{-\lambda t}$ (1M) • $F(t)=P(T\le t)=1-P(T>t)=1-e^{-\lambda t}$ (2M) • The pdf of T is given by $\lambda e^{-\lambda t}$ which is an exponential distribution. (1M) (ii) • $P\left[X(t_3)=n_3 / X(t_2)=n_2; X(t_1)=n_1\right]=\frac{e^{-\lambda(t_3-t_2)}\lambda^{n_3-n_2}(t_3-t_2)^{n_3-n_2}}{(n_3-n_2)!}$ (3M) • $P\left[X(t_3)=n_3 / X(t_2)=n_2; X(t_1)=n_1\right]=P\left[X(t_3)=n_3 / X(t_2)=n_2\right]$ which is Markov process. (1M)
12	**Suppose that customers arrive at a bank according to a Poisson process with mean rate of 3 per minute; find the probability that during a time interval of 2 min (i) exactly 4 customers arrive and (ii) more than 4 customers arrive. (iii) fewer than 4 customers arrive. (8M) (Nov/Dec 2015)** BTL5 **Answer: Page:3.100- Dr. A. Singaravelu** • The probability of Poisson distribution is $P\{X(t)=n\}=\frac{e^{-\lambda t}(\lambda t)^n}{n!}$, n=0,1,2,… (1M) • P[4 customers arrive in 2 min time interval] = P{X(2)=4} = 0.1339 (2M) • P[More than 4 customers arrive in 2 min interval] =P{X(2)>4} = $1-P\left[X(2)\le 4\right]$= 0.715(3M) • P[Fewer than 4 customers arrive in 2 min interval] = P{X(2)<4} = 0.1512. (2M)
13	**A fisherman catches a fish at a Poisson rate of 2 per hour from a large lake with lots of fish. If he starts fishing at 10.00 a.m. What is the probability that he catches one fish by 10.30 a.m and three fishes by noon? (8M) (Apr/May 2017)** BTL5 **Answer: Classwork**

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- The probability of Poisson distribution is $P\{X(t)=n\}=\frac{e^{-\lambda t}(\lambda t)^n}{n!}$, n=0,1,2,… (2M)
- P[He catches one fish by 10.30 a.m] =P[X(0.5)=1] $=\frac{e^{-1}(1)^1}{1!}$ =0.3679 (3M)
- P[He catches three fishes by noon] = P[X(2) = 3] = $\frac{e^{-4}(4)^3}{3!}=0.1954$ (2M)

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<tr><td>14</td><td>

A hard disk fails in a computer system and it follows Poisson process with mean rate of 1 per week. Find the probability that 2 weeks have elapsed since the last failure. If there are 5 extra hard disks and the next supply is not due in 10 weeks, find the probability that the machine will not be out of order in the next 10 weeks. (8M) (Nov/Dec 2017) BTL5

Answer: Page:3.102- Dr. A. Singaravelu

- The probability of Poisson distribution is $P\{X(t)=n\}=\frac{e^{-\lambda t}(\lambda t)^n}{n!}$, n=0,1,2,… (2M)
- P[No failure in 2 weeks since last failure] = P[X(2)=0] = e^{-2} = 0.135 (3M)
- $P[X(10)\le 5]=P[X(10)=0]+[X(10)=1]+[X(10)=2]+[X(10)=3]+[X(10)=4]+[X(10)=5]=0.067$ (3M)

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<tr><td>15</td><td>

If customers arrive at a counter in accordance with a Poisson process with a mean rate of 2 per minute, find the probability that the interval between 2 consecutive arrivals is (i) more than 1 minute, (ii) between 1 min and 2 min and (iii) 4 min or less. (8M) (May/June 2012) BTL5

Answer: Page: 3.100- Dr. A. Singaravelu

- Using inter arrival property of Poisson process, $f(t)=\lambda e^{-\lambda t}$ (1M)
- $P(T>1)=\int_1^\infty 2e^{-2t}dt=0.135$ (2M)
- $P(1<T<2)=\int_1^2 2e^{-2t}dt=0.117$ (2M)
- $P(T\le 4)=\int_0^4 2e^{-2t}dt=1$ (3M)

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<tr><td>16</td><td>

If {X_1(t)} and {X_2(t)} are two independent Poisson process with parameter λ_1 **and** λ_2 **respectively, show that P[X_1(t) =x / X_1(t)+ X_2(t) = n] is Binomial where** $P=\frac{\lambda_1}{\lambda_1+\lambda_2}$**.(8M) (Apr/May 2018)** BTL5

Anwer: Page: 3.84-Dr G. Balaji

- $P[X_1(t)=x/X_1(t)+X_2(t)=n]=\frac{P[\{X_1(t)=x\}\cap\{X_1(t)+X_2(t)=n\}]}{P(X_1(t)+X_2(t)=n)}$ (3M)
- $P[X_1(t)=x/X_1(t)+X_2(t)=n]=\frac{\frac{e^{-\lambda_1 t}(\lambda_1 t)^x}{x!}\cdot\frac{e^{-\lambda_2 t}(\lambda_2 t)^{n-x}}{(n-x)!}}{\frac{e^{-(\lambda_1+\lambda_2)t}((\lambda_1+\lambda_2)t)^n}{n!}}$ (3M)
- $P[X_1(t)=x/X_1(t)+X_2(t)=n]=nC_xP^xq^{n-x}$ where $P=\frac{\lambda_1}{\lambda_1+\lambda_2}$ and $q=\frac{\lambda_2}{\lambda_1+\lambda_2}$ (2M)

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Define semi-random telegraph signal process and random telegraph signal process and prove that the former is evolutionary and the latter is wide sense stationary(Covariance stationary process). (16M) (Nov/Dec 2013, Nov/Dec 2017, Apr/May 2015, Apr/May 2017) BTL5

Answer: 3.106- -Dr.A. Singaravelu

- A random telegraph process is a discrete random process X(t) satisfying the following conditions:
  X(t) assumes only one of the two possible values 1 or -1 at any time ‘t’, randomly
  X(0) = 1 or -1 with equal probability ½.
  The number of level transitions or flips, $N(\tau)$, from one value to another occurring in any interval of length τ is a Poisson process with rate λ so that the probability of exactly ‘r’ transitions is $P[N(\tau)=r]=\frac{e^{-\lambda\tau}(\lambda\tau)^r}{r!}$, $r=0,1,2,...$ (2M)
- If N(t) represents the number of occurrences of a specified event in (0,t) and $X(t) = (-1)^{N(t)}$, then {X(t)} is called a semi-random telegraph signal process. (2M)
- $P\{X(t)=1\} = P\{N(t) \text{ is even}\} = e^{-\lambda t}\cosh\lambda t$ (1M)
- $P\{X(t)=-1\} = P\{N(t) \text{ is odd}\} = e^{-\lambda t}\, Sinh\,\lambda t$ (1M)
- $E[X(t)] = e^{-2\lambda t}$ (1M)
- $P[X(t_1)=1, X(t_2)=1] = P[X(t_1)=1/X(t_2)=1]\times P[X(t_2)=1] = e^{-\lambda\tau}\cosh\lambda\tau\, e^{-\lambda t_2}\cosh\lambda t_2$ (1M)
- $P[X(t_1)=-1, X(t_2)=-1] = e^{-\lambda\tau}\cosh\lambda\tau\, e^{-\lambda t_2}\, Sinh\,\lambda t_2$ (1M)
- $P[X(t_1)=1, X(t_2)=-1] = e^{-\lambda\tau}\sinh\lambda\tau\, e^{-\lambda t_2}\, Sinh\,\lambda t_2$ (1M)
- $P[X(t_1)=-1, X(t_2)=1] = e^{-\lambda\tau}\sinh\lambda\tau\, e^{-\lambda t_2}\cosh\lambda t_2$ (1M)
- $P[X(t_1)\times X(t_2)=1] = e^{-\lambda\tau}\cosh\lambda\tau$ (1M)
- $P[X(t_1)\times X(t_2)=-1] = e^{-\lambda\tau}\sinh\lambda\tau$
- $R(t_1,t_2) = E[X(t_1)X(t_2)] = e^{-2\lambda(t_2-t_1)}$ (1M)
- {X(t)} is evolutionary
- For Random telegraph signal process Y(t), $P(\alpha=1)=\frac{1}{2}$, $P(\alpha=-1)=\frac{1}{2}$ (1M)
- $E(\alpha)=0, E(\alpha^2)=1$ (1M)
- $R_{YY}(t_1,t_2) = E[Y(t_1)Y(t_2)] = E[\alpha^2 X(t_1)X(t_2)] = e^{-2\lambda(t_2-t_1)}$ which is WSS. (1M)
-

	UNIT-IV CORRELATION AND SPECTRAL DENSITIES
	Auto correlation functions – Cross correlation functions – Properties – Power spectral density - Cross spectral density – Properties.
Q.No	**PART*A**
1.	**List any two properties of an autocorrelation function. [N/D14] BTL 1** • $R(\tau)$ is an even function of τ. • If $R(\tau)$ is the autocorrelation function of a stationary process $\{X(t)\}$ with no periodic component, then $\lim_{\tau\to\infty} R(\tau) = \mu_x^2$, provided the limit exists.
2	**Prove that for a WSS process $\{X(t)\}$, $R_{XX}(\tau) = R_{XX}(-\tau)$.** **[A/M11,N/D11,N/D12,N/D15,M/J16,*N/D16*,A/M17,N/D17] BTL 5** $R_{XX}(\tau) = E[X(t)X(t-\tau)]$ $R_{XX}(-\tau) = E[X(t)X(t+\tau)] = E[X(t+\tau)X(t)] = R_{XX}(\tau)$ Therefore $R(\tau)$ is an even function of τ.
3	**Show that the autocorrelation function $R_{XX}(\tau)$ is maximum at $\tau = 0$. [*N/D17*] BTL 5** $R_{XX}(\tau)$ is maximum at $\tau = 0$ *i.e.* $\lvert R(\tau)\rvert \le R(0)$ Cauchy-Schwarz inequality is $(E[XY])^2 \le E[X^2]E[Y^2]$ Put $X = X(t)$ and $Y = X(t-\tau)$, then $(E[X(t)X(t-\tau)])^2 \le E[X^2(t)]E[X^2(t-\tau)]$ *i.e.* $(R(\tau))^2 \le (E[X^2(\tau)])^2$ [Since $E[X(t)]$ and $Var[X(t)]$ are constants for a stationary process] $[R(\tau)]^2 \le [R(0)]^2$ Taking square root on both sides, $\lvert R(\tau)\rvert \le R(0)$. [Since $R(0) = E[X^2(t)]$ is positive].
4	**The autocorrelation function of a stationary process is $R_{XX}(\tau) = 16 + \frac{9}{1+6\tau^2}$. Find the mean and variance of the process. [A/M10, A/M11, M/J12] BTL5** Given $R_{XX}(\tau) = 16 + \frac{9}{1+6\tau^2}$ $\mu_x^2 = \lim_{\tau\to\infty} R(\tau) = \lim_{\tau\to\infty}\left(16 + \frac{9}{1+6\tau^2}\right) = 16 + \lim_{\tau\to\infty}\left(\frac{9}{1+6\tau^2}\right)$ $= 16 + 0 = 16$ Mean $= \mu_x = E[X(t)] = 4$

	$E\left[X^2(t)\right] = R_{XX}(0) = 16 + \frac{9}{1+6(0)} = 16 + 9 = 25$ Variance $= E\left[X^2(t)\right] - \left(E\left[X(t)\right]\right)^2 = 25 - (4)^2 = 25 - 16 = 9$.
5	**If the autocorrelation function of a stationary processes is** $R_{XX}(\tau) = 25 + \frac{4}{1+6\tau^2}$ **. Find the mean and variance of the process.[N/D11,M/J14,N/D14,*N/D15*,*A/M18*] BTL5** Given $R_{XX}(\tau) = 25 + \frac{4}{1+6\tau^2}$ $\mu_x^2 = \lim_{\tau\to\infty} R(\tau) = \lim_{\tau\to\infty}\left(25 + \frac{4}{1+6\tau^2}\right) = 25 + \lim_{\tau\to\infty}\left(\frac{4}{1+6\tau^2}\right) = 25 + 0 = 25$ Mean $= \mu_x = E\left[X(t)\right] = 5$ $E\left[X^2(t)\right] = R_{XX}(0) = 25 + \frac{4}{1+6(0)} = 25 + 4 = 29$ Variance $= E\left[X^2(t)\right] - \left(E\left[X(t)\right]\right)^2 = 29 - (5)^2 = 29 - 25 = 4$.
6	**Find the variance of the stationary process** $\{X(t)\}$ **whose autocorrelation function is given by** $R_{XX}(\tau) = 2 + 4e^{-2\|\tau\|}$ **. [N/D10,N/D12,A/M17,*N/D19*] BTL5** Given $R_{XX}(\tau) = 2 + 4e^{-2\|\tau\|}$ $\mu_x^2 = \lim_{\tau\to\infty} R(\tau) = \lim_{\tau\to\infty}\left(2 + 4e^{-2\|\tau\|}\right) = 2 + \lim_{\tau\to\infty}\left(4e^{-2\|\tau\|}\right) = 2 + 0 = 2$ Mean $= \mu_x = E\left[X(t)\right] = \sqrt{2}$ $E\left[X^2(t)\right] = R_{XX}(0) = 2 + 4e^{-2(0)} = 2 + 4 = 6$ Variance $= E\left[X^2(t)\right] - \left(E\left[X(t)\right]\right)^2$ $= 6 - \left(\sqrt{2}\right)^2 = 6 - 2 = 4$.
7	**Define cross correlation function and state any two of its properties. [N/D10, M/J13, M/J14,*A/M15* ,M/J19] BTL1** If the process $\{X(t)\}$ and $\{Y(t)\}$ are jointly wide sense stationary, then $E\left[X(t)Y(t-\tau)\right]$ is a function of τ, denoted by $R_{XY}(\tau)$. This function $R_{XY}(\tau)$ is called the cross correlation function of the process $\{X(t)\}$ and $\{Y(t)\}$. Properties of cross correlation function are: i. $R_{XY}(-\tau) = R_{YX}(\tau)$. ii. If the process $\{X(t)\}$ and $\{Y(t)\}$ are orthogonal, then $R_{XY}(\tau) = 0$. iii. If the process $\{X(t)\}$ and $\{Y(t)\}$ are independent, then $R_{XY}(\tau) = E\left[X(t)\right]E\left[Y(t-\tau)\right]$.
8	**Prove that** $R_{XY}(\tau) = R_{YX}(-\tau)$**. [*M/J16*] BTL5** By definition, we have

	$R_{YX}(\tau)=E[Y(t)X(t-\tau)]$ $R_{YX}(-\tau)=E[Y(t)X(t+\tau)]$ $R_{YX}(-\tau)=E[X(t+\tau)Y(t)]$ $R_{YX}(-\tau)=R_{XY}(\tau)$ [by definition] Therefore, $R_{XY}(\tau)=R_{YX}(-\tau)$.
9	. **Define power spectral density function of stationary random processes $X(t)$. [N/D13,A/M15] BTL1** If $\{X(t)\}$ is a stationary process with autocorrelation function $R(\tau)$, then the Fourier transform of $R(\tau)$ is called the power spectral density function of $\{X(t)\}$ and denoted as $S(\omega)$ or $S_{XX}(\omega)$. *i.e.* $S(\omega)=\int_{-\infty}^{\infty}R(\tau)e^{-i\omega\tau}d\tau$.
10	. **A random process $X(t)$ is defined by $X(t)=k\cos\omega t, t\geq 0$ where ω is a constant and k is uniformly distributed over $(0,2)$. Find the autocorrelation function of $X(t)$.[M/J13] BTL5** Given k is uniformly distributed over $(0,2)$, the density function is given by $f_K(k)=\frac{1}{2-0}=\frac{1}{2}$, $0<k<2$ The autocorrelation function $R_{XX}(\tau)$ is given by $R_{XX}(\tau)=E[X(t)X(t-\tau)]=\int_0^2 X(t)X(t-\tau)f(k)dk=\int_0^2 k\cos\omega t.k\cos\omega(t-\tau)\frac{1}{2}dk$ $=\frac{\cos\omega t\cos\omega(t-\tau)}{2}\int_0^2 k^2\,dk=\frac{\cos\omega t\cos\omega(t-\tau)}{2}\left[\frac{k^3}{3}\right]_0^2=\frac{8}{6}\cos\omega t\cos\omega(t-\tau)$ $R_{XX}(\tau)=\frac{4}{3}\cos\omega t\ \cos\omega(t-\tau)$.
11	. **If $R_{XX}(\tau)=\frac{25\tau^2+36}{6.25\tau^2+4}$. Find the mean and variance of X . [A/M15] BTL5** Given $R_{XX}(\tau)=\frac{25\tau^2+36}{6.25\tau^2+4}$ $\mu_x{}^2=\lim_{\tau\to\infty}R_{XX}(\tau)=\lim_{\tau\to\infty}\frac{25\tau^2+36}{6.25\tau^2+4}=\lim_{\tau\to\infty}\frac{\tau^2\left(25+\frac{36}{\tau^2}\right)}{\tau^2\left(6.25+\frac{4}{\tau^2}\right)}$ $=\lim_{\tau\to\infty}\frac{25+\frac{36}{\tau^2}}{6.25+\frac{4}{\tau^2}}=\frac{25+0}{6.25+0}=\frac{25}{6.25}=4$ Mean = $\mu_x=E[X(t)]=2$

	$E\left[X^2(t)\right] = R_{XX}(0) = \frac{25(0)+36}{6.25(0)+4} = \frac{36}{4} = 9$ Variance $= E\left[X^2(t)\right] - \left(E\left[X(t)\right]\right)^2 = 9 - (2)^2 = 9 - 4 = 5$.
12	. **Write any two properties of the power spectral density of the WSS process. [*A/M18*] BTL1** (i) The spectral density of a real random process is an even function. (ii) The spectral density of a process $\{X(t)\}$, real or complex is a real function of ω and non negative.
13	. **Prove that the spectral density of a real random process is an even function. [*N/D15*] BTL5** By definition, we have $S_{XX}(\omega) = \int_{-\infty}^{\infty} R_{XX}(\tau) e^{-i\omega\tau}\, d\tau$ $S_{XX}(-\omega) = \int_{-\infty}^{\infty} R_{XX}(\tau) e^{i\omega\tau}\, d\tau$ Put $\tau = -u$ when $\tau = -\infty$, $u = \infty$ $d\tau = -du$ when $\tau = \infty$, $u = -\infty$ $S_{XX}(-\omega) = \int_{\infty}^{-\infty} R_{XX}(-u) e^{-i\omega u}(-du)$ $S_{XX}(-\omega) = -\int_{\infty}^{-\infty} R_{XX}(-u) e^{-i\omega u}\, du$ $S_{XX}(-\omega) = \int_{-\infty}^{\infty} R_{XX}(-\tau) e^{-i\omega\tau}\, d\tau$, treating u as a dummy variable $S_{XX}(-\omega) = \int_{-\infty}^{\infty} R_{XX}(\tau) e^{-i\omega\tau}\, d\tau$, since $R_{XX}(-\tau) = R_{XX}(\tau)$ $S_{XX}(-\omega) = S_{XX}(\omega)$. Hence the spectral density of a real random process is an even function.
14	. **State any two properties of cross-power density spectrums. [A/M17] BTL1** Properties of cross-power density spectrums are (1) $S_{YX}(\omega) = S_{XY}(-\omega)$ (2) If $\{X(t)\}$ and $\{Y(t)\}$ are independent, then $S_{XY}(\omega) = S_{YX}(\omega) = 0$
15	ıte and prove any one of the properties of the cross spectral density function.[A/M15] Cross spectral density function is not an even function of ω, but it has a symmetry relationship. *i.e.* $S_{YX}(\omega) = S_{XY}(-\omega)$ <u>Proof</u>:

	$S_{XY}(\omega)=\int_{-\infty}^{\infty}R_{XY}(\tau)e^{-i\omega\tau}d\tau$ $S_{XY}(-\omega)=\int_{-\infty}^{\infty}R_{XY}(\tau)e^{i\omega\tau}d\tau$ Putting $\tau=-u$ when $\tau=-\infty, u=\infty$ $d\tau=-du$ when $\tau=\infty, u=-\infty$ $S_{XY}(-\omega)=\int_{\infty}^{-\infty}R_{XY}(-u)e^{-i\omega u}(-du)$ $S_{XY}(-\omega) \quad =\int_{-\infty}^{\infty}R_{YX}(u)e^{-i\omega u}du \qquad \because R_{XY}(-\tau)=R_{YX}(\tau)$ $=\int_{-\infty}^{\infty}R_{YX}(\tau)e^{-i\omega\tau}d\tau=S_{YX}(\omega)$ *i.e.* $S_{YX}(\omega)=S_{YX}(-\omega)$.
16	**An autocorrelation function $R(\tau)$ of $\{X(t);\tau\in T\}$ is given by c$e^{-\alpha\|\tau\|};c>0;\alpha>0$. Obtain the spectral density of $X(t)$. [N/D16] BTL5** Given $R_{XX}(\tau)=ce^{-\alpha\|\tau\|}$ $S(\omega)=\int_{-\infty}^{\infty}R_{XX}(\tau)e^{-i\omega\tau}d\tau \qquad =\int_{-\infty}^{\infty}c\,e^{-\alpha\|\tau\|}e^{-i\omega\tau}d\tau$ $=c\int_{-\infty}^{\infty}e^{-\alpha\|\tau\|}(\cos\omega\tau-i\sin\omega\tau)d\tau=c\int_{-\infty}^{\infty}e^{-\alpha\|\tau\|}(\cos\omega\tau)d\tau-ic\int_{-\infty}^{\infty}e^{-\alpha\|\tau\|}(\sin\omega\tau)d\tau$ $=2c\int_{0}^{\infty}e^{-\alpha\|\tau\|}\cos\omega\tau\,d\tau$ (Since the first integrand is even and the second integral is odd) $=2c\int_{0}^{\infty}e^{-\alpha\tau}\cos\omega\tau\,d\tau=2c\left[\frac{e^{-\alpha\tau}}{(-\alpha)^2+\omega^2}(-\alpha\cos\omega\tau+\omega\sin\omega\tau)\right]_0^{\infty}$ $=2c\left[0-\frac{1}{\alpha^2+\omega^2}(-\alpha+0)\right]\Rightarrow S(\omega)=\frac{2c\alpha}{\alpha^2+\omega^2}$
17	**An autocorrelation function $R(\tau)$ of $\{X(t);\tau\in T\}$ is given by c$e^{-\alpha\|\tau\|};c>0;\alpha>0$. Obtain the spectral density of $X(t)$. [N/D16] BTL5** Given $R_{XX}(\tau)=ce^{-\alpha\|\tau\|}$ $S(\omega)=\int_{-\infty}^{\infty}R_{XX}(\tau)e^{-i\omega\tau}d\tau \qquad =\int_{-\infty}^{\infty}c\,e^{-\alpha\|\tau\|}e^{-i\omega\tau}d\tau$ $=c\int_{-\infty}^{\infty}e^{-\alpha\|\tau\|}(\cos\omega\tau-i\sin\omega\tau)d\tau=c\int_{-\infty}^{\infty}e^{-\alpha\|\tau\|}(\cos\omega\tau)d\tau-ic\int_{-\infty}^{\infty}e^{-\alpha\|\tau\|}(\sin\omega\tau)d\tau$ $=2c\int_{0}^{\infty}e^{-\alpha\|\tau\|}\cos\omega\tau\,d\tau$ (Since the first integrand is even and the second integral is odd)

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$$= 2c\int_0^\infty e^{-\alpha\tau}\cos\omega\tau\, d\tau = 2c\left[\frac{e^{-\alpha\tau}}{(-\alpha)^2+\omega^2}\left(-\alpha\cos\omega\tau+\omega\sin\omega\tau\right)\right]_0^\infty$$

$$= 2c\left[0-\frac{1}{\alpha^2+\omega^2}(-\alpha+0)\right] \Rightarrow S(\omega)=\frac{2c\alpha}{\alpha^2+\omega^2}$$

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Find the power spectral density of the random process $\{X(t)\}$ whose autocorrelation is $R(\tau)=\begin{cases}-1\,;\,-3<\tau<3\\ 0\ ;\ otherwise\end{cases}$. [<u>*N/D16*</u>] BTL5

Given $R(\tau)=\begin{cases}-1\,;\,-3<\tau<3\\ 0\ ;\ otherwise\end{cases}$

$$S(\omega) = \int_{-\infty}^{\infty} R_{XX}(\tau)e^{-i\omega\tau}d\tau = \int_{-3}^{3}(-1)e^{-i\omega\tau}\,d\tau = -\left[\frac{e^{-i\omega\tau}}{-i\omega}\right]_{-3}^{3}$$

$$=\frac{1}{i\omega}\left(e^{-i\omega3}-e^{i\omega3}\right)=-\frac{1}{i\omega}\left(e^{i3\omega}-e^{-i3\omega}\right)=\frac{i}{\omega}(2\sin h3\omega)=\frac{2i}{\omega}\sin h3\omega\,.$$

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he autocorrelation function of the random telegraph signal process is given by $R(\tau)=a^2e^{-2\lambda|\tau|}$. Determine the power density spectrum of the random telegraph signal. BTL3

Given $R(\tau)=a^2e^{-2\lambda|\tau|}$

$$S(\omega)=\int_{-\infty}^{\infty}R_{XX}(\tau)e^{-i\omega\tau}d\tau = \int_{-\infty}^{\infty}a^2e^{-2\lambda|\tau|}e^{-i\omega\tau}d\tau = a^2\int_{-\infty}^{\infty}e^{-2\lambda|\tau|}(\cos\omega\tau-i\sin\omega\tau)d\tau$$

$$=a^2\int_{-\infty}^{\infty}e^{-2\lambda|\tau|}(\cos\omega\tau)d\tau-ia^2\int_{-\infty}^{\infty}e^{-2\lambda|\tau|}(\sin\omega\tau)d\tau$$

$=2a^2\int_0^\infty e^{-2\lambda|\tau|}\cos\omega\tau\,d\tau$ (Since the first integrand is even and the second integral is odd)

$$=2a^2\left[\frac{e^{-2\lambda\tau}}{(-2\lambda)^2+\omega^2}\left(-2\lambda\cos\omega\tau+\omega\sin\omega\tau\right)\right]_0^\infty$$

$$=2a^2\left[0-\frac{1}{4\lambda^2+\omega^2}(-2\lambda+0)\right]\Rightarrow S(\omega)=\frac{4a^2\lambda}{4\lambda^2+\omega^2}$$

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<tr><td>20</td><td>

Find the power spectral density of a WSS process with autocorrelation function $R(\tau)=e^{-\alpha\tau^2}$. BTL4

Given $R(\tau)=e^{-\alpha\tau^2}$

$$S(\omega) = \int_{-\infty}^{\infty}R(\tau)e^{-i\omega\tau}d\tau$$

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	$$= \int_{-\infty}^{\infty} e^{-\alpha\tau^2} e^{-i\omega\tau} d\tau = \int_{-\infty}^{\infty} e^{-\alpha\left(\tau^2 + \frac{i\omega\tau}{\alpha}\right)} d\tau = \int_{-\infty}^{\infty} e^{-\alpha\left(\tau^2 + \frac{i\omega\tau}{\alpha} + \left(\frac{i\omega}{2\alpha}\right)^2 - \left(\frac{i\omega}{2\alpha}\right)^2\right)} d\tau$$ $$= \int_{-\infty}^{\infty} e^{-\alpha\left(\tau + \frac{i\omega}{2\alpha}\right)^2} e^{-\alpha\left(\frac{\omega^2}{4\alpha^2}\right)} d\tau = e^{-\frac{\omega^2}{4\alpha}} \int_{-\infty}^{\infty} e^{-\alpha\left(\tau + \frac{i\omega}{2\alpha}\right)^2} d\tau$$ Put $\sqrt{\alpha}\left(\tau + \frac{i\omega}{2\alpha}\right) = x \Rightarrow \sqrt{\alpha}\, d\tau = dx \Rightarrow d\tau = \frac{dx}{\sqrt{\alpha}}$ When $\tau = -\infty, x = -\infty$ When $\tau = \infty, x = \infty$ $$S(\omega) = e^{-\frac{\omega^2}{4\alpha}} \int_{-\infty}^{\infty} e^{-x^2} \frac{dx}{\sqrt{\alpha}} = \frac{e^{-\frac{\omega^2}{4\alpha}}}{\sqrt{\alpha}} \int_{-\infty}^{\infty} e^{-x^2} dx = \frac{e^{-\frac{\omega^2}{4\alpha}}}{\sqrt{\alpha}} \sqrt{\pi} = \sqrt{\frac{\pi}{\alpha}} e^{-\frac{\omega^2}{4\alpha}}$$
21	**If the power spectral density of a WSS process is given by** $S(\omega) = \begin{cases} \frac{b}{a}(a - \lvert\omega\rvert) & , \lvert\omega\rvert < a \\ 0 & , \lvert\omega\rvert > a \end{cases}$ **.Find** $R(\tau)$**. BTL4** $$R(\tau) = \frac{1}{2\pi} \int_{-\infty}^{\infty} S(\omega) e^{i\omega\tau} d\omega$$ $$= \frac{1}{2\pi}\left[\int_{-\infty}^{-a} S(\omega) e^{i\omega\tau} d\omega + \int_{-a}^{a} S(\omega) e^{i\omega\tau} d\omega + \int_{a}^{\infty} S(\omega) e^{i\omega\tau} d\omega\right]$$ $$= \frac{1}{2\pi}\left[\int_{-a}^{a} \frac{b}{a}(a - \lvert\omega\rvert) e^{i\tau\omega} d\omega\right] = \frac{b}{2\pi a} \int_{-a}^{a} (a - \lvert\omega\rvert)(\cos\tau\omega + i\sin\tau\omega) d\omega$$ $$= \frac{b}{2\pi a} \int_{-a}^{a} (a - \lvert\omega\rvert)(\cos\tau\omega) d\omega + i\frac{b}{2\pi a} \int_{-a}^{a} (a - \lvert\omega\rvert)(\sin\tau\omega) d\omega$$ $$= \frac{b}{2\pi a} 2\int_{0}^{a} (a - \lvert\omega\rvert)(\cos\tau\omega) d\omega + i\frac{b}{2\pi a}(0) = \frac{b}{\pi a} \int_{0}^{a} (a - \omega)(\cos\tau\omega) d\omega$$ $$= \frac{b}{\pi a}\left[(a-\omega)\frac{\sin\tau\omega}{\tau} - \frac{\cos\tau\omega}{\tau^2}\right]_0^a = \frac{b}{\pi a}\left[\left(0 - \frac{\cos a\tau}{\tau^2}\right) - \left(0 - \frac{1}{\tau^2}\right)\right]$$ $$= \frac{b}{\pi a}\left(\frac{1}{\tau^2} - \frac{\cos a\tau}{\tau^2}\right)$$ $$R(\tau) = \frac{b}{\pi a \tau^2}(1 - \cos a\tau).$$
22	**The power spectral density function of a zero mean wide sense stationary process** $\{X(t)\}$ **is given by** $S(\omega) = \begin{cases} 1 & ; \lvert\omega\rvert < \omega_0 \\ 0 & ; Elsewhere \end{cases}$ **. Find** $R(\tau)$**. BTL4**

	$R(\tau) = \frac{1}{2\pi}\int_{-\infty}^{\infty} S(\omega)e^{i\omega\tau}d\omega$ $= \frac{1}{2\pi}\left[\int_{-\infty}^{-\omega_0} S(\omega)e^{i\omega\tau}d\omega + \int_{-\omega_0}^{\omega_0} S(\omega)e^{i\omega\tau}d\omega + \int_{\omega_0}^{\infty} S(\omega)e^{i\omega\tau}d\omega\right]$ $= \frac{1}{2\pi}\left[\int_{-\omega_0}^{\omega_0} 1.e^{i\omega\tau}d\omega\right] = \frac{1}{2\pi}\int_{-\omega_0}^{\omega_0}(\cos\tau\omega + i\sin\tau\omega)d\omega$ $= \frac{1}{2\pi}\int_{-\omega_0}^{\omega_0}(\cos\tau\omega)d\omega + i\frac{1}{2\pi}\int_{-\omega_0}^{\omega_0}(\sin\tau\omega)d\omega$ $= \frac{1}{2\pi}2\int_{0}^{\omega_0}(\cos\tau\omega)d\omega + i\frac{1}{2\pi}(0)$ [$\because$ The 1st integrand is even and the 2nd is odd] $= \frac{1}{\pi}\left(\frac{\sin\tau\omega}{\tau}\right)_0^{\omega_0} = \frac{1}{\pi\tau}(\sin\tau\omega_0 - 0) \quad \Rightarrow R(\tau) = \frac{\sin\omega_0\tau}{\pi\tau}.$
23	**Find the auto correlation function whose spectral density is** $S(\omega) = \begin{cases} \pi \ ; \|\omega\| < 1 \\ 0 \ ; \ otherwise \end{cases}$ **. [*A/M15, M/J16* ,M/J16] BTL4** $R(\tau) = \frac{1}{2\pi}\int_{-\infty}^{\infty} S(\omega)e^{i\omega\tau}d\omega$ $= \frac{1}{2\pi}\left[\int_{-\infty}^{-1} S(\omega)e^{i\omega\tau}d\omega + \int_{-1}^{1} S(\omega)e^{i\omega\tau}d\omega + \int_{1}^{\infty} S(\omega)e^{i\omega\tau}d\omega\right]$ $= \frac{1}{2\pi}\left[\int_{-1}^{1} \pi.e^{i\omega\tau}d\omega\right] = \frac{1}{2\pi}\int_{-1}^{1}\pi(\cos\tau\omega + i\sin\tau\omega)d\omega$ $= \frac{1}{2}\int_{-1}^{1}(\cos\tau\omega)d\omega + i\frac{1}{2}\int_{-1}^{1}(\sin\tau\omega)d\omega$ $= \frac{1}{2}2\int_{0}^{1}(\cos\tau\omega)d\omega + i\frac{1}{2\pi}(0)$ [$\because$ The 1st integrand is even and the 2nd is odd] $= \left(\frac{\sin\tau\omega}{\tau}\right)_0^{1} = \frac{1}{\tau}(\sin\tau - 0) \quad \Rightarrow R(\tau) = \frac{\sin\tau}{\tau}.$
24	**Determine the autocorrelation function of the random process with the spectral density given by** $S_{XX}(\omega) = \begin{cases} S_0 & ; \|\omega\| < \omega_0 \\ 0 & ; \ otherwise \end{cases}$ **. [A/M17,*A/M18*] BTL3**

$$R(\tau)=\frac{1}{2\pi}\int_{-\infty}^{\infty}S(\omega)e^{i\tau\omega}d\omega$$

$$=\frac{1}{2\pi}\left[\int_{-\infty}^{-\omega_0}S(\omega)e^{i\tau\omega}d\omega+\int_{-\omega_0}^{\omega_0}S(\omega)e^{i\tau\omega}d\omega+\int_{\omega_0}^{\infty}S(\omega)e^{i\tau\omega}d\omega\right]$$

$$=\frac{1}{2\pi}\left[\int_{-1}^{1}S_0\,e^{i\tau\omega}d\omega\right]=\frac{S_0}{2\pi}\int_{-\omega_0}^{\omega_0}(\cos\tau\omega+i\sin\tau\omega)d\omega=\frac{S_0}{2\pi}\int_{-\omega_0}^{\omega_0}(\cos\tau\omega)d\omega+i\frac{S_0}{2\pi}\int_{-\omega_0}^{\omega_0}(\sin\tau\omega)d\omega$$

$$=\frac{S_0}{2\pi}2\int_{0}^{\omega_0}(\cos\tau\omega)d\omega+i\frac{S_0}{2\pi}(0)\,[\because \text{The 1}^{st}\text{ integrand is even and the 2}^{nd}\text{ is odd}]$$

$$=\frac{S_0}{\pi}\left(\frac{\sin\tau\omega}{\tau}\right)_0^{\omega_0}=\frac{S_0}{\pi\tau}(\sin\tau\omega_0-0)\quad\Rightarrow\quad R(\tau)=\frac{S_0}{\pi\tau}\sin\omega_0\tau\,.$$

25

State Wiene–Khinchine theorem.[N/D13,N/D15] OR Write the Wiener–Khinchine relation. [N/D14,N/D16,N/D17] BTL1

If $X_T(\omega)$ is the Fourier transform of the truncated random process defined as $X_T(t)=\begin{cases}X(t) & for\ |t|\le T\\ 0 & for\ |t|>T\end{cases}$ where $\{X(t)\}$ is a real WSS process with power spectral density function $S(\omega)$, then $S(\omega)=\lim_{T\to\infty}\frac{1}{2T}\,E\left[|X_T(\omega)|^2\right]$.

PART * B

1

Consider two random processes $X(t)=3\cos(\omega t+\theta)$ **and** $Y(t)=2\cos(\omega t+\phi)$ **where** $\phi=\theta-\frac{\pi}{2}$ **and** θ **is uniformly distributed random variable over** $(0,2\pi)$**. Verify whether** $|R_{XY}(\tau)|\le\sqrt{R_{XX}(0)R_{YY}(0)}$**. [*A/M15*,A/M17,*A/M2019*] BTL3**

Answer:Page: 4.26-Dr.A. Singaravelu

- RXX(0) = 9 / 2 (2M)
- RYY(0) = 2 (2M)
- RXY(τ) = 3 sin ωτ (2M)
- |RXY(τ)| ≤ √RXX(0) . RYY(0) (2M)

2

Find the power spectral density function whose autocorrelation function is given by $R_{XX}(\tau)=\frac{A^2}{2}\cos(\omega_0\tau)$**. [M/J12] BTL4**

Answer:Page: 4.50-Dr.A. Singaravelu

- Sxx(W) $=\int_{-\infty}^{\infty}RXX(\tau)e^{-i\omega\tau}\,d\tau$ (2M)
- Sxx(W) $=\frac{\pi A^2}{2}\,[\sigma(W+W_0)+\delta(W-W_0)]$ (6M)

3	**If $\{X(t)\}$ and $\{Y(t)\}$ are two random processes with autocorrelation function $R_{XX}(\tau)$ and $R_{YY}(\tau)$ respectively, then prove that $\left\|R_{XY}(\tau)\right\| \le \sqrt{R_{XX}(0)R_{YY}(0)}$. Establish any two properties of autocorrelation function $R_{XX}(\tau)$. [N/D10,N/D12,*M/J16*,*N/D16*] BTL5** **Answer:Page: 4.23-Dr.A. Singaravelu** • $RXX(0) = E[x^2(t)], RYY(0) = E[y^2(t+\tau)]$ (2M) • $\|RXY(\tau)\| \le \sqrt{RXX(0)\ RYY(0)}$ (4M) • $RXX(\tau) = RXX, \|RXX(\tau)\| \le RXX(0)$ (2M)
4	**If $X(t) = 5\sin(\omega t+\phi)$ and $Y(t) = 2\cos(\omega t+\theta)$ where ω is a constant, $\theta+\phi = \frac{\pi}{2}$ and ϕ is a random variable uniformly distributed in $(0,2\pi)$, find $R_{XX}(\tau)$, $R_{YY}(\tau)$, $R_{XY}(\tau)$ and $R_{YX}(\tau)$. Verify two properties of autocorrelation function and cross correlation function. [*N/D16*] BTL5** **Answer:Page: 4.26-Dr.A. Singaravelu** • $RXX(\tau) = \frac{25}{2}\cos w\,\tau$ (2M) • $RYY(\tau) = 2\cos w\,\tau$ (3M) • $RXY(\tau) = 5\sin w\,\tau$ (3M) • $\|RXY(\tau)\| \le \sqrt{RXX(0)\ RYY(0)}$ (4M) • $\|RXY(\tau)\| \le \frac{1}{2}[RXX(0) + RYY(0)]$ (4M)
5	**Two random processes $X(t)$ and $Y(t)$ are defined as follows: $X(t) = A\cos(\omega t+\theta)$ and $Y(t) = B\sin(\omega t+\theta)$ where A, B and ω are constants; θ is a uniform random variable over $(0,2\pi)$. Find the cross correlation function of $X(t)$ and $Y(t)$. [M/J13,*N/D15*] BTL5** **Answer:Page: 4.24-Dr.A. Singaravelu** • $RXY(t,t+\tau) = E[X(t).Y(t+\tau)]$ (2M) • $RXY(t,t+\tau) = \frac{A^2}{2}\sin w\,\tau$ (6M)
6	**Define spectral density of a stationary random process $X(t)$. Prove that for a real random process $X(t)$ the power spectral density is an even function. [M/J13,N/D17] BTL5** **Answer:Page: 4.33-Dr.A. Singaravelu** • $Sxx(w) = \int_{-\infty}^{\infty} Rxx(\tau)\, e^{-iw\tau}\, d\tau$ (2M) • $Sxx(-w) = Sxx(w)$ (2M)
7	**State and prove Wiener Khintchine theorem and hence find the power spectral density of a WSS process $X(t)$ which has an autocorrelation $R_{XX}(\tau) = A_0\left[1-\frac{\|\tau\|}{T}\right], -T \le \tau \le T$. [Nov/Dec2019] BTL5**

	Answer:Page: 4.43-Dr.A. Singaravelu • $Sxx(w) = \lim_{T\to\infty}\left(\frac{1}{2T}\, E\{\,\lvert X_T(W)\rvert^2\}\right)$ (2M) • $Sxx(w) = \frac{2}{Tw^2}\,[1-\cos WT]$ (6M)
8	**State Wiener-Khinchine relation and define cross power spectral density and its properties. [M/J16] BTL5** **Answer:Page: 4.36-Dr.A. Singaravelu** • $Sxx(W) = \lim_{T\to\infty}[\frac{1}{2T}\, E\{\lvert x_T(W)\rvert^2\}]$ (3M) • $Sxy(W) = \int_{-\infty}^{\infty} Rxy(\tau)e^{-1w\tau}d\tau$ (2M) • $Sxy(w) = Syx(-w)$ (1M) • $Sxy(w) = Syx(w) - 2\pi\, E(x)E(y)\,\sigma(w)$ (1M) If {x(t)} and {y(t)} are orthogonal then $Sxy(w) = 0$ and $Syx(w) = 0$ (1M)
9	**Find the power spectral density of a random signal with auto correlation function $e^{-\lambda\lvert\tau\rvert}$. [A/M15,Apr/May19] BTL5** **Answer:Page: 4.42-Dr.A. Singaravelu** • $Sxx(w) = \int_{-\infty}^{\infty} Rxx(\tau)e^{-iw\tau}d\tau$ (2M) • $Sxx(w) = \frac{2\lambda}{\lambda^2+w^2}$ (6M)
10	**Given that a process $X(t)$ has an autocorrelation function $R_{XX}(\tau)=Ae^{-\alpha\lvert\tau\rvert}\cos\omega_0\tau$ where $A>0, \alpha>0$ and ω_0 are real constants, find the power spectral density of $X(t)$. [N/D16,*A/M18*] BTL5** **Answer:Page: 4.49-Dr.A. Singaravelu** • $Sxx(w) = \int_{-\infty}^{\infty} Rxx(\tau)e^{-iw\tau}\,d\tau$ (2M) • $Sxx(w) = \frac{2A\alpha}{\alpha^2+w^2}$ (6M)
11	**Autocorrelation function of an ergodic process $\{X(t)=X\}$ is $R_{XX}(\tau)=\begin{cases}1-\lvert\tau\rvert & , \lvert\tau\rvert\le 1\\ 0 & , otherwise\end{cases}$. Obtain the spectral density of X. [N/D10,N/D12, *M/J16*,*N/D17*] BTL5** **Answer:Page: 4.44-Dr.A. Singaravelu** • $Sxx(w) = \int_{-\infty}^{\infty} Rxx(\tau)e^{-iw\tau}\,d\tau$ (2M) • $Sxx(w) = [\frac{\int in\,(\frac{W}{2})}{\frac{W}{2}}]^2$ S(6M)
12	**The autocorrelation function of the random telegraph signal process is given by $R(\tau)=a^2 e^{-2\lvert\tau\rvert}$. Determine the power density spectrum of the random telegraph signal.[N/D13] (OR) The autocorrelation function of the random telegraph signal process is given by $R(\tau)=a^2 e^{-2\gamma\lvert\tau\rvert}$. Determine the power density spectrum of the random telegraph**

	signal. [*N/D15* , M/J16] BTL5 **Answer:Page: 4.42-Dr.A. Singaravelu** • $Sxx(w) = \int_{-\infty}^{\infty} Rxx(\tau)e^{-iw\tau}\, d\tau$ (2M) • $Sxx(w) = \frac{4a^2r}{4r^2w^2}$ (6M)
13	**Find the spectral density of a WSS random process $\{X(t)\}$ whose autocorrelation function is $e^{-\frac{\alpha^2\tau^2}{2}}$. [N/D15,*Nov/Dec19*] BTL5** **Answer:Page: 4.46-Dr.A. Singaravelu** • $\delta xx(w) = \int_{-\infty}^{\infty} Rxx(\tau)e^{-iw\tau}\, d\tau$ (2M) • $Sxx(w) = \frac{4a^2r}{4r^2w^2}$ (6M) Type equation here.
14	**The autocorrelation function of the random process $X(t)$ is given by $R(\tau) = \begin{cases} 1-\frac{\|\tau\|}{T} & , \|\tau\| \le T \\ 0 & , \|\tau\| > T \end{cases}$.** **Find the power spectrum of the process $X(t)$. [A/M10,*A/M15*,M/J16,N/D16] BTL5** **Answer:Page: 4.43-Dr.A. Singaravelu** • $Sxx(w) = \int_{-\infty}^{\infty} Rxx(\tau)e^{-iw\tau}\, d\tau$ (2M) • $Sxx(w) = \frac{2}{TW^2}\,[1-\cos WT]$ (6M)
15	**If the power spectral density of a WSS process is given by $S(\omega) = \begin{cases} \frac{b}{a}(a-\|\omega\|) & ,\|\omega\| \le a \\ 0 & ,\|\omega\| > a \end{cases}$** **Find the autocorrelation function of the process. [N/D13,N/D14,*N/D16*,*N/D17*] BTL5** **Answer:Page: 4.60-Dr.A. Singaravelu** • $Rxx(\tau) = \frac{1}{2\pi}\int_{-\infty}^{\infty} Sxx(w)e^{iw\tau}\, dw$ (2M) • $Rxx(\tau) = \frac{b}{a\pi\tau^2}\; 2\, sin^2\left(\frac{a\tau}{2}\right)$ (6M)
16	**The autocorrelation function of the Poisson increment process is given by $R(\tau) = \begin{cases} \lambda^2 & for\ \|\tau\| > \varepsilon \\ \lambda^2 + \frac{\lambda}{\varepsilon}\left(1-\frac{\|\tau\|}{\varepsilon}\right) & for\ \|\tau\| \le \varepsilon \end{cases}$. Find the power spectral density of the process.** **[N/D11] BTL5** **Answer:Page: 4.51-Dr.A. Singaravelu** • $Sxx(w) = \int_{-\infty}^{\infty} Rxx(\tau)e^{-iw\tau}\, d\tau$ (2M)

	• $Sxx(w) = 2\pi\lambda^2\sigma(w) + 4\boldsymbol{\lambda}\, \frac{\boldsymbol{sin^2(\frac{ew}{2})}}{\boldsymbol{e^2w^2}}$ (6M)
17	**If $X(t)$ and $Y(t)$ are uncorrelated random processes, then find the power spectral density of $Z(t)$ if $Z(t) = X(t)+Y(t)$. Also find the cross spectral density $S_{XZ}(\omega)$ and $S_{YZ}(\omega)$.[N/D16] BTL5** **Answer:Page: 4.81-Dr.A. Singaravelu** • $Szz(w) = Sxx(w) + Syy(w) + Sxy(w) + Syx(w)$ (4M) • $Sxz(w) = Sxx(w) + Sxy(w)$ (2M) • $Syz(w) = Syy(w) + Syx(w)$ (2M)
18	**The power spectral density of a zero mean WSS process $\{X(t)\}$ is given by $S(\omega) = \begin{cases} 1 \ ; \lvert\omega\rvert < \omega_0 \\ 0 \ ; elsewhere \end{cases}$. Find $R(\tau)$ and show also that $X(t)$ and $X\left(t+\frac{\pi}{\omega_0}\right)$ are uncorrelated. [A/M11] BTL5** **Answer:Page: 4.63-Dr.A. Singaravelu** • $Rxx(\tau) = \frac{1}{\pi\tau}\sin(w_0\tau)$ (4M) • $c\left[x(t).x\left(t+\frac{\pi}{w_0}\right)\right] = 0$ (4M)
19	**Find the autocorrelation function of the process $\{X(t)\}$ for which the power spectral density is given by $S_{XX}(\omega) = 1+\omega^2 \ \ for\ \lvert\omega\rvert<1$ and $S_{XX}(\omega) = 0 \ \ for\ \lvert\omega\rvert>1$. [A/M10,N/D16,*A/M17*] BTL5** **Answer:Page: 4.68-Dr.A. Singaravelu** • $Rxx(\tau) = \frac{1}{2\pi}\int_{-\infty}^{\infty} Sxx(w)e^{iw\tau}\,dw$ (2M) • $Rxx(\tau) = \frac{2}{\pi\tau^2}[\tau^2\sin\tau + \tau\cos\tau - \sin\tau]$ (6M)
20	**If the power spectral density of a continuous process is $S_{XX}(\omega) = \frac{\omega^2+9}{\omega^4+5\omega^2+4}$, find the mean square value of the process. [N/D11,*A/M15, M/J16*] BTL5** **Answer:Page: 4.67-Dr.A. Singaravelu** • $Rxx(\tau) = F^{-1}\left[\frac{w^2+9}{w^4+5w^2+4}\right]$ (2M) • $Rxx(\tau) = \frac{8}{6}\,e^{-\lvert\tau\rvert} - \frac{5}{12}\,e^{-2\lvert\tau\rvert}$ (3M) • $Rxx(0) = \frac{11}{12}$ (3M)

21	**The power spectrum of a Wide sense stationary process $\{X(t)\}$ is given by $S(\omega)=\frac{1}{(1+\omega^2)^2}$. Find its autocorrelation function $R(\tau)$. [A/M15,N/D15,*N/D15*,A/M17] BTL5** **Answer:Page: 4.63-Dr.A. Singaravelu** • $Rxx(\tau) = \frac{1}{2\pi}\int_{-\infty}^{\infty} Sxx(w)e^{iw\tau}\,dw$ (2M) • $Rxx(\tau) = \frac{1}{4}(1+\tau)e^{-\tau}$ (6M)
22	**The cross power spectrum of real random process $X(t)$ and $Y(t)$ is given by $S_{XY}(\omega)=\begin{cases} a+jb\omega & ; \lvert\omega\rvert<1 \\ 0 & ; elsewhere \end{cases}$. Find the cross correlation function. [N/D10,A/M11, N/D11,N/D15, *M/J16* , M/J16,N/D16,*A/M17*,*A/M18*] BTL4** **Answer:Page: 4.77-Dr.A. Singaravelu** • $Rxy(\tau) = \frac{1}{2\pi}\int_{-\infty}^{\infty} Sxy(w)e^{iw\tau}\,dw$ (2M) • $Rxx(\tau) = \frac{1}{\pi\tau^2}[(a\tau-b)\sin\tau + b\,\tau\cos\tau]$ (6M)
23	**If the cross power spectral density of $X(t)$ and $Y(t)$ is given by $S_{XY}(\omega)=a+\frac{ib\omega}{\alpha}$, $-\alpha<\omega<\alpha$, $\alpha>0$ where a and b are constants, find the cross correlation function. [M/J13,*N/D17*] BTL4** **Answer:Page: 1.80-Dr.A. Singaravelu** • $Rxy(\tau) = \frac{1}{2\pi}\int_{-\infty}^{\infty} Sxy(w)e^{iw\tau}\,dw$ (2M) • $Rxy(\tau) = \frac{1}{\pi\tau^2}\left[\left(\tau a-\frac{b}{w}\right)\sin w\tau + \tau b\cos\omega\tau\right]$ (6M)
24	**If $\{X(t)\}$ is a WSS process with autocorrelation function $R_{XX}(\tau)$ and if $Y(t)=X(t+a)-X(t-a)$. Show that $R_{YY}(\tau)=2R_{XX}(\tau)-R_{XX}(\tau+2a)-R_{XX}(\tau-2a)$. BTL5** **Answer:Page: 4.47-Dr.A. Singaravelu** • $Rxx(\tau) = E[x(t).x(t+\tau)]$ (1M) • $Ryy(\tau) = E[y(t).y(t+\tau)]$ (1M) • $Ryy(\tau) = 2\,Rxx(\tau) - Rxx(\tau+2a) - Rxx(\tau-2a)$ (6M)
	UNIT V-LINEAR SYSTEM WITH RANDOM INPUTS
	Linear time invariant system- System transfer function – Linear system with random inputs –Auto correlation and cross correlation functions of input and output.
	PART*A
1	**Define a system. When is it called a linear system? [M/J14,A/M15,M/J16,N/D17] BTL1** A system is a functional relationship between the input $x(t)$ and the output $y(t)$. The functional

	relationship is written as $y(t) = f[x(t)]$. If $f[a_1 X_1(t) \pm a_2 X_2(t)] = a_1 f[X_1(t)] \pm a_2 f[X_2(t)]$, then f is called a linear system.
2	**Define linear time- invariant system. [A/M10, M/J13,N/D16] BTL1** If $f[a_1 X_1(t) \pm a_2 X_2(t)] = a_1 f[X_1(t)] \pm a_2 f[X_2(t)]$, then f is called a linear system. If $Y(t+h) = f[x(t+h)]$ where $Y(t) = f[X(t)]$, f is called a time – invariant system or $X(t)$ and $Y(t)$ are said to form a time invariant system.
3	**Define casual system. [*N/D15*] BTL1** If the value of the output $Y(t)$ at $t = t_1$ depends only on the past values of the input $X(t)$, $t \le t_1$ (ie) $Y(t_1) = f[X(t); t \le t_1]$, then the system is called a casual system.
4	**When a system is said to be stable? BTL5** A linear time invariant system, $y(t) = f[x(t)]$ is said to be stable if its response to any bounded input is bounded.
5	**Prove that $Y(t) = 2X(t)$ is linear. [*A/M15*] BTL5** Let $Y_1(t) = 2X_1(t)$ and $Y_2(t) = 2X_2(t)$ If the input $X(t) = a_1 X_1(t) + a_2 X_2(t)$, then $Y(t) = 2(a_1 X_1(t) + a_2 X_2(t)) = 2a_1 X_1(t) + 2a_2 X_2(t) = a_1(2X_1(t)) + a_2(2X_2(t))$ $Y(t) = a_1 Y_1(t) + a_2 Y_2(t)$. Hence $Y(t) = 2X(t)$ is linear.
6	**Check whether the system $Y(t) = X^3(t)$ is linear or not. [N/D15,A/M17,*A/M17*] BTL5** Let $Y_1(t) = X_1^3(t)$ and $Y_2(t) = X_2^3(t)$ If the input $X(t) = a_1 X_1(t) + a_2 X_2(t)$, then $Y(t) = (a_1 X_1(t) + a_2 X_2(t))^3 = a_1^3 X_1^3(t) + 3a_1^2 a_2 X_1^2(t) X_2(t) + 3a_1 a_2^2 X_1(t) X_2^2(t) + a_2^3 X_2^3(t)$ $Y(t) \ne a_1 Y_1(t) + a_2 Y_2(t)$. Hence $Y(t) = X^3(t)$ is not linear.
7	**State the properties of linear system. [N/D11] BTL1** The properties of linear system are (i) If a system is such that its input $X(t)$ and its output $Y(t)$ are related by a convolution integral, then the system is a linear time invariant system. (ii) If the input to a time-invariant, stable linear system is a WSS process, the output will also be a WSS process. (iii) The power spectral densities of the input and output processes in the system are connected by the relation $S_{YY}(\omega) = \lvert H(\omega)\rvert^2 S_{XX}(\omega)$, where $H(\omega)$ is the Fourier transform of unit impulse response function $h(t)$.
8	**Define system weighting function. BTL1** If the output $Y(t)$ of a system is expressed as the convolution of the input $X(t)$ and a function

	$h(t)$(ie) $Y(t) = \int_{-\infty}^{\infty} h(u) X(t-u) du$, then $h(t)$ is called the system weighting function.
9	**Prove that the mean of the output process is the convolution of the mean of the input process and the impulse response.[*A/M18*] BTL5** The output $Y(t)$ is expressed as a convolution of the input $X(t)$ with a system weighting function $h(t)$. i.e. the input-output relationship will be of the form $Y(t) = X(t) * h(t)$. Hence, the mean of the output process is $E[Y(t)] = E[X(t)] * h(t)$ (i.e) the convolution of the mean of the input process and the impulse response.
10	**State the relation between input and output of a linear time invariant system. [*A/M15*] BTL1** The output $Y(t)$ is expressed as a convolution of the input $X(t)$ with a system weighting function $h(t)$. i.e. the input-output relationship will be of the form $Y(t) = \int_{-\infty}^{\infty} h(u) X(t-u) du$.
11	**What is unit impulse response of a system? Why is it called so? [M/J12, N/D17] BTL5** If a system $Y(t) = \int_{-\infty}^{\infty} h(u) X(t-u) du$, then the system weighting function $h(t)$ is also called unit impulse response of the system. It is called so because the response (output) $Y(t)$ will be $h(t)$, when the input $X(t)$= the unit impulse function $\delta(t)$.
12	**Prove that if the input of a system is the unit impulse function then the output is the system wieghting function. [N/D17] BTL5** If the input of a linear system is a Gaussian random process, then the output will also be a Gaussian random process.
13	**If the input $X(t)$ of the system $Y(t) = \int_{-\infty}^{\infty} h(u) X(t-u) du$ is the unit impulse function, prove that $Y(t) = h(t)$. BTL5** Given $Y(t) = \int_{-\infty}^{\infty} h(u) X(t-u) du$ Put $X(t) = \delta(t)$ Therefore , $X(t-u) = \delta(t-u)$ $Y(t) = \int_{-\infty}^{\infty} h(u) \delta(t-u) du$ $Y(t) = \int_{-\infty}^{\infty} h(t-u) \delta(u) du$ (By the property of convolution) $Y(t) = h(t-o) = h(t)$.

14	**If a system is defined as $Y(t)=\frac{1}{T}\int_0^{\infty} X(t-u)e^{-\frac{u}{T}}du$, find its unit impulse function. BTL4** Given $Y(t)=\frac{1}{T}\int_0^{\infty} X(t-u)e^{-\frac{u}{T}}du$ $Y(t)=\int_0^{\infty}\frac{1}{T}e^{-\frac{u}{T}}X(t-u)du$ Unit impulse function is given by $h(t)=\begin{cases}\frac{1}{T}e^{-\frac{t}{T}} & , t\geq 0\\ 0 & , elsewhere\end{cases}$.
15	**If $\{X(t)\}$ and $\{Y(t)\}$ in the system $Y(t)=\int_{-\infty}^{\infty} h(u)X(t-u)du$ are WSS processes, how are their autocorrelation functions related? [N/D11] BTL4** The autocorrelation functions are related as $R_{YY}(\tau)=R_{XY}(\tau)*h(\tau)$ (or) $R_{XY}(\tau)=R_{XX}(\tau)*h(-\tau)$ where $*$ denotes convolution.
16	**If the input and output of the system $Y(t)=\int_{-\infty}^{\infty} h(u)X(t-u)du$ are WSS processes, how are their power spectral densities related? BTL5** The power spectral densities are related as $S_{YY}(\omega)=S_{XX}(\omega)\lvert H(\omega)\rvert^2$ where $H(\omega)$ is the Fourier transform of $h(t)$.
17	**Define the power transfer function or system function of the system. [*N/D15*] BTL5** The power transfer function or system function of the system is the Fourier transform of the unit impulse response function of the system.
18	**If the system has the impulse response $h(t)=\begin{cases}\frac{1}{2c} & for\ \lvert t\rvert\leq c\\ 0 & , for\ \lvert t\rvert > c\end{cases}$. Write down the relation between the spectrums of input $X(t)$ and output $Y(t)$. [*May2019*] BTL4** $H(\omega)=F[h(t)]$ $=\int_{-\infty}^{\infty} h(t)e^{-i\omega t}dt$ $=\int_{-c}^{c}\frac{1}{2c}e^{-i\omega t}dt=\frac{1}{2c}\int_{-c}^{c}(\cos\omega t-i\sin\omega t)dt$ $=\frac{1}{2c}\int_{-c}^{c}\cos\omega t\,dt-i\,\frac{1}{2c}\int_{-c}^{c}\sin\omega t\,dt$

	$= \frac{1}{2c}\, 2\int_0^c \cos\omega t\, dt - i\,\frac{1}{2c}(0)$ [since the first integrand is an even function and second integrand is an odd function] $= \frac{1}{c}\left[\frac{\sin\omega t}{\omega}\right]_0^c = \frac{1}{\omega c}\left[\sin c\omega - 0\right] = \frac{\sin c\omega}{c\omega}$ $S_{YY}(\omega) = \lvert H(\omega)\rvert^2 S_{XX}(\omega) \quad \Rightarrow \quad S_{YY}(\omega) = \frac{\sin^2 c\omega}{c^2\omega^2} S_{XX}(\omega).$
19	**Find the system transfer function, if a linear time invariant system has an impulse function** $H(t) = \begin{cases} \frac{1}{2c} & ; \lvert t\rvert \le c \\ 0 & ; \lvert t\rvert \ge c \end{cases}$ **. [A/M11, N/D12] BTL5** $System\ transfer\ function = H(\omega) = F\left[H(t)\right] = \int_{-\infty}^{\infty} H(t) e^{-i\omega t}\, dt = \int_{-c}^{c} \frac{1}{2c} e^{-i\omega t}\, dt$ $= \frac{1}{2c}\int_{-c}^{c} (\cos\omega t - i\sin\omega t) dt = \frac{1}{2c}\int_{-c}^{c}\cos\omega t\, dt - i\,\frac{1}{2c}\int_{-c}^{c}\sin\omega t\, dt$ $= \frac{1}{2c}\, 2\int_0^c \cos\omega t\, dt - i\,\frac{1}{2c}(0)$ [since the 1st integrand is even and 2ndintegrand is odd] $= \frac{1}{c}\left[\frac{\sin\omega t}{\omega}\right]_0^c = \frac{1}{\omega c}\left[\sin c\omega - 0\right] = \frac{\sin c\omega}{c\omega}$
20	**If the input to a linear time invariant system is white noise $\{N(t)\}$, what is power spectral density function of the output? BTL5** If the input to a linear time invariant system is white noise $\{N(t)\}$, then the power spectral density of the output $S_{YY}(\omega)$ is given by $S_{YY}(\omega) = S_{XX}(\omega)\lvert H(\omega)\rvert^2 \Rightarrow S_{YY}(\omega) = \frac{N_0}{2}\lvert H(\omega)\rvert^2$ where $\{Y(t)\}$ is the output process and $H(\omega)$ is the power transfer function.
21	**A wide sense stationary noise process $N(t)$ has an autocorrelation function $R_{NN}(\tau) = P e^{-3\lvert\tau\rvert}$,$-\infty<\tau<\infty$ with P as a constant. Find its power density spectrum. BTL4** $S_{NN}(\omega) = \int_{-\infty}^{\infty} R_{NN}(\tau) e^{-i\omega\tau}\, d\tau = \int_{-\infty}^{\infty} P e^{-3\lvert\tau\rvert} e^{-i\omega\tau}\, d\tau$ $= \int_{-\infty}^{\infty} P e^{-3\lvert\tau\rvert}(\cos\omega\tau - i\sin\omega\tau) d\tau$

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$$= P\left[\int_{-\infty}^{\infty} e^{-3|\tau|}\cos\omega\tau\,d\tau - i\int_{-\infty}^{\infty} e^{-3|\tau|}\sin\omega\tau\,d\tau\right]$$

$= P\ 2\int_{0}^{\infty} e^{-3|\tau|}\cos\omega\tau\,d\tau - P\ i\ (0)$[since the first integrand is an even function and second integrand is an odd function]

$$= 2\ P\int_{0}^{\infty} e^{-3\tau}\cos\omega\tau\,d\tau \ = 2\ P\left[\frac{e^{-3\tau}}{(-3)^2+\omega^2}\left(-3\cos\omega\tau+\omega\sin\omega\tau\right)\right]_0^{\infty}$$

$$= 2P\left[0-\frac{1}{9+\omega^2}(-3+0)\right] = \frac{6P}{9+\omega^2}.$$

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If $X(t)$ is a WSS process and if $Y(t)=\int_{-\infty}^{\infty}h(u)X(t-u)du$ then prove that $R_{XY}(\tau)=R_{XX}(\tau)*h(-\tau)$. [*A/M17*] BTL5

Given $Y(t)=\int_{-\infty}^{\infty}h(u)X(t-u)du$

$$X(t+\tau)Y(t)=\int_{-\infty}^{\infty}X(t+\tau)X(t-u)h(u)du$$

$$E\left[X(t+\tau)Y(t)\right]=\int_{-\infty}^{\infty}E\left[X(t+\tau)X(t-u)du\right]$$

$$R_{XY}(\tau)=\int_{-\infty}^{\infty}R_{XX}(\tau+u)h(u)du$$

Put $u=-\beta \quad\Rightarrow\quad du=-d\beta$

When $u=-\infty,\ \beta=\infty$

When $u=\infty,\ \beta=-\infty$

$$R_{XY}(\tau)=\int_{\infty}^{-\infty}R_{XX}(\tau-\beta)h(-\beta)(-d\beta)=-\int_{\infty}^{-\infty}R_{XX}(\tau-\beta)h(-\beta)d\beta$$

$$=\int_{-\infty}^{\infty}R_{XX}(\tau-\beta)h(-\beta)d\beta=\int_{-\infty}^{\infty}R_{XX}(\tau-u)h(-u)du=R_{XX}(\tau)*h(-\tau)$$

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Define Time invariant system. (Apr/May 2019)BTL1

Let $\boldsymbol{y(t)=f[x(t)]}$. If $\boldsymbol{y(t+h)=f[x(t+h)]}$then 'f' is called a time variant system or x(t) and y(t) are said to form a time invariant system.

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Define memoryless system. BTL1

If the value of the output y(t) at t = t_0 depends only on the past values of the input x(t), t ≤ t_0 i.e., if $\mathbf{y(t0)}\ =\ \mathbf{f[x(t)\colon t\le t_0]}$ then such a system is called a casual system.

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25	**Define stable system.** BTL1 A linear time invariant system is said to be stable if its response to any bounded input is bounded.
	PART*B
1	**Show that if $\{X(t)\}$ is a WSS process, then the output $\{Y(t)\}$ is a WSS process. Also find $R_{XY}(\tau)$. [N/D10,N/D11,N/D12,M/J13,M/J14,A/M15,*A/M15*,N/D16,*N/D16*,A/M17] BTL5** **Answer:Page: 5.6,5,7-Dr.A. Singaravelu** • $y(t) = \int_{-\infty}^{\infty} h(u)x\,(t-u)du$ (2M) • $Ryy(t, t+\tau) = g(\tau)\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} h(u_1)h(u_2)du_1du_2$ (6M)
2	**If a system is connected by a convolution integral $Y(t) = \int_{-\infty}^{\infty} h(u)X(t-u)du$ where $X(t)$ is the input and $Y(t)$ is the output then prove that the system is a linear time invariant system. [*A/M17*] BTL5** **Answer:Page: 5.5-Dr.A. Singaravelu** • $y(t) = a_1y_1(t) + a_2y_2(t)$ (4M) • $y(t) = y(t+h)$ (4M)
3	**For a linear system with random input $x(t)$, the impulse response $h(t)$ and output $y(t)$, obtain the cross correlation function $R_{XY}(\tau)$ and the output autocorrelation function $R_{YY}(\tau)$ BTL4** **Answer:Page: 5.7-Dr.A. Singaravelu** • $y(t) = \int_{-\infty}^{\infty} h(u)x(t-u)du$ (2M) • $Rxy(\tau) = Rxx(\tau) * h(\tau)$ (3M) • $Ryy(\tau) = Rxx(\tau) * h(-\tau)$ (3M)
4	**For a linear system with random input $x(t)$, the impulse response $h(t)$ and output $y(t)$, obtain the power spectrum $S_{YY}(\omega)$ and cross power spectrum $S_{XY}(\omega)$. BTL4** **Answer:Page: 5.9-Dr.A. Singaravelu** • $y(t) = \int_{-\infty}^{\infty} h(u)x(t-u)du$ (2M) • $Sxy(w) = Sxx(w)\,H(w)$ (4M) • $Syy(w) = Sxx(w)\,\|H(w)\|^2$ (2M)

5	**Let $X(t)$ be a WSS process which is the input to a linear time invariant system with unit impulse $h(t)$ and output $Y(t)$, then prove that $S_{YY}(\omega)=\lvert H(\omega)\rvert^2 S_{XX}(\omega)$. [N/D11 , M/J13,A/M15,*A/M15* , M/J16,*N/D16*,*A/M17*,*A/M18*] BTL5** **Answer:Page: 5.9-Dr.A. Singaravelu** • $Rxy(\tau) = Rxx(\tau) * h(\tau)$ (5M) • $S_{XY}(\omega)=S_{XX}(\omega)H^*(\omega)$ (6M) • $Syy(w) = Sxx(w)\,\lvert H(w)\rvert^2$ (5M)
6	**If $\{X(t)\}$ is a WSS process and if $Y(t)=\int_{-\infty}^{\infty} h(u)\times X(t-u)du$, prove that** **(i)** $R_{XY}(\tau)=R_{XX}(\tau)*h(-\tau)$ **(ii)** $R_{YY}(\tau)=R_{XY}(\tau)*h(\tau)$ **where * denotes convolution** **(iii)** $S_{XY}(\omega)=S_{XX}(\omega)H^*(\omega)$ **where** $H*(\omega)$ **is the complex conjugate of** $H(\omega)$ **(iv)** $S_{YY}(\omega)=S_{XX}(\omega)\lvert H(\omega)\rvert^2$. **[*N/D15*,*N/D17*,N/D17] BTL5** **Answer:Page: 5.6,5.9-Dr.A. Singaravelu** • $Rxy(\tau) = Rxx(\tau) * h(\tau)$ (5M) • $Sxy(w) = Sxx(w)\,H(w)$ (6M) • $Syy(w) = Sxx(w)\,\lvert H(w)\rvert^2$ (5M)
7	**A system has an impulse response function $h(t)=e^{-\beta t}u(t)$, find the power spectral density of the output $Y(t)$ corresponding to the input $X(t)$.** **[N/D10,12,M/J14,M/J16,*M/J16*,*N/D17*,*Apr/May2019*]** **TL5** **Answer:Page: 5.23-Dr.A. Singaravelu** • $H(w) = \int_{-\infty}^{\infty} h(t)e^{-iwt}\,dt$ (2M) • $\lvert H(w)\rvert^2 = \frac{1}{B^2+W^2}$ (2M) • $Syy(w) = \frac{1}{B^2+W^2}\,Sxx(w)$ (4M)
8	**. A linear time invariant system has an impulse response $h(t)=e^{-\beta t}u(t)$. Find the output auto correlation function $R_{YY}(\tau)$ corresponding to an input $X(t)$. [N/D15,*N/D16*] BTL4** **Answer:Page: 5.23-Dr.A. Singaravelu** • $\lvert H(w)\rvert^2 = \frac{1}{B^2+W^2}$ (3M) • $Syy(w) = \frac{1}{B^2+W^2}\,Sxx(w)$ (3M) • $Ryy(\tau) = F^{-1}\,[Syy(w)]$ (2M)

9	**A circuit has an impulse response given by** $h(t)=\begin{cases}\frac{1}{T}\end{cases}, 0\le t\le T$ **. Express** $S_{YY}(\omega)$ **in terms of** $S_{XX}(\omega)$**. [*A/M15*,N/D15, *M/J16*] BTL5** **Answer:Page: 5.21-Dr.A. Singaravelu** • $H(w)=\frac{1}{TW}[\sin w\tau - i(1-\cos w\tau)]$ (2M) • $\lvert H(w)\rvert^2=\frac{4}{T^2W^2}\, sin^2\left(\frac{WT}{2}\right)$ (1M) • $Syy(w)=\lvert H(w)\rvert^2\ Sxx(w)$ (1M) $=\left(\frac{\sin\frac{WT}{2}}{\frac{WT}{2}}\right)^2\ Sxx(w)$ (4M)
10	**Given** $R_{XX}(\tau)=Ae^{-\alpha\lvert\tau\rvert}$ **and** $h(t)=e^{-\beta t}u(t)$ **where** $u(t)=\begin{cases}1\,;\,t\ge 0\\0\,;\,otherwise\end{cases}$ **. Find the spectral density of the output** $Y(t)$**. [*Apr/May2019*] BTL4** **Answer:Page: 1.80-Dr.A. Singaravelu** • $\lvert H(w)\rvert^2=\frac{1}{B^2+W^2}$ (2M) • $Sxx(w)=\frac{2\alpha}{\alpha^2+W^2}$ (3M) • $Syy(w)=\frac{1}{B^2+W^2}\,\frac{2\alpha}{\alpha^2+W^2}$ (3M)
11	**A random process** $X(t)$ **is the input to a linear system whose impulse function is** $h(t)=2e^{-t};t\ge 0$**. The autocorrelation function of the process is** $R_{XX}(\tau)=e^{-2\lvert\tau\rvert}$**. Find the power spectral density of the output process** $Y(t)$**. [M/J13,*Nov/Dec2019*] BTL4** **Answer:Page: 5.26-Dr.A. Singaravelu** • $\lvert H(w)\rvert^2=\frac{4}{W^2+1}$ (2M) • $Sxx(w)=\frac{4}{4+W^2}$ (3M) • $Syy(w)=\frac{16}{(w^2+1)(w^2+4)}$ (3M)
12	**A random process** $X(t)$ **with** $R_{XX}(\tau)=e^{-2\lvert\tau\rvert}$ **is the input to a linear system whose impulse response is** $h(t)=2e^{-t}, t>0$ **. Find the cross correlation coefficient** $R_{XY}(\tau)$ **between the input process** $X(t)$ **and output process** $Y(t)$**. [A/M15,*A/M18*] BTL4**

	Answer:Page: 5.15-Dr.A. Singaravelu • $\lvert H(w)\rvert^2 = \frac{4}{W^2+1}$ (2M) • $Sxx(w) = \frac{4}{4+W^2}$ (3M) • $Syy(w) = \frac{16}{(w^2+1)(w^2+4)}$ (3M)
13	**. $X(t)$ is the input voltage to a circuit (system) and $Y(t)$ is the output voltage. $\{X(t)\}$ is a stationary random process with $\mu_x = 0$ and $R_{XX}(\tau) = e^{-\alpha\lvert\tau\rvert}$. Find μ_y , $S_{YY}(\omega)$ and $R_{YY}(\tau)$ if the power transfer function is $H(\omega) = \frac{R}{R+iL\omega}$.[N/D13, M/J14,A/M17,*N/D17*] BTL4** **Answer:Page: 5.16-Dr.A. Singaravelu** • $Sxx(w) = \frac{2\alpha}{\alpha^2+W^2}$ (4M) • $E(y) = 0$ (2M) • $Syy(w) = \left(\frac{2\alpha}{\alpha^2+w^2}\right).\frac{R^2}{R^2+W^2}$ (5M) • $Ryy(\tau) = \frac{\lambda}{2\alpha}\, e^{-\alpha\lvert\tau\rvert} + \frac{\mu}{2}\left(\frac{L}{R}\right) e^{-\frac{R}{L}\lvert\tau\rvert}$ (5M)
14	**. Consider a White Gaussian noise of zero mean and power spectral density $\frac{N_0}{2}$ applied to a low pass RC filter whose transfer function $H(f) = \frac{1}{1+i\,2\pi fRC}$. Find the autocorrelation function of the output random process. Also find the mean square value of the output process. [Nov/Dec2019] BTL4** **Answer:Page: 5.32-Dr.A. Singaravelu** • $Syy(w) = \frac{NO\,\beta^2}{2(\beta^2+w^2)}$ (3M) • $Ryy(\tau) = \frac{NO\beta}{4}\, e^{-\beta\lvert\tau\rvert}$ (3M) • $E(y^2(t)] = Ryy(0) = \frac{NO\beta}{4}$ (2M)
15	**. Assume a random process $X(t)$ is given as input to a system with transfer function $H(\omega) = 1$ for $-\omega_0 < \omega < \omega_0$. If the autocorrelation function of the input process is $\frac{N_0}{2}\delta(\tau)$, find the autocorrelation function of the output process. [A/M10, *M/J16*] BTL4**

	Answer:Page: 5.31-Dr.A. Singaravelu • $Sxx(w) = \frac{NO}{2}$ (2M) • $Syy(w) = \frac{NO}{2}$ (3M) • $Ryy(\tau) = \frac{NO.\sin(wo\tau)}{2\pi\tau}$ (3M)
16	**If $X(t)$ is the input voltage to a circuit and $Y(t)$ is the output voltage. $\{X(t)\}$ is a stationary random process with $\mu_X = 0$ and $R_{XX}(\tau) = e^{-2\|\tau\|}$. Find the mean μ_Y and power spectrum $S_{YY}(\omega)$ of the output if the system transfer function is given by $H(\omega) = \frac{1}{\omega + 2i}$.** **[N/D10,Nov/Dec2019] BTL4** **Answer:Page: 5.16-Dr.A. Singaravelu** • $E(y) = 0$ (1M) • $Sxx(w) = \frac{4}{w^2+4}$ (3M) • $Syy(w) = \frac{4}{(w^2+4)^2}$ (4M)
17	**A linear system is described by the impulse response $h(t) = \frac{1}{RC} e^{-\frac{t}{RC}} u(t)$. Assume an input process whose autocorrelation is $B\delta(\tau)$. Find the mean and autocorrelation function of the output process. [A/M11,N/D14,*A/M17*] BTL4** **Answer:Page: 5.33-Dr.A. Singaravelu** • $\|H(w)\|^2 = \frac{\beta^2}{\beta^2 + w^2}$ (2M) • $E[y(t)] = 0$ (1M) • $Syy(w) = \frac{\beta^2}{\beta^2 + w^2} .\beta$ (2M) • $Ryy(\tau) = \frac{\beta}{2RC} e^{-\frac{\|\tau\|}{RC}}, -\infty \le \tau \le \infty$ (3M)
18	**If $\{N(t)\}$ is a band limited white noise centered at a carrier frequency ω_0 such that $S_{NN}(\omega) = \begin{cases} \frac{N_0}{2} & , for \|\omega - \omega_0\| < \omega_B \\ 0 & , elsewhere \end{cases}$. Find the autocorrelation of $\{N(t)\}$. [A/M11 , M/J12] BTL4**

Answer:Page: 5.36-Dr.A. Singaravelu

- $RNN(\tau) = \frac{1}{2\pi}\int_{-\infty}^{\infty} \delta NN\,(w)\,.\,e^{iw\tau}\;dw$ (2M)
- $RNN(\tau) = \frac{NOWB}{2\pi}\left(\frac{\sin wB\tau}{wB\tau}\right)\cos(wB\tau)$ (6M)

EC8452 **ELECTRONIC CIRCUITS II** **L T P C**
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OBJECTIVES:

- To give a comprehensive exposure to all types of amplifiers and oscillators constructed with discrete components. This helps to develop a strong basis for building linear and digital integrated circuits
- To study about feedback amplifiers and oscillators principles
- To design oscillators.
- To study about turned amplifier.
- To understand the analysis and design of LC and RC oscillators, amplifiers, multi vibrators, power amplifiers and DC convertors.

UNIT I - FEEDBACK AMPLIFIERS AND STABILITY **9**

Feedback Concepts – gain with feedback – effect of feedback on gain stability, distortion, bandwidth, input and output impedances; topologies of feedback amplifiers – analysis of series-series, shunt-shunt and shunt-series feedback amplifiers-stability problem-Gain and Phase-margins-Frequency compensation.

UNIT II - OSCILLATORS **9**

Barkhausen criterion for oscillation – phase shift, Wien bridge - Hartley & Colpitt‘s oscillators – Clapp oscillator-Ring oscillators and crystal oscillators – oscillator amplitude stabilization.

UNIT III - TUNED AMPLIFIERS **9**

Coil losses, unloaded and loaded Q of tank circuits, small signal tuned amplifiers –Analysis of capacitor coupled single tuned amplifier – double tuned amplifier - effect of cascading single tuned and double tuned amplifiers on bandwidth – Stagger tuned amplifiers - Stability of tuned amplifiers – Neutralization - Hazeltine neutralization method.

UNIT IV WAVE SHAPING AND MULTIVIBRATOR CIRCUITS **9**

Pulse circuits – attenuators – RC integrator and differentiator circuits – diode clampers and clippers –Multivibrators - Schmitt Trigger- UJT Oscillator.

UNIT V POWER AMPLIFIERS AND DC CONVERTERS **9**

Power amplifiers- class A-Class B-Class AB-Class C-Power MOSFET-Temperature Effect- Class AB Power amplifier using MOSFET –DC/DC convertors – Buck, Boost, Buck-Boost analysis and design

TOTAL: 45 PERIODS

OUTCOMES:

After studying this course, the student should be able to:

- Analyze different types of amplifier, oscillator and multivibrator circuits
- Design BJT amplifier and oscillator circuits
- Analyze transistorized amplifier and oscillator circuits
- Design and analyze feedback amplifiers
- Design LC and RC oscillators, tuned amplifiers, wave shaping circuits, multivibrators, power amplifier and DC convertors.

TEXT BOOKS:

1. Sedra and Smith, ―Micro Electronic Circuits‖; Sixth Edition, Oxford University Press, 2011. (UNIT I, III, IV, V)
2. Jacob Millman, ‗Microelectronics ‘, McGraw Hill, 2nd Edition, Reprinted, 2009. (UNIT I, II, IV, V)

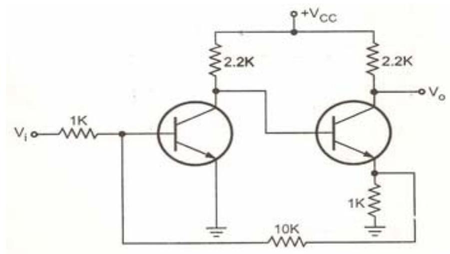
REFERENCES

1. Robert L. Boylestad and Louis Nasheresky, ―Electronic Devices and Circuit Theory‖, 10th Edition, Pearson Education / PHI, 2008.
2. David A. Bell, ―Electronic Devices and Circuits‖, Fifth Edition, Oxford University Press, 2008.
3. Millman J. and Taub H., ―Pulse Digital and Switching Waveforms‖, TMH, 2000.
4. Millman and Halkias. C., Integrated Electronics, TMH, 2007.

Subject Code: EC8452 **Year/Semester: II /04**
Subject Name: ELECTRONIC CIRCUITS II **Subject Handler: Dr.R.Thandaiah Prabu**

UNIT I-FEEDBACK AMPLIFIERS AND STABILITY	
Feedback Concepts – gain with feedback – effect of feedback on gain stability, distortion, bandwidth, input and output impedances; topologies of feedback amplifiers – analysis of series-series, shunt-shunt and shunt-series feedback amplifiers-stability problem-Gain and Phase-margins-Frequency compensation.	
PART * A	
Q.No.	**Questions**
1.	**Define feedback and its types.** BTL1 A portion of the output signal is taken from the output of the amplifier and is combined with the normal input signal. This is known as feedback. There are two types Positive Feedback If the feedback signal is in phase with input signal, then the net effect of the feedback will increase the input signal given to the amplifier. This type of feedback is said to be positive or regenerative feedback. Negative Feedback If the feedback signal is out of phase with the input signal then the input voltage applied to the basic amplifier is decreased and correspondingly the output is decreased. This type of feedback is known as negative or degenerative feedback.
2	**List the different types of feedback topologies. (Nov 2011)** BTL1 • Voltage – series feedback topology • Voltage – shunt feedback topology • Current – series feedback topology • Current – shunt feedback topology.
3	**What are the effects of negative feedback? (Or) What are the advantages and disadvantages of negative feedback? (Nov 2012, Nov 2016)** BTL1 Advantages: • It improves the stability of the circuit. • It improves the frequency response of the amplifier. • It improves the percentage of harmonic distortion. • It improves the signal to noise ratio (SNR). • It reduces the gain of the circuit. Disadvantages: • Reduced circuit overall gain. • Reduced stability at high frequency.
4	**Define positive feedback.** BTL1 If the feedback signal is in phase with input signals, then the net effect of the feedback will increase the input signal given to the amplifier. This type of feedback is said to be positive or regenerative feedback.

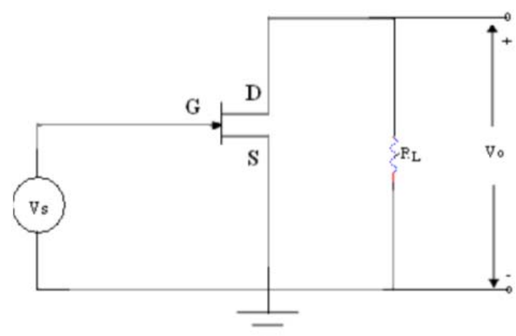
5	**What is Node and Loop Sampling?** BTL1 **Node Sampling:** When the output voltage is sampled by connecting the feedback network in shunt across the output, the connection is referred to as Voltage or Node Sampling. **Loop Sampling:** When the output voltage is sampled by connecting the feedback network in series across the output, the connection is referred to as Current or Loop Sampling.
6	**Define Frequency compensation and its types. (Apr/ May 2019)** BTL1 If the feedback amplifier has more than two poles, it can be unstable. The technique is used to make unstable feedback amplifier to stable is called Frequency compensation. There are two types, • Dominant pole compensation: In this compensation technique if dominant pole is introduced into the amplifier so that phase shift is less than -1800 when the loop gain is unity. • Miller compensation: It is implemented by connecting a capacitor between input and output of a gain stages of a multistage amplifier.
7	**What is the nature of input and output resistance in negative feedback?** BTL1 Voltage series feedback: Input impedance: Zif = Zi * (1+A β) Output impedance: Zof = Zo / (1+Aβ) Voltage shunt feedback: Input impedance: Rif = Ri * (1+A β) Output impedance: Zof = Zo * (1+ A β) Current series feedback: Input impedance: Rif = Zi / (1+A β) Output impedance: Zof = Zo / (1+A β) Current shunt feedback: Input impedance: Rif = Ri / (1+A β) Output impedance: Rof = Ro * (1+A β)
8	**Mention the three basic networks that are connected around the basic amplifier to implement feedback concept. (NOV/DEC'12)** BTL2 • Mixing Network • Sampling Network • Feedback Network
9	**What is the purpose of mixer network in feedback amplifier?** BTL1 The mixer network is used to combine feedback signal and input at input of an amplifier.
10	**Define Sensitivity and Desensitivity of gain in feedback amplifiers. (April 2011)** BTL1 Sensitivity: The fractional change in amplification with feedback divided by the fractional change in amplification without feedback is called the sensitivity of the transfer gain. Desensitivity: Desensitivity is defined as the reciprocal of sensitivity. It indicates the factor by which the voltage gain has been reduced due to feedback network. Desensitivity factor D = 1+A β. Where A = Amplifier gain and β = Feedback factor.
11	**State the Nyquist criterion for stability of feedback amplifiers.** BTL1 • The amplifier is unstable if the curve encloses the point -1+j0. The system is called as unstable system. • The amplifier is stable if the curve encloses the point -1+jo. That system is called as stable system.

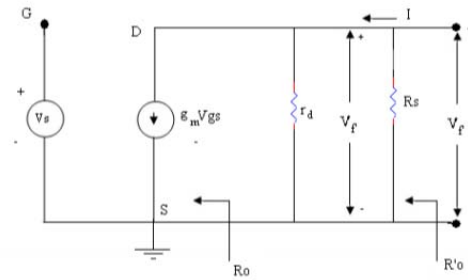
12	**Identify the topology for the circuit drawn in Fig.** BTL3  $V_o = 0$, does not make feedback zero, $I_o = 0$ makes feedback zero; Feedback is fed in shunt with input signal so its **Current shunt feedback.**
13	**The voltage gain of an amplifier without feedback is 60 dB and decreases to 40 dB with feedback. Determine the feedback factor of the feedback network.** BTL5 From $A_{vf} = \frac{A_v}{1+\beta A_v}$ $\beta = \frac{A_v - A_{vf}}{A_v A_{vf}} = \frac{60-40}{60x40} = 8.33x10^{-3}$
14	**Give the expression for gain of an amplifier with feedback.** BTL1 Avf = AV/ 1+ AV β Where, Avf – feedback voltage gain. AV – Voltage gain. β - Feedback factor
15	**What is loop gain or return ratio?** BTL1 A path of a signal from input terminals through basic amplifier, through the feedback network and back to the input terminals forms a loop. The gain of this loop is the product -A β . This gain is known as loop gain or return ratio.
16	**What is the effect of negative feedback on bandwidth?** BTL1 Bandwidth of amplifier with feedback is greater than bandwidth of amplifier without feedback.
17	**Why gain bandwidth product remains constant with the introduction of negative feedback?** BTL1 Since bandwidth with negative feedback increases by factor (1+A β) and gain decreases by same factor, the gain-bandwidth product of an amplifier does not alter, when negative feedback is introduced.
18	**A feedback amplifier has an open loop gain of 600 and feedback factor β = 0.01. Find the closed loop gain with feedback.** BTL1 Avf = AV/ 1+ AV β = 600/ (1+ 600*0.01) = 85.714.
19	**The distortion in an amplifier is found to be 3%, when the feedback ratio of negative feedback amplifier is 0.04. When the feedback is removed, the distortion becomes 15%. Find the open and closed loop gain.** BTL5 Solution: Given: β = 0.04 Distortion with feedback = 3%, Distortion without feedback = 15% D = 15/3 = 5: Where D = 1+A β =5

20	**Voltage gain of an amplifier without feedback is 60dB. It decreases to 40dB with feedback. Calculate the feedback factor.** BTL5 Solution: Given: $A_v = 60dB$ and $A_{vf} = 40$ dB. We know that, $A_{vf} = AV / 1+ AV\beta$ $\beta = (AV- A_{vf}) / (AVA_{vf})$ $= (60-40) / (60*40)$ $\beta = 0.00833$.
21	**What is Nyquist diagram?** BTL1 The plot which shows the relationship between gain and phase-shift as a function of frequency is called as Nyquist diagram.

22	**Write the steps which are used to identify the method of feedback topology.** BTL1
	• Identify topology (type of feedback)
	    o To find the type of sampling network.
	    o To find the type of mixing network
	• Find the input circuit.
	• Find the output circuit.
	• Replace each active device by its h-parameter model at low frequency.
	• Find the open loop gain (gain without feedback), A of the amplifier.
	• Indicate X_f and X_o on the circuit and evaluate $\beta = X_f.X_O$.
	• Calculate A, and β, find D, Ai, Rif, Rof, and Rof'.

23	**What are the types of distortions in an amplifier?** BTL1 • Frequency • Noise and non-linear
24	**What is the effect of lower cut-off frequency & upper cut-off frequency with negative feedback?** BTL1 Lower cut off frequency with feedback is less than lower cut off frequency without feedback by factor $(1+A_{mid}\ \beta)$ Upper cut off frequency with feedback is greater than upper cut off frequency without feedback by factor $(1+A_{mid}\ \beta)$
25	**Define feedback factor or feedback ratio.** BTL1 The ratio of the feedback voltage to output voltage is known as feedback factor or feedback ratio.
	PART B
1	**Explain with neat diagram, the two stage voltage series feedback amplifier and determine the AV, AVf. (13M) (May 2018)** BTL2 **Answer: Page 545 - S.Salivahanan** **FET Common drain Amplifier: -** (2M) • The feedback signal - voltage V_f across R, • The sampled signal - voltage V_o across R. • To find the input circuit, set $V_o= 0$, and hence V_s appears directly between G and S. • To find the output circuit, set $I_i = 0$, and hence R appears only in the output loop. **Low – frequency model Source Follower** (3M)





FET replaced by its Small – Signal Low frequency model.

Vf = Vo ; β = Vf / Vo = 1 (2M)

This topology stabilizes voltage gain.

Without feedback Vi = Vs,

$A_v = \frac{\mu R}{r_d + R}$ (1M)

$A_{vf} = \frac{\mu R}{r_d + (1+\mu)R}$ (1M)

$R_{of} = \frac{r_d}{1+\mu}$ (2M)

$R'_{of} = \frac{r_d R}{r_d + (1+\mu)R}$ (2M)

2

Derive the expression for lower and higher cut off frequency of feedback amplifier. (13M) (Nov 2010, Apr 2010, Nov 2006, Apr/May 2019) BTL3

Answer: Page 539 - S. Salivahanan

Lower cut off frequency of feedback amplifier:

voltage gain at low frequency f L (3M)

$A_L = \frac{A_m}{1 - j\frac{fL}{f}}$

Where,

Amid = Voltage gain in mid frequency range.

f_L = Lower cut off frequency without using feedback.

After the application of feedback, (3M)

$A_{LF} = \frac{A_L}{1 - A\beta}$

$$A_{LF} = \frac{A_{mF}}{1 - j\frac{fL}{f}}$$

Where, f

L = f_L / [1 + Amid β] = Lower cut off frequency using feedback.

A_{mf} = Amid / [1 + A_Lmβ] = Mid band gain with feedback.

FL > fl i.e., the negative feedback decreases the lower cut off frequency by the factor of [1 + Amid β] .

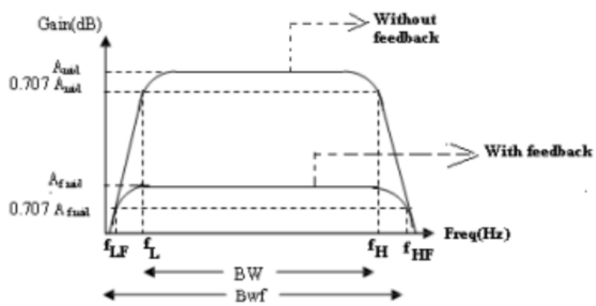
Higher cut off frequency of feedback amplifier:

Voltage gain at high frequency fL is given by (3M)

$A_H = \frac{A_m}{1 - j\frac{f}{fH}}$

Where,

Am id = Voltage gain in mid frequency range.

	f_h = upper cut off frequency without using feedback. After the negative feedback is applied, (3M) $$A_{HF} = A_H/(1 - A_H\beta)$$ $$A_{HF} = \frac{A_{mF}}{1 - j\frac{f}{fH}}$$ Where, $F_H = f_h$ [1 + Amid β] = Upper cut off frequency using feedback. A_{mf} = Amid / [1 + ALmidβ] = Mid band gain with feedback. $F_H > f_h$ i.e., Upper cut off frequency – increased- due to - negative feedback- Band width is increased. **Bandwidth Plot:** (1M) 
3	**An amplifier has a mid-band gain of 125 and a bandwidth of 250 KHZ. (a) If 4%negative feedback is introduced, find the new bandwidth and gain. (b) If the bandwidth is to be restricted to 1 MHZ, find the feedback ratio. (8M)** BTL5 **Answer: Page 544 - S. Salivahanan** **Solution**: Given A=125, BW=250KHZ & β=4%=0.04 (a) We know that, BWf = (1+Aβ) BW (4M) = (1+125 X 0.04) X 250 X 103 = 1.5MHz Gain with feedback, Af = A / 1+Aβ =125 / 1+ (125 X 0.04) Af = 20.83 (b) BWf = (1+Aβ) BW (4M) $1 * 10^6 = (1+125\beta) * 250 * 10^3$ $= (1+125\beta) = 1 * 106/250 * 10^3$ β = 3/125 = 0.024 β = 2.4%
4	**Sketch the block diagram of a feedback amplifier, and derive the expressions for gain with positive feedback and negative feedback. (9M) (May 2017, Apr/ May 2019).** BTL3 **Answer: Page 532 - S. Salivahanan** **Introduction**: (2M) • The input signal = Xs • The output signal = Xo = A Xi • Feedback signal = Xf = β Xo • Difference signal = Xd = Xs-X f =Xi • Gain of the amplifier without feedback A = Xo / Xi • The feedback factor = β = Xf / Xo

- Input signal applied to the amplifier is, Xi = Output of the mixer or summer.

  Xi = Xs + Xf

Negative feedback: (2M)

Af = Xo / Xs

= A Xi / Xi [1 + A β]

= A / [1 + A β]

'-+ve' sign for positive feedback i.e.,

Positive feedback: (2M)

'- ve' sign for positive feedback i.e.,

Af = A / [1 - A β]

The denominator term '1 - A β' - as "Desensitivity factor".

Negative feedback - '1 + A β'.

Positive feedback - '1 - A β'.

Block Diagram: (3M)

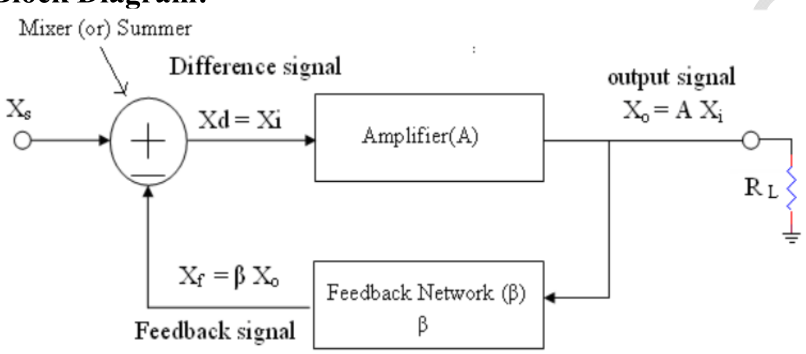


Fig (a)

5 **An amplifier has a voltage gain of 400, f1=50HZ, f2=200KHZ and a distortion of 10% without feedback determine the amplifier voltage gain, f1f , f2f and Df when a negative feedback is applied with feedback ratio of 0.01. (8M)** BTL5

Answer: Page 544 - S. Salivahanan

Solution: Given: A=400, f1=50HZ, f2=200KHZ, D=10%, β= 0.01

We know that, voltage gain with feedback (2M)

A_f = A / 1+Aβ = 400 / 1 + 400 X 0.01 = 80

New lower 3db frequency, (2M)

$F_{1f} = f_l/1+A\beta$ = 50 / 1+400 X 0.01 = 10Hz

New upper 3db frequency, (2M)

$F_{2f} = (1+A\beta)f_2$= (1 + 400 X 0.01) X 200 X 10^3

F_{2f} = 1MHz

Distortion with feedback, D_f = D / 1+Aβ = 10 / 5 = 2% (2M)

6 **Draw the circuit of voltage series and current shunt feedback amplifier and derive the expressions for input impedance Rif. (10M) (May 2017).** BTL2

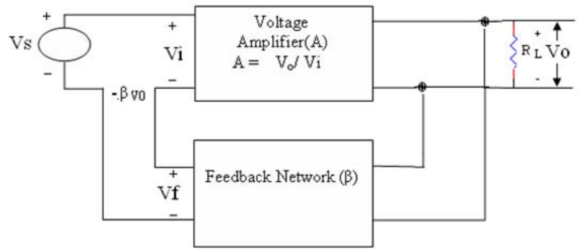
Answer: Page 545 - S. Salivahanan

Voltage series feedback connection. (or) Series – Shunt feedback: -

Output voltage is directly proportional to the input voltage, thus it is used as "Voltage amplifier".

A = Vo / Vi (or) Vo = A Vi.

Block Diagram: (2M)



Gain: (1M)

The amplifier has a gain of without feedback,
A = Vo / Vi (or) AVi= Vo.
If feedback is connected then
Vs = Vi + Vf ------------- (1)
(or) Vi = Vs – Vf
AVF = A / (1 + Aβ).
Substituting the Vf value in Eqn (1),
Vs = Vi+ β Vo.
= Vi + β A Vi. (Vo = A Vi)
Vs = (1+A β). Vi
AVF = Vo / Vs
= A Vi / (1+A β). Vi

Input Impedance:- (1M)

=Vs = Vi + Vf
= Vi + β Vo.
= Ri Ii + β Vo. (Vi = Ri Ii)
= Ri Ii + β AVi. (Vo = β Vi)
= Ri Ii + Ri Ii β A
Vs = Zi Ii [1+ A β] (Zi = Ri)
Z if = Vs / Ii
= Zi (1 + A β)
Z if = Zi (1 + A β)

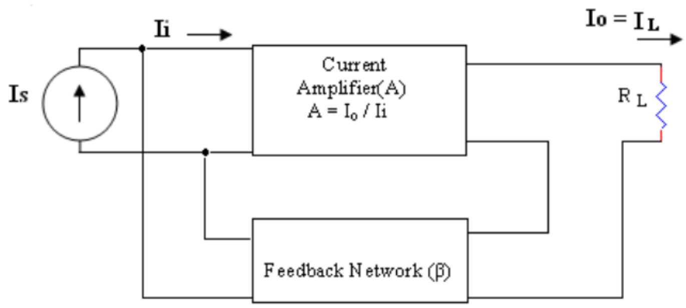
Ouput Impedance:- (1M)

Vo = I Zo + A Vi [Ro = Zo]
Vo = I Zo – A Vf
{ As we know Vi = Vs - Vf ,Vs is transferred to the output side hence Vs = 0 thus
Vi = - Vf = - β Vo }
Vo = I Zo – A β Vo
Vo + A β Vo = I Zo.
Vo [1 + A β] = I Zo
Vo /Io=Zo /1 + A β
ZOF = Zo/ 1 + A β
Zo = output impedance - without feedback.
ZOF = output impedance - with feedback.
Output impedance - reduced by a factor of (1 + A β) - output impedance of the amplifier without feedback.

Current Shunt feedback connection. (Or) Shunt Series feedback:-

Output current - directly proportional - Input current - "Current amplifier ".
i.e., A = Io / Ii (or) Io = A Ii.

Block Diagram: (2M)



Output current - parallel with the input circuit - current shunt feedback configuration.
"Current amplifier" - amplifiers - input current at the output.

Gain of the amplifier without feedback is (1M)

A = Io / Ii And β = If / Io

We know,

Is = Ii + If ; If = β Io and Io = A Ii

$$A_F = \frac{A}{1 + A\beta}$$

Input Impedance: - (1M)

$$Rif = \frac{Ri}{1 + A\beta}$$

Where, Rif = Input resistance - with feedback. Input impedance - decreased by the factor (1 + Aβ).

Output Impedance: - (1M)

We know Is = Ii + If (or) Ii = Is - If = - If

Rof = Ro [1 + Aβ] Thus the output impedance increased by (1 + Aβ)

7

Write about the Nyquist criterion for stability of feedback amplifiers. (3M) (May 2017), (Nov2012)(Apr/May 2019). BTL1

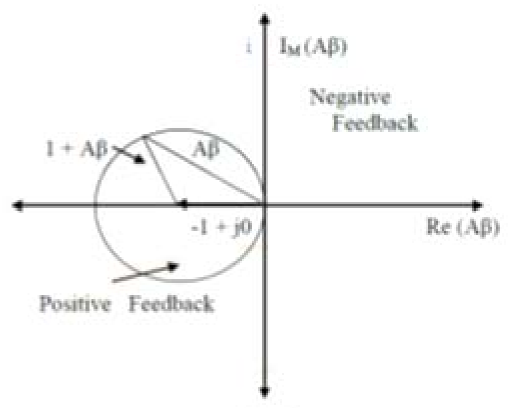
Answer: Page 537 - S. Salivahanan

- Aβ - function of frequency - points in the complex plane – obtained - for the values of Aβ corresponding - 'f' from –α to + α .
- Locus - all these points forms - closed curve.
- The criterion of Nyquist - the amplifier - unstable if this curve encloses the points -1 + j 0
- Amplifier - stable - the curve - does not enclose - this point.

Rules for stability: (2M)

- | 1 + Aβ | = 1 represents a circle - unit radius, with its center - point -1 + j0.
- If, for any frequency, Aβ extends outside this circle, - feedback - negative, since then | 1+ Aβ | > 1.
- If Aβ lies within this circle-| 1+ Aβ | < 1, - feedback - positive.
- The system - not oscillate unless Nyquist's criterion - satisfied.

Nyquist plot: (1M)



8

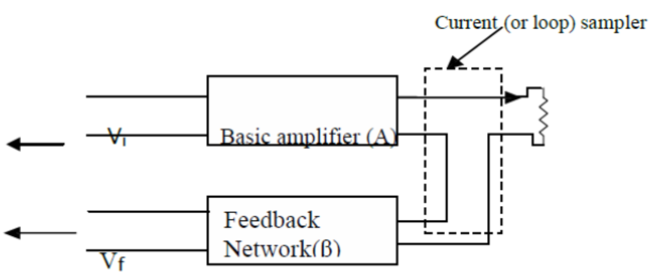
Sketch the block diagram of a feedback amplifier and derive the expression for gain
(1) With positive feedback and
(2) With negative feedback state the advantages of negative feedback (6M) (Dec 12)
BTL2

Answer: Page 532 - S. Salivahana

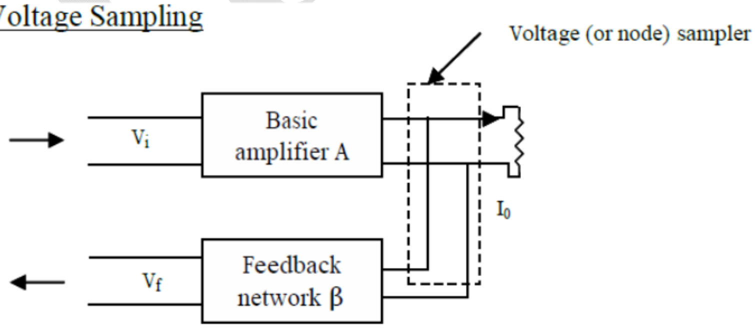
The Feedback connection has three networks.
1. Sampling network
2. Feedback network
3. Mixer network

Sampling network: (2M)

Based on the sampling signal
i. Voltage Sampling or Node sampler
ii. Current Sampling or Loop sampler



<u>Voltage Sampling</u>



Feedback Network : (2M)

$V_f = \beta V_0$; 'β' is a feedback factor or feedback ratio.
The symbol β is always lies between 0 and 1.

- **Negative feedback:**

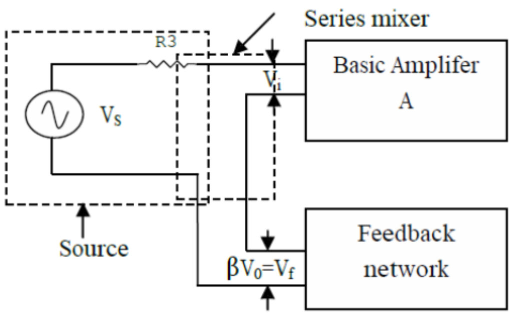
Af = Xo / Xs
= A Xi / Xi [1 + A β]
= A / [1 + A β]
'-+ve' sign for positive feedback i.e.,

- **Positive feedback:**

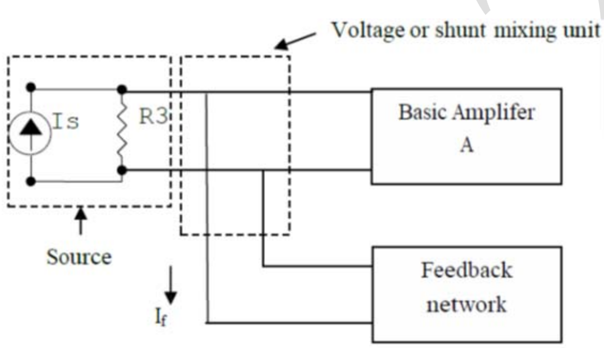
'- ve' sign for positive feedback i.e.,
Af = A / [1 - A β]
The denominator term '1 - A β' - as "desensitivity factor".
If the amplifier uses negative feedback, it is '1 + A β'.
If the amplifier uses positive feedback, it is '1 - A β'.

Mixing Network : (2M)

- **Series Mixing:**



- **Shunt Mixing:**



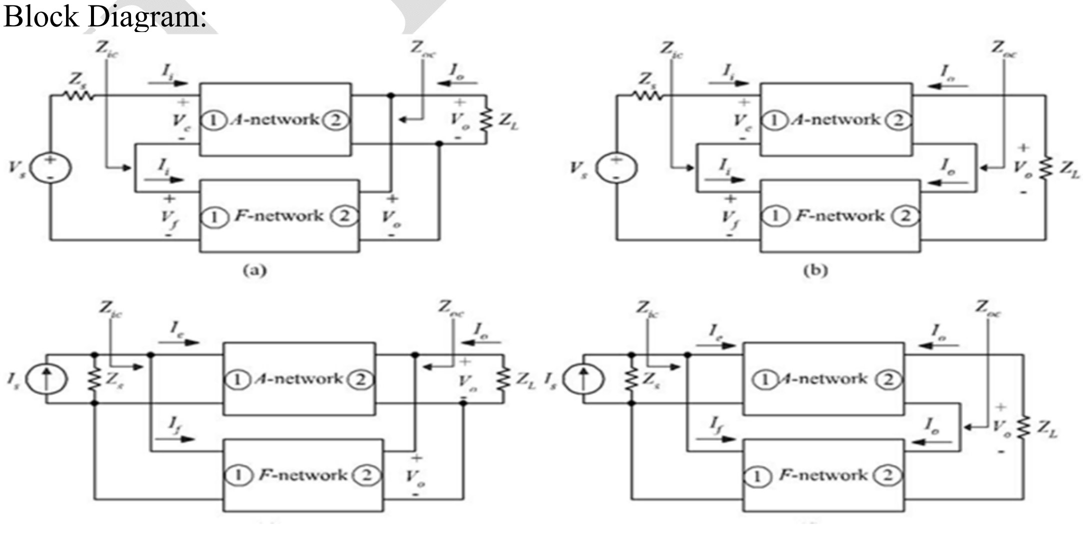
9 **A single stage transistor amplifier has a voltage gain of 600 without feedback, and 50 with feedback. Calculate the percentage of output which is feedback to the input. (6M)** BTL4

Answer: Page 538 - S. Salivahanan

Solution:

- Voltage Gain without feedback (A) = 600 (2M)
- Voltage Gain with feedback, (Af) =50 (2M)

Af = A / 1+βA
50 = 600 / 1+ (β X 600)
1+ (β X 600) = 600 / 50 = 12
600β = 11
∴β = 0.01833
∴ % of output voltage that is feedback to the input = β X 100=1.833. (2M)

<table>
<tr><td>10</td><td>
An amplifier with a negative feedback provides an output voltage of 5 volt with an input voltage of 0.2volt. On removal of feedback, it needs only 0.1V input to give the same output. Determine a. gain without feedback, b. Gain with feedback, c. Feedback ratio (6M)
Answer: Page 538 - S. Salivahanan
A=50 BTL5
Solution:
a. Gain without feedback, A= output voltage / input voltage = 5 / 0.1 (2M)
b. Gain with feedback, Af = output voltage / input voltage = 5 /0.2 (2M)
∴Af = 25
c. We know that, AF = A /1+βA (2M)
=25 / 1+25β
□=0.02
</td></tr>
<tr><td>11</td><td>
Determine the voltage gain and input impedance with feedback for a voltage series feedback having the following parameters; $A = -100$; $R_i = 10\ k\Omega$; $R_o = 20\ k\Omega$; for (i) $\beta = -0.1$; (ii) $\beta = -0.5$. (13M) BTL5
Answer: Page 552 - S. Salivahanan
$A_{vf} = \frac{A_v}{1+\beta A_v} = \frac{-100}{11} = -9.09$ (2M)
$R_{if} = R_i(1+\beta A_v) = 10x11 = 110\ k\Omega$ (2M)
$R_{of} = \frac{R_o}{1+\beta A_v} = \frac{20}{11} = 1.81\ k$ (2M)
$A_{vf} = \frac{A_v}{1+\beta A_v} = \frac{-100}{51} = -1.96$ (2M)
$R_{if} = R_i(1+\beta A_v) = 10x51 = 510\ k\Omega$ (2M)
$R_{of} = \frac{R_o}{1+\beta A_v} = \frac{20}{51} = 0.392\ k\Omega$ (3M)
</td></tr>
<tr><td></td><td>PART * C</td></tr>
<tr><td>1</td><td>
Compare all the four feedback amplifiers with neat diagrams. (15M) BTL4
Answer: Page 552 - S. Salivahanan
Block Diagram: (8M)


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</table>

	Parameters Comparison (7M)

Feedback connection	Appropriate Two-port parameter representation	Input Variable (source form)	Output variable	Transfer function stabilized	Z_{ic} Input Impedance	Z_{oc} Output Impedance
Series-Shunt	h-parameters	Voltage, V_s (Thevenin)	Voltage, V_o	(V_o/V_s) Voltage transfer function	Increases	Decreases
Series-Series	z-parameters	Voltage, V_s (Thevenin)	Current, I_o	(I_o/V_s) Transfer admittance	Increases	Increases
Shunt-Shunt	y-parameters	Current, I_s (Norton)	Voltage, V_o	(V_o/I_s) Transfer Impedance	Decreases	Decreases
Shunt-Series	g-parameters	Current, I_s (Norton)	Current, I_o	(I_o/I_s) Current transfer function	Decreases	Increases

2

Draw a single stage current series feedback amplifier and draw the basic amplifier without feedback and its equivalent circuit. Also derive for voltage gain without feedback. (13M) (Nov 2017) (or)

What is the effect of current series negative feedback on input resistance and output resistance of a BJT amplifier? Explain the same with necessary circuits, equivalent circuit and equations. (13M), (May 2017) (or)

Draw the equivalent circuit of current series feedback amplifier and explain. Also derive Rif, Rof, Av, Avf .(13M) (May2018) (Nov 2016) BTL2

Answer: Page 551- S. Salivahanan

The Common Emitter Transistor amplifier: (2M)

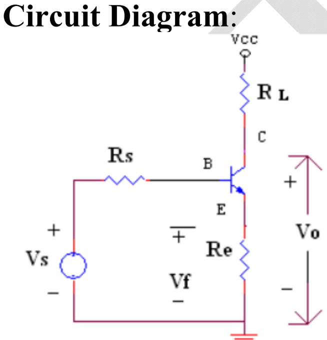
The feedback signal is the voltage Vf across Re, and the sampled signal is the load current Io.

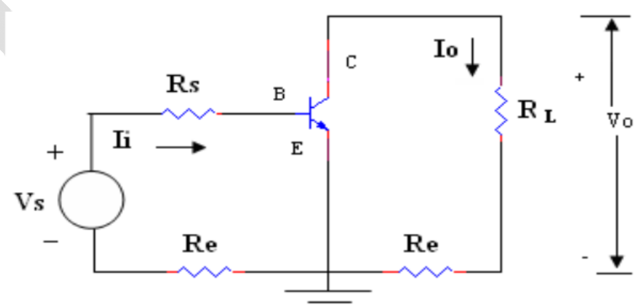
β = Vf/ Vo = -Io Re / Io*RL

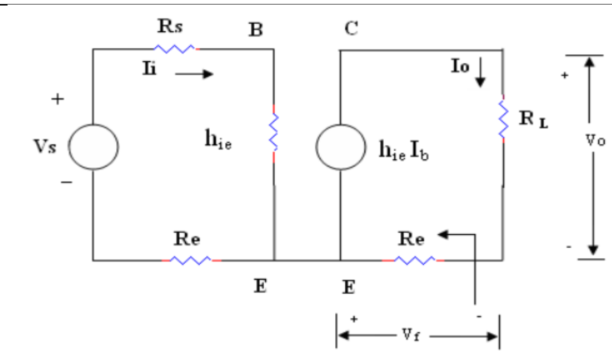
= - Re/ RL

β - function -the load RL.

Circuit Diagram: (3M)



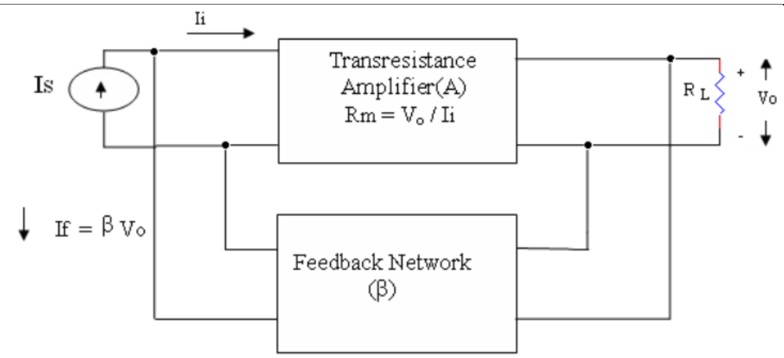




$\beta = Vf / Vo = (-Io\ Re) / Io$ (2M)
$= -Re$
Since the input signal Vi without feedback is the Vs, then
$Gm = Io/Vi = (-hfe \,.\, Ib)/ Vs$
$= -hfe /(Rs+hie+ Re)$ ----------------------------(A)
$D = 1+\beta * Gm = 1+(hfe*Re)/(Rs+hie+Re)$ (2M)
$D = [Rs + hie + (1+hfe) Re] / (Rs + hie +Re)$
$Gmf = Gm / D$
$Gmf = -hfe / [Rs + hie + (1+hfe) Re]$
If $(1+hfe)*Re >> Rs+hie$, and
Since $hfe >> 1$; then $Gmf \sim -1/Re$; $Gmf \sim 1/\beta$.

Voltage gain (2M)
$Avf = (Io*RL) / Vs = Gmf * RL = (- hfe * RL) / [Rs + hie+(1+hfe)* Re]$
$Avf \sim - RL / Re$; the voltage gain is stable if RL, Re are stable resistors.
$Ri = Rs + hie + Re$.
$Rif = Ri *D = Rs+hie+ (1+hfe) Re$. (1M)
Since $Ro = \infty$, then $Rof = Ro (1+\beta\ Gm) = \infty$. (1M)
Hence $R'of = RL \,||\, Rof = RL$.
An alternative derivation is $R'of = R'o (1+\beta\ Gm)/ (1+\beta\ GM)$
Since Gm represents the short circuit Trans conductance, then $Gm = \lim_{R\to 0} GM$
From equation (A), GM is independent of RL,
And hence $Gm = GM$ and $R'of = R'o = RL$

3 **Draw the circuits of voltage shunt and current series feedback amplifiers and derive the expression for input impedance Rif. (10M) (Dec 12)** BTL1
Answer: Page 561 - S. Salivahanan
Voltage shunt feedback connection. (or) Shunt Shunt feedback:-
Output voltage - directly proportional - Input current - “Trans resistance amplifier”.
i.e., $A = Vo / Ii$ (or) $Vo = A\ Ii$.
Block Diagram: (2M)



Voltage Gain: (1M)

A = Vo / Ii = Gain of amplifier without feedback.

β = If / Vo

Is = Ii + If

= Ii + β Vo

= Ii + β A Ii

Is = Ii(1 + A β)

Af = Vo / Is = Gain of amplifier with feedback.

$$A_F = \frac{A}{1 + A\beta}$$

Input Impedance: - (1M)

$$Zif = \frac{Zi}{1 + A\beta}$$

Output Impedance: - (1M)

$$Rof = \frac{Ro}{1 + A\beta}$$

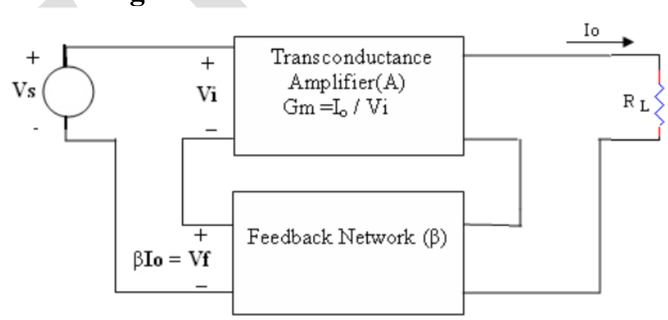
Output impedance of voltage shunt feedback - reduced - the Desensitivity factor of (1 + Aβ) - output impedance of amplifier without feedback Zo = Ro.

Current Series feedback connection. (or) Series Series feedback:-

Output current - directly proportional - Input voltage-"Trans conductance amplifier '".

i.e., A = Io / Vi (or) Io = A Vi.

Block Diagram: (2M)



The property of Trans conductance amplifier

Ri >> Rs ; Ro >> RL thus Io = IL

Voltage Gain: (1M)

Let the gain of amplifier without feedback

A= Io / Vi and β = Vf / Io.

	We Know, Vs = Vi + Vf The gain of the amplifier with feedback Af = Io / Vs $$A_F = \frac{A}{1 + A\beta}$$ **Input Impedance:** (1M) Vs = Vi + Vf = I iRi + Vf = Ii Ri + β Io = Ii Ri + A β Vi Where, Io = A Vi Vs = Ii Ri + A β Ii Ri Vs = Ii Ri [1+ A β] Rif = Ri [1+ A β] Input impedance gets increased by the factor (1 + Aβ). **Output Impedance:** (1M) Assume - source voltage - transferred - output terminals - Vs shorted i.e Vs = 0, resulting - current Io into the circuit. Vs = Vi + Vf Zof = Zo[1 + A β] Output impedance - amplifier with feedback- Output impedance - increased by a factor of (1 + A β).

UNIT II – OSCILLATORS

Barkhausen criterion for oscillation – phase shift, Wien bridge - Hartley & Colpitt's oscillators – Clapp oscillator-Ring oscillators and crystal oscillators – oscillator amplitude stabilization.

PART * A

Q.No.	Questions
1.	**Define an Oscillator circuit.** BTL1 An Oscillator is a circuit, which basically act as a Generator, generating the output signal which oscillates with a constant amplitude and constant desired frequency.
2.	**Classify Oscillators based on different criterions**. BTL2 Based on waveform generated: • Sinusoidal Oscillator. • Non-Sinusoidal Oscillator or Relaxation Oscillator Example: Square wave, Triangular wave, Rectangular wave etc. According to principle involved: • Negative resistance Oscillator, • Feedback Oscillator. According to frequency generated: • Audio frequency oscillator - 20Hz – 20 KHz • Radio frequency oscillator - 30 KHz – 30 MHz • Ultrahigh frequency oscillator - 30 MHz – 3 GHz • Microwave Oscillator - 3 GHZ above • Crystal oscillator
3.	**Name the various types of feedback oscillators.** BTL1 RC oscillators – Types • RC phase shift oscillator • Wein bridge oscillator LC oscillators – Types • Tuned collector oscillator • Tuned emitter oscillator • Tuned collector base oscillator • Hartley oscillator • Colpitts oscillator • Clapp oscillator.
4.	**Discuss the conditions to be satisfied for oscillation. (Nov 2017)** BTL6 The total phase shift of an oscillator should be 360° for feedback, product of open loop gain & feedback factor should be unity. Oscillator should satisfy Barkhausen criterion.
5.	**Define piezoelectric effect.** BTL1 When applying mechanical energy to some type of crystals called piezoelectric crystals the mechanical energy is converted into electrical energy is called piezoelectric effect.
6.	**What is Miller crystal oscillator? Explain its operation?** BTL1 It is nothing but a Hartley oscillator with its feedback Network is replaced by a crystal. Crystal normally has higher frequency reactance due to the miller capacitance that are in effect between the transistor terminal.

7.	**Define Barkhausen Criteria. (May 2014) (April 2015, April 2017) (Nov 2017)** BTL1 1. The total phase shift around a loop, as the signal proceeds from input through amplifier, feedback network back to input again, completing a loop, is precisely 0^0 or 360^0. 2. The magnitude of the product of the open loop gain of the amplifier (A) and the feedback factor β is unity. i.e., $A\ \beta = 1$.
8.	**Name two low frequency and high frequency oscillators. (Nov 2017)** BTL1 Low frequency oscillators are • RC phase shift oscillator • Wein bridge oscillator High frequency oscillators are • Hartley oscillator • Colpitts oscillator
9.	**List the advantages of crystal oscillators.** BTL1 Frequency stability is greater. Hence,they are used in watches, communication transmitters and receivers.
10.	**List the advantages of the RC phase shift oscillator. (May 2016, Nov 2017).** BTL1 • The circuit is simple to design • Can produce output over AF range • Produces sinusoidal output waveform • It is fixed frequency oscillation.
11.	**Identify which oscillator uses both positive and negative feedback.** BTL3 Wein bridge oscillator
12.	**Discuss about the construction of Armstrong oscillator.** BTL6 It is a type of *LC* oscillator. In this oscillator, a transformer is used, whose primary acts as L in the circuit while the voltage across the secondary is used as a feedback.
13.	**List the factors that affect the frequency stability of an oscillator. (Nov-2016)** BTL1 • Change in temperature • Change in load • Change in power supply
14.	**List the essential parts of an oscillator.** BTL1 • Tank circuits (or) oscillatory circuit. • Amplifier (Transistor amplifier) and • Feedback circuit.
15	**List the disadvantages of crystal oscillator.** BTL1 • It is suitable for only low power circuits. • Large amplitude of vibrations may crack the crystal. The change in frequency is only possible replacing the crystal with another one by different frequency.
16	**Compare an oscillator & an amplifier**. BTL4

Oscillator	Amplifier

They are self-generating circuits. The generate waveforms like sine, square and triangular waveforms of their own, without having input signal.	They are not self-generating circuits. They need a signal at the input and they just increase the level of the input waveform.
It has infinite gain	It has finite gain.
Oscillator uses positive feedback	Amplifier uses negative feedback

17. **List the disadvantages of RC phase shift oscillator. (April 2008)** BTL1

- It is ideal for frequency adjustment over a wide range.
- It requires a high β transistor to overcome losses in the network.

18. **Explain about resonant circuit oscillators.** BTL5

LC oscillators are known as resonant circuit oscillator because the frequency of operation of LC oscillator is nothing but a resonant frequency of tank circuit or LC tank circuit which produces sustained, oscillation at resonant circuit oscillator output.

19. **Justify the need of RC phase shift in a RC phase shift oscillator.** BTL5

The amplifier used causes a phase shift of 180 then the feedback network should create phase shift of 180°, to satisfy the Barkhausen criterion. Hence in phase shift oscillators, three sections of RC circuit are connected in cascade, each introducing a shift of 60, thus introducing a total phase shift 180°, due to feedback network, a phase shift of 180° is introducing providing a total phase shift of 360°.

20. **Wein Bridge oscillator is used for operation at 10 KHz. If the value of resistance R is 100 kΩ, Evaluate the value of C required (Nov 2008).** BTL5

F=1/(2πRC)

C= 159.155PF

21. **Discuss about frequency stability of an oscillator (May 2009) (Apr/ May 2019)** BTL6

The analysis of the dependence of the oscillating frequency on the various factors like stray capacitance, temperature etc. is called frequency stability analysis.

22. **In a RC phase shift oscillator, if R1 =R2 =R3= 200k and C1=C2=C3=100pf, Estimate the frequency of the oscillator. (April 2010).** BTL5

The frequency of oscillator is F=1/(2πRC) = 7.957 *kHZ*

23. **A crystal has the following parameters L= 0.5 H, C=0.05pf, and mounting capacitance is 2 pf, Estimate its series and parallel resonating frequencies. (Nov 2010)** BTL5

Series resonance frequency:

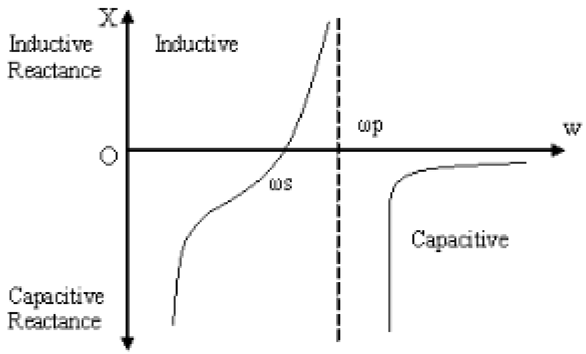
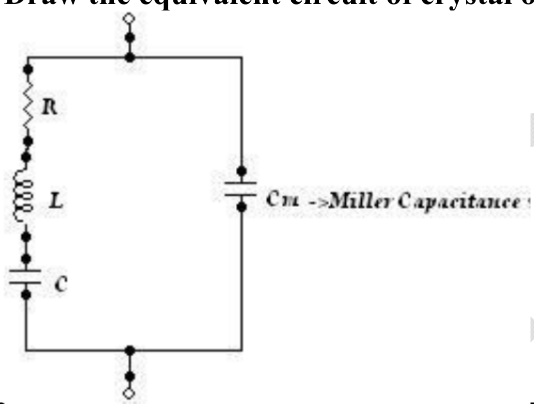
$$f_s = 1/(2\pi\sqrt{LCs}\,)$$

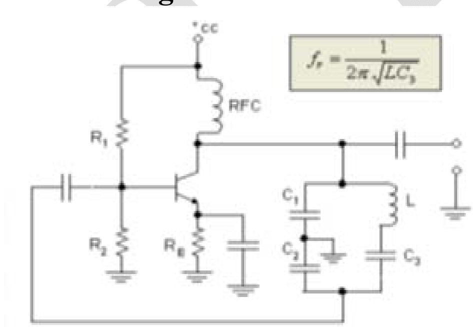
$$= 1/2\pi\sqrt{(0.5 * 0.05 * 10^{-12})}$$

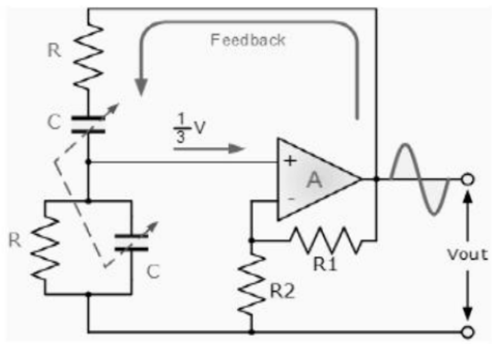
$$fs\ = 1 \text{ MHz}$$

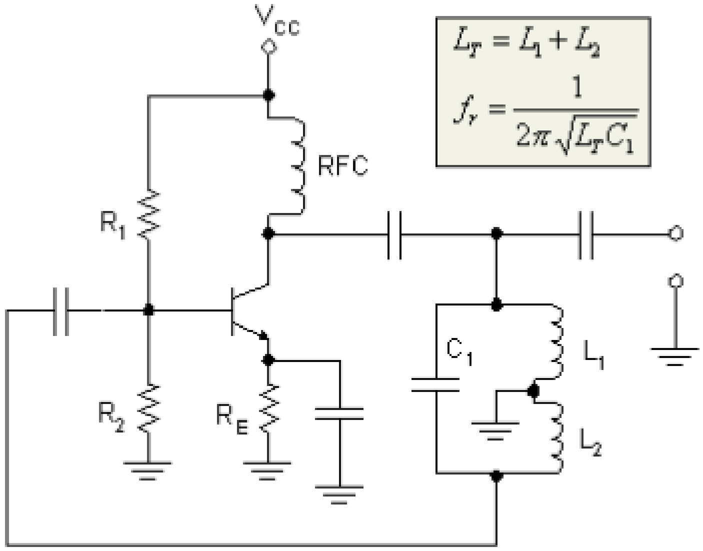
Parallel resonance frequency:

$$\boldsymbol{f_p = \frac{1}{2\pi}\sqrt{\frac{Cs+Cp}{LCsCp}}}$$

	$= \frac{\mathbf{1}}{\mathbf{2\pi}}\sqrt{\frac{0.05*10^{-12}+2*10^{-12}}{0.05*10^{-12}*2*10^{-12}*0.5}}$ = 1MHz
24.	**Draw the frequency V3 reactance curve for a crystal oscillator.** BTL1 
25.	**Draw the equivalent circuit of crystal oscillator. (Apr/May 2019)** BTL1 
26.	**Compare between Colpitts's and Clap Oscillator. (April 2015)** BTL4 Colpitts oscillator: An LC Oscillator which uses 2 capacitive reactances and one inductive reactance in the feedback network. Clapp oscillator: • It is similar to that of colpitts oscillator but modification in the tank circuit is that one more capacitor C3 is introduced in series with the inductance. • Good frequency stability. • The stray capacitances have no effect on C3 which decides the frequency.
	PART*B
1.	**A crystal with L=0.4H, C=0.085PF and Cm=1PF, with R=5KΩ,** **Find Series Resonant frequency, (4M)** **Parallel resonant frequency, (3M)** **By what percent does parallel resonant frequency exceeds the series resonant frequency? (3M)** **Find the Q factor (3M) (May2018)** BTL4 **Answer: Page 611- S. Salivahanan**

	Series resonance frequency: (4M) $f_s = 1/(2\pi\sqrt{LCs})$ $= 1/2\pi\sqrt{(0.4 * 0.085 * 10^{-12})}$ fs =863.13 KHz **Parallel resonance frequency:** (3M) $\boldsymbol{f_p = \frac{1}{2\pi}\sqrt{\frac{Cs+Cp}{LCsCp}}}$ $= \frac{\mathbf{1}}{\mathbf{2\pi}}\sqrt{\frac{0.085 * 10^{-12} + 1 * 10^{-12}}{0.085 * 10^{-12} * 1 * 10^{-12} * 0.4}}$ = 899.07 KHz parallel resonant frequency exceeds the series resonant frequency by 899.07-863.13 KHz = 36 KHz. (3M) **Q Factor:** Q =ωL/R = 0.45 (3M)
2.	**Illustrate the working principle of Clapp oscillator with neat diagram (7M) (May2018)** BTL2 **Answer: Page 590- S. Salivahanan** **Introduction:** • Modified colpitts oscillator circuit - called clap oscillator. (2M) • The basic tank circuit with two capacitive reactances --one inductive reactance remains same. Modification -one more capacitor C3 is introduced in series with inductance. • C3 much smaller than C1 and C2. **Frequency of Oscillation & Condition for Sustained Oscillation:** (2M) $h_{fe} = \frac{C1}{C2}$ $f = \frac{A}{2\pi\sqrt{LC_{eq}}}$ **Circuit Diagram:** (3M) 
3.	**Draw the Wein bridge oscillator using BJT, explain and derive the condition for oscillation. (10M) (Nov 2017) (Nov/Dec- 2003), (Nov/Dec- 2004) (April- 2004) (Apr/ May 2019)** (or) **Draw the circuit of Wein bridge oscillator using BJT. Show that the gain of the amplifier must be at least three for the oscillation to occur (10M) (Nov 12)** BTL5 **Answer: Page 605- S. Salivahanan** **Introduction**: (3M)

	• Wein bridge oscillator -audio frequency oscillator. • Involves both positive and negative feedback. • Negative feedback – stability. • Positive feedback - oscillations. • Feedback network - not produce - phase shift. • The circuit consists -two transistors- operated - CE configuration. • The transistors- individually -provide - phase shift of 180^o - overall phase shift is 360^o - fed back - first stage - bridge network. **Circuit Diagram:** (3M)  **The frequency of oscillator** is F=1/(2πRC) (2M) **Advantages of wein bridge oscillator :-** (2M) 1. Good sine wave output. 2. Good frequency stability. 3. Good Amplitude stability.
4.	**In Colpitts oscillator, C1=1µF, C2=0.2µF. If the frequency of oscillation is 10 KHz, find the value of inductor; also find the required gain for sustained oscillation. (3M) (Nov 2017)** BTL2 **Answer: Page 588- S. Salivahanan** **Frequency of Oscillation**: $f = \frac{1}{2\pi\sqrt{LC_{eq}}}$ (1M) Ceq = $C_1C_2/(C_1+C_2)$ (1M) L=0.422mH (1M)
5.	**Draw Hartley oscillator using FET, explain and derive the condition for oscillation. (13M) (Nov 2017)** BTL4 **Answer: Page 582- S. Salivahanan** **Introduction:** (2M) • LC Oscillator • Two inductive reactance's - one capacitive reactance - feedback network - Hartley Oscillator. **Frequency of Oscillation:** (3M) $$f = \frac{1}{2\pi\sqrt{L_{eq}C}}$$ $$L_{eq} = L1 + L2$$ **Circuit Diagram** & **Explanation** (4M+4M) 180^0 phase shift – feedback network- another 180^0 phase shift – CE amplifier. Total 360^0 phase shift.

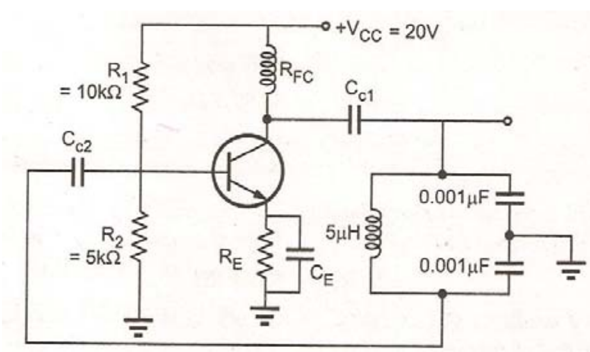


$$L_T = L_1 + L_2$$
$$f_r = \frac{1}{2\pi\sqrt{L_T C_1}}$$

6. **With the help of circuit diagram, explain the principle of operation of Colpitts oscillator. Obtain the frequency of operation of the circuit. (13M) (May 17), (Nov 12), (Nov2014)** BTL4

Answer: Page 585- S. Salivahanan

- **Oscillator**: Generate signal – without input signal. (1M)
- **Components:** $Z_1 = C_1$, $Z_2 = C_2$, $Z_3 = L$ (1M)
- **Circuit Diagram & Explanation**: (4M+4M)
  180^0 phase shift – feedback network- another 180^0 phase shift – CE amplifier. Total 360^0 phase shift.



- **Frequency of Oscillation**: $f = \frac{1}{2\pi\sqrt{LC_{eq}}}$ (3M)

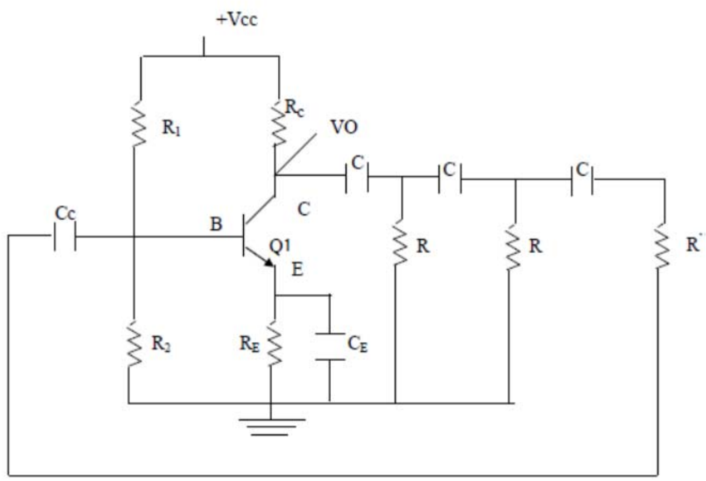
7. **Sketch the circuit of RC phase shift oscillator, and explain its design approach. (10M) (May 2017)(May 2003).** BTL2

Answer: Page 593- S. Salivahanan

Introduction: (3M)

- RC phase shift oscillator - audio frequency - low frequency oscillator.
- CE amplifier -output - to three RC networks.
- Phase shift- pr
- oduced by the CE amplifier -180^o.
- Oscillator- requires - phase shift - 0^o or 360^o, - additional 180^o -phase shift - obtained -three RC networks - individual shift of 60^o each.

Circuit Diagram: (3M)



Barkhausen criterion, (4M)
$A\beta = 1$
Condition for Oscillation:
$f = 1/2\pi RC\sqrt{6}$
$A\beta = 1$.
Sustained oscillations $\beta = -1/29$

9. **In a colpitts oscillator, inductor and capacitor of the tank circuit are H=40mH, C1=100pF, C2=500pF, Find the frequency of oscillation. (3M) (May 2017).** BTL2
Answer: Page 589- S. Salivahanan
Frequency of oscillation:
$f = \frac{1}{2\pi\sqrt{LC_{eq}}}$ (1M)
Ceq =C1*C2/C1+C2 = 83.33 pF (1M)
F= 87.17KHz (1M)

10. **Discus thoroughly, the factors affecting frequency stability of oscillators. (6M)** BTL6
Answer: Page 613- S. Salivahanan
- Change in temperature (6M)
- Values of tank circuit components get affected.
- Parameters of active device get affected.
- Variation in power supply
- Change in atmospheric condition, aging.
- Changes in load connected.
- Stray capacitances

PART * C

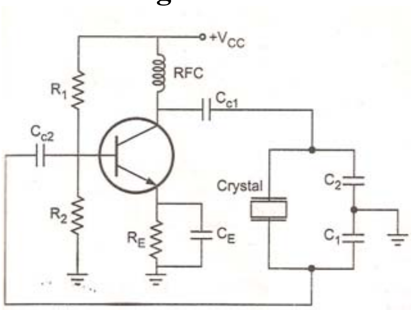
1. **Design a Hartley oscillator of frequency 100 KHz, and explain its working with neat circuit diagram, Assume L1=L2=4mH. (15M) (May2018)** BTL6
Answer: Page 584- S. Salivahanan
$f = \frac{1}{2\pi\sqrt{CL_{eq}}}$ (3M)
Leq =L1+L2 =8mH (3M)
$100*10^3 = \frac{1}{2\pi\sqrt{C*8*10^{-3}}}$
C=316.6pF (3M)

Diagram: (6M)

2. **Using a circuit diagram of a transistorized pierce crystal oscillator, explain its operation. (10M)** BTL2

Answer: Page 609- S. Salivahanan

Circuit Diagram: (4M)



Resonant frequency of the crystal -change in temp- voltage supply- transistor parameter - no effect on frequency stability. (6M)

$$f = \frac{1}{2\pi\sqrt{LC_s}}$$

3. **Explain the working of miller crystal oscillator. (Apr/ May 2019) (10M)** BTL1

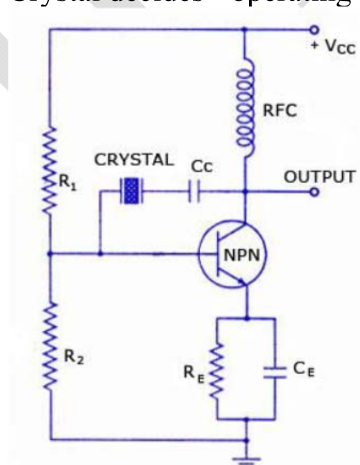
Answer: Page 612- S. Salivahanan

Introduction: (2M)

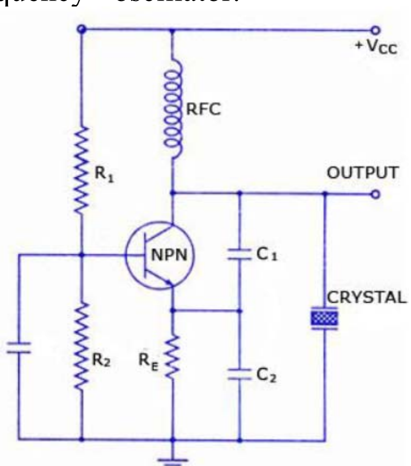
Miller crystal oscillator - modifications -colpitts oscillator- Hartley oscillator.

Circuit Diagram & Explanation: (4M+4M)

- Hartley oscillator circuits- two inductors -one capacitor - required - tank circuit.
- One inductor - replaced - crystal, which acts as an inductor - frequencies slightly -greater than - series resonant frequency.
- The tuned circuit - ‘L1’ - ‘C’ - off tuned - behave - inductor i.e. L1.
- The crystal - behaves - other inductance L2 between base - ground.
- The internal capacitance - transistor acts - capacitor - to fulfil the elements - tank circuit.
- The common emitter - provides a phase shift of 180^o.
- Tank circuit - additional phase shift of 180^o - satisfy oscillation conditions.
- Crystal decides - operating frequency - oscillator.



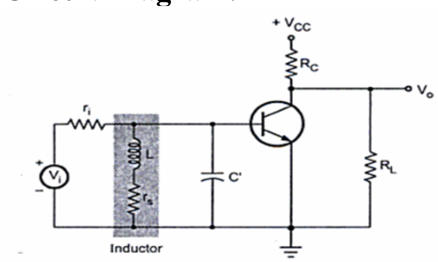
Oscillator With Crystal Operating in Series Resonance

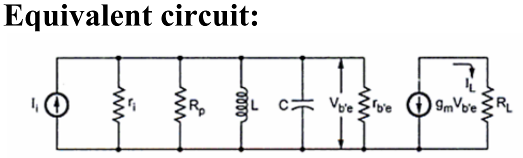


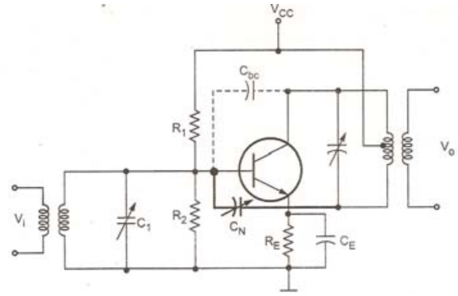
Oscillator With Crystal Operating in Parallel Resonance

UNIT III – TUNED AMPLIFIERS	
Coil losses, unloaded and loaded Q of tank circuits, small signal tuned amplifiers –Analysis of capacitor coupled single tuned amplifier – double tuned amplifier - effect of cascading single tuned and double tuned amplifiers on bandwidth – Stagger tuned amplifiers - Stability of tuned amplifiers – Neutralization - Hazeltine neutralization method.	
PART * A	
Q.No.	**Questions**
1.	**What is a tuned amplifier?** BTL1 The amplifier with a circuit that is capable of amplifying a signal over a narrow band of frequencies are called tuned amplifiers.
2	**List the advantages and disadvantages of tuned amplifiers.** BTL1 Advantages: • They amplify defined frequencies. • Signal to Noise ratio at output is good. • They are well suited for radio transmitters and receivers. • The band of frequencies over which amplification is required can be varied. Disadvantages: • Since they use inductors and capacitors as tuning elements, the circuit is bulky and costly. • If the band of frequency is increased, design becomes complex. • They are not suitable to amplify audio frequencies.
3	**What are the different coil losses?** BTL1 • Hysteresis loss • Copper loss • Current loss
4	**What is the classification of tuned amplifiers?** BTL1 • Single tuned • Double tuned • Stagger tuned
5	**What are the advantages of tuned amplifiers?** BTL1 • They amplify defined frequencies. • Signal to noise ratio at output is good • They are suited for radio transmitters and receivers
6	**What is neutralization?** BTL1 The effect of collector to base capacitance of the transistor is neutralized by introducing a signal that cancels the signal coupled through collector base capacitance. This process is called neutralization.
7	**What are the advantages of double tuned over single tuned?** BTL1 • Possess flatter response having steeper sides • Provides larger 3 dB bandwidth • Provides large gain-bandwidth product.
8	**What are the different types of neutralization?** BTL1 • Hazeltine neutralization • Rice neutralization • Neutrodyne neutralization.

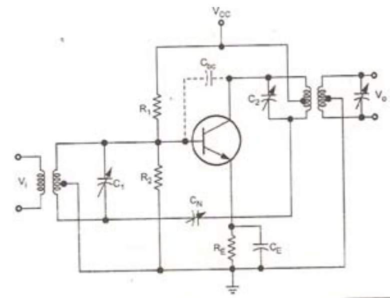
9	**What is rice neutralization?** BTL1 It uses centre tapped coil in the base circuit. The signal voltages at the end of tuned base coil are equal and out of phase.
10	**Define Q factor of resonant circuit.** BTL1 • It is the ratio of reactance to resistance. • It also can be defined as the measure of efficiency with which inductor can store the energy. Q=2π *(Maximum Energy Stored per cycle / Energy dissipated per cycle)
11	**Define unloaded and loaded Q of tuned circuit. (Apr/May 2019)** BTL1 The unloaded Q or QU is the ratio of stored energy to dissipated energy in a reactor or resonator. The loaded Q or QL of a resonator is determined by how tightly the resonator is coupled to its terminations.
12	**What is the response of tuned amplifiers?** BTL1 The response of tuned amplifier is maximum at resonant frequency and it falls sharply for frequencies below and above the resonant frequency.
13	**What are stagger tuned amplifiers?** BTL1 Stagger tuned amplifiers use a number of single tuned stages in cascade, the successive tuned circuits being tuned to slightly different frequencies. (OR) It is a circuit in which two single tuned cascaded amplifiers having certain bandwidth are taken and their resonant frequencies are adjusted that they are separated by an amount equal to the bandwidth of each stage. Since resonant frequencies are displaced it is called stagger tuned amplifier.
14	**What is the effect of cascading single tuned amplifiers on bandwidth?** BTL1 Bandwidth reduces due to cascading single tuned amplifiers.
15	**What are the advantages of double tuned amplifier over single tuned amplifier?** BTL1 • It provides larger 3 dB bandwidth than the single tuned amplifier and hence provides the larger gain-bandwidth product. • It provides gain versus frequency curve having steeper sides and flatter top.
16	**What is the use of Neutralization?** BTL1 • BJT and FET are potentially unstable over some frequency range due to the feedback parameter presents in them. • If the feedback can be cancelled by an additional feedback signal that is equal in amplitude and opposite in sign, the transistor becomes unilateral from input to output the oscillations completely stop. • This is achieved by Neutralization.
17	**Mention the applications of class C tuned amplifier.** BTL1 • Class C amplifiers are used primarily in high-power, high-frequency applications such as Radio-frequency transmitters. • In these applications, the high frequency pulses handled by the amplifier are not themselves the signal, but constitute what is called the Carrier for the signal
18	**What the advantages are of stagger tuned amplifier?** BTL1 The advantage of stagger tuned amplifier is to have better flat, wideband characteristics.
19	**How single tuned amplifiers are classified?** BTL1 • Capacitance coupled single tuned amplifier. • 2. Transformer coupled or inductively coupled single tuned amplifier.

<table>
<tr><td>20</td><td>What is dissipation factor? BTL1
It is defined as 1/Q. It can be referred to as the total loss within a component.</td></tr>
<tr><td></td><td>PART*B</td></tr>
<tr><td>1.</td><td>Demonstrate on single tuned amplifier and derive for gain and resonant frequency. (13M) (May2018) (Nov 2017) (Apr/ May 2019) BTL2
Answer: Page 497- S. Salivahanan
Introduction: (2M)
Single tuned amplifier - consists - CE amplifier - which a tuning circuit - included - - input (base terminal) - output (collector terminal).
Circuit Diagram: (3M)


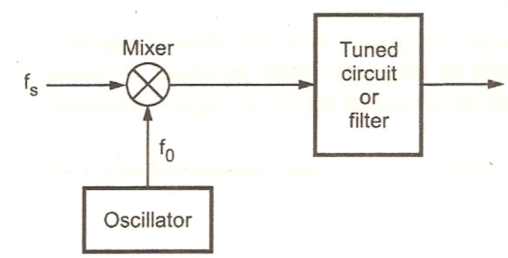
Equivalent circuit: (3M)


$$A_i = \frac{-g_m R}{1 + jQ_i(\omega/\omega_o - \omega_o/\omega)}$$ (2M)
$$BW = \frac{1}{2\pi RC}$$ (3M)</td></tr>
<tr><td>2</td><td>Explain the stability of tuned amplifiers using Neutralization techniques. (13M) (May2018) (Nov 2017) BTL1
Answer: Page 521- S. Salivahanan
i) Internal capacitance C_{bc} -feeds - signal from top end - coil - neutralization capacitance C_N feeds an equal signal - opposite polarity. (5M)

</td></tr>
</table>

ii) Uses a center tapped coil - base circuit, - signal voltages - both ends -e tuned base coil -equal -out of phase. (5M)



The mixer accepts two inputs, f_s & f_o -performs mathematical multiplication - produce; f_s ,f_o ,$f_s + f_o$ and $f_s - f_o$. (3M)



3

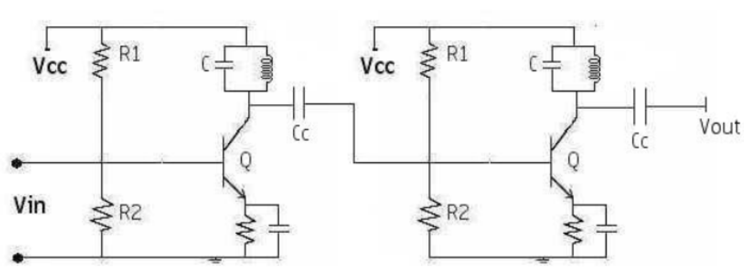
Explain Stagger tuned Amplifiers (4M) (Nov 2017) (Nov 2012) (Apr/May 2019) BTL1

Answer: Page 514- S. Salivahanan

Introduction:

- The double tuned amplifier - greater 3dB bandwidth - steeper sides - flat top.
- Alignment - double tuned amplifier - difficult.
- To overcome -problem: two single tuned cascaded amplifiers - certain bandwidth - taken - resonant frequencies - adjusted - equal to the bandwidth
- Resonant frequencies - displaced or staggered - stagger tuned amplifiers.
- Advantage: better flat, wideband characteristic

Circuit Diagram:



(2M)

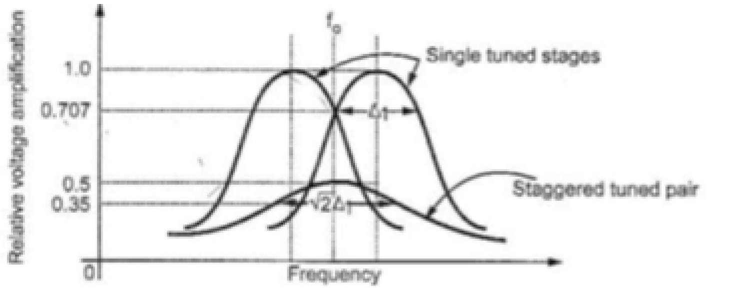
Gain:

$$\left|\frac{A_v}{A_v\ (\text{at resonance})}\right|_{\text{cascaded}} = \frac{1}{\sqrt{4+(2Q_{eff}\,\delta)^4}} = \frac{1}{\sqrt{4+16\,Q_{eff}^4\,\delta^4}}$$

$$= \frac{1}{2\sqrt{1+4Q_{eff}^4\,\delta^4}}$$

(1M)

Characteristic curve:



Response of individually tuned and staggered tuned pair

(1M)

4

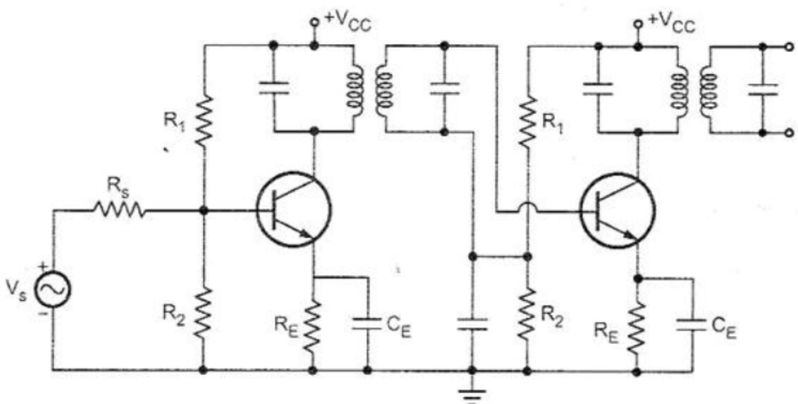
Draw the circuit of double tuned amplifier and explain its operation. Sketch the nature of frequency-gain characteristics, and write the expression for 3dB bandwidth. (13M) (May 2017) (Nov 2012). BTL2

Answer: Page 503- S. Salivahanan

Introduction: (2M)

- Double tuned RF amplifier in CE configuration.
- Voltage developed - tuned circuit - coupled inductively - another tuned circuit.
- Both tuned circuits - tuned - same frequency.

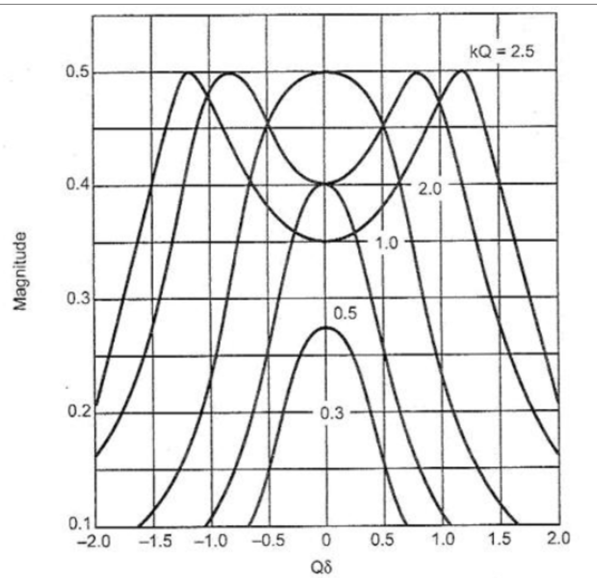
Circuit Diagram: (4M)



Gain: (3M)

$$|A_v| = g_m\,\omega_r\,\sqrt{L_1\,L_2}\;Q\,\frac{kQ}{\sqrt{1+k^2Q^2-4\,Q^2\,\delta^2+16\,Q^2\,\delta^2}}$$

Characteristic Curve: (4M)



5

Draw the circuit diagram of a two-stage synchronously tuned amplifier and also its equivalent circuit. Derive the expression for bandwidth. (8M) (Nov 2012) (Apr 2019) BTL2

Answer: Page 503- S. Salivahanan

Introduction: (2M)

- Cascaded stage - single tuned amplifiers - tuned same frequency.
- Assume - individual amplifier stages - identical.
- Overall gain - product of the individual gain.
- Gain is high - bandwidth is reduced.

Gain and BW: (2M)

The overall gain of the amplifier is Ai (Overall) = [Ai] $_{\text{I stage}}$ * [Ai] $_{\text{II stage}}$

The resonant frequency $fo = \frac{1}{2\pi\sqrt{L1C1}}$

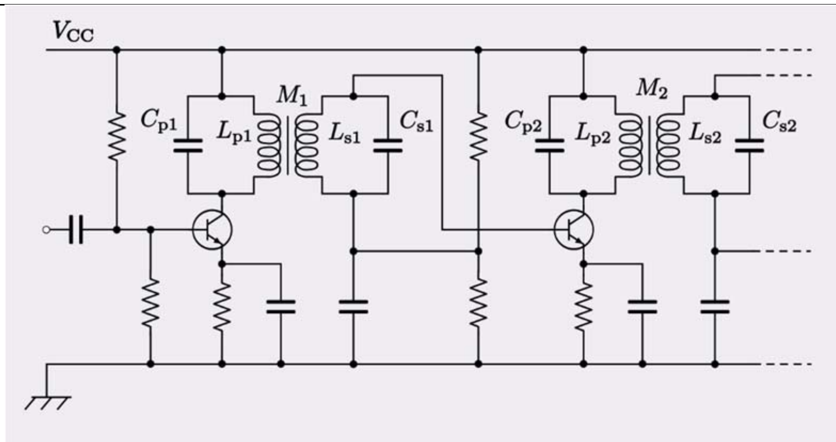
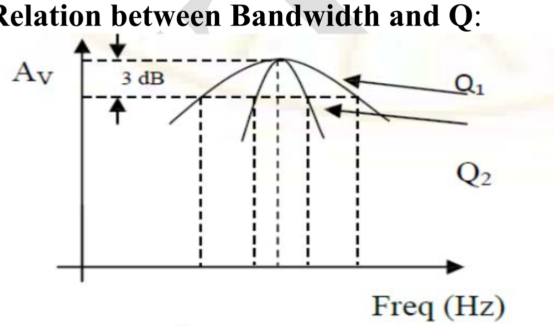
$$BW = f3 - f1 = \frac{1}{2\pi RC}\sqrt{2^{\frac{1}{2}} - 1}$$

Bandwidth of cascaded stage = 0.643 B.W (individual stage).

Bandwidth decreases on cascading.

Bandwidth of 'n' cascaded stage = $\sqrt{2^n - 1}$* B.W (individual stage). (2M)

Circuit Diagram: (2M)

	
6	**Discuss in detail the quality factor of the loaded and unloaded tank Circuits. (8M)** BTL6 **Answer: Page 494- S. Salivahanan** **Q Factor:** (2M) Quality factor (Q) - important characteristics of an inductor. The Q - ratio - reactance - resistance - unit less. Measure - how 'Pure' or 'real' an inductor. **Unloaded Q (QU)** (2M) When the tank circuit (parallel LC circuit) - assumed - not connected - any external circuit - load, Q accounts for the internal losses - called unloaded quality factor 'Qu'. Ro = (ωOL) / QU **Loaded Q (QL):** (2M) RC = (ωO L) / QL. The circuit efficiency for the above tank circuit. $\eta = (I^2 R_c) / [I^2 (R_c+R_o)]$ The quality factor QL - the 3-db bandwidth - resonant circuit - B.W = f r / QL fr -represents the centre frequency. **Relation between Bandwidth and Q**: (2M) 
7	**Calculate the resonant frequency of a class c tuned amplifier whose Capacitor=10pf and inductor L=1mH. (8M)** BTL2 **Answer: Page 518- S. Salivahanan** **Solution:** The resonant frequency of class-c tuned amplifier is fr = 1 / 2 π *LC* (4M) fr = 1.59 MHz (4M)
8	**Write a short on coil losses. (8M)** BTL1

Answer: Page 503- S. Salivahanan

- Tuned circuit consists - coil.
- Practically-coil -not purely inductive.
- It consists - few losses - represented - leakage resistance - series with the resistor.

Losses in Inductor: (1M)

1. Copper loss
2. Hysteresis loss
3. Eddy-currents loss

Copper loss (2M)

Copper loss -heat produced by electrical currents - conductors - transformer windings, - other electrical devices.

Copper Loss=I^2R=Copper Loss = 1/ f

Eddy-currents loss (2M)

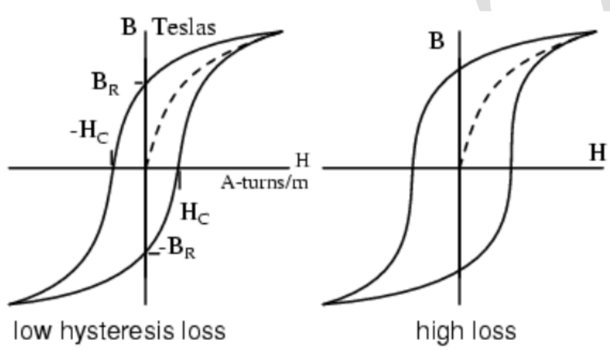
- Eddy current loss in iron and copper coil -due to currents flowing within the copper or core- cased by induction.
- Loss- due - heating within - inductors copper - core.
- Eddy current losses - directly proportional - frequency.

Hysteresis loss (2M)

If - magnetic field applied - magnetic material - increased -then decreased back - original value, t- magnetic field inside the material does not return - original value.

The internal field 'lags' behind - external field- behaviour results - loss - energy, called the **hysteresis loss**, when a sample - repeatedly magnetized and demagnetized.

(1M)



9

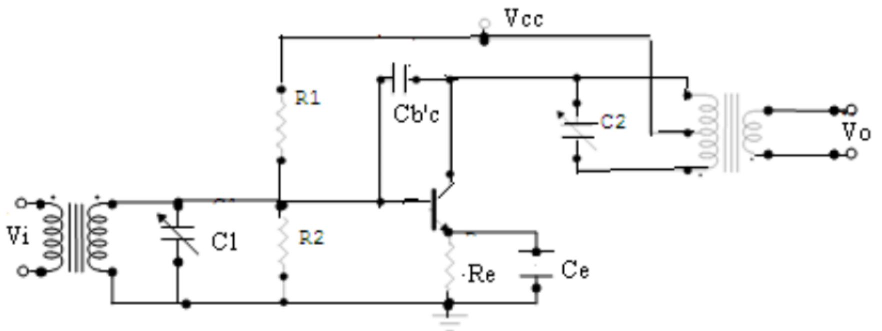
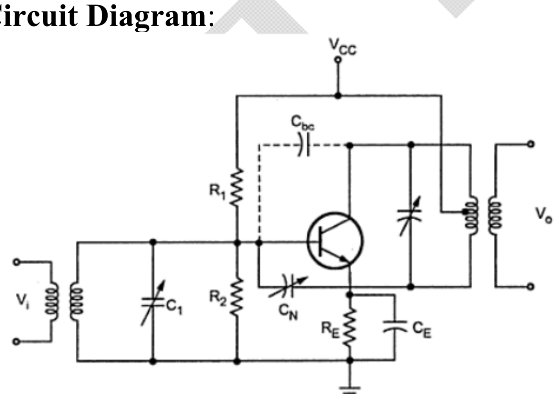
Explain the stabilization techniques used in tuned amplifier. (4M) BTL2

Answer: Page 519- S. Salivahanan

High frequency effects: (2M)

In tuned RF amplifiers, transistors - used at - frequencies nearer - their unity gain bandwidths (i.e fT), - amplify a narrow band - high frequencies cantered around - radio frequency.

Circuit Diagram: (2M)

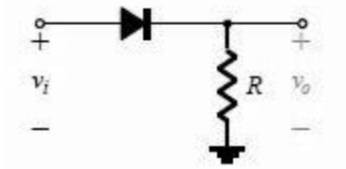
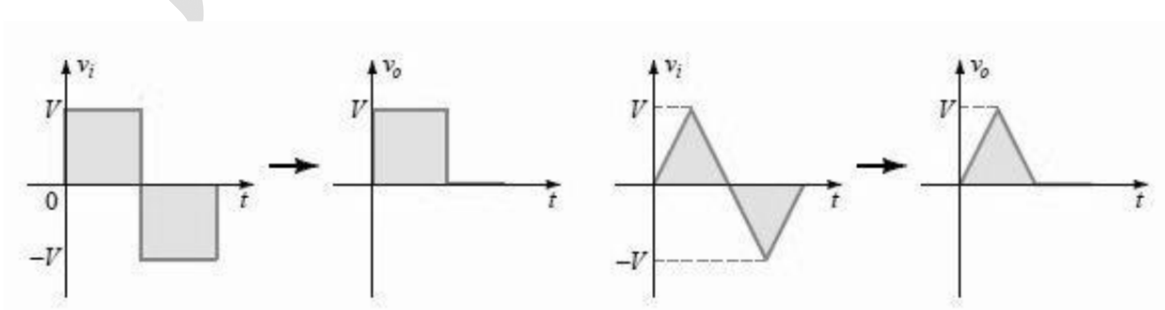
	 The neutralization - achieved - deliberating feeding back a portion - output signal - input -same amplitude - unwanted feedback - opposite phase.
	PART * C
1	**A tank circuit having 5mH coil with resistance 22Ω, and C=1nF, is connected as a load to a single tuned amplifier with R0=10K. Calculate the loaded and unloaded Q factor. (6M) (Nov 2017)** BTL4 **Answer: Page 494- S. Salivahanan** **Unloaded Q (Q_U)** (3M) Ro = (ωOL) / QU **Loaded Q (QL):** (3M) RC = (ωO L) / QL.
2	**Explain the Hazeltine method of neutralization. (8M) (or) What is Hazeltine Method of neutralization? How does a Neutrodyne circuit differ from the Hazeltine Circuit? [APR-2003]** BTL1 **Answer: Page 522- S. Salivahanan** **Introduction:** (2M) Grid to plate capacitance - tube - neutralized - introducing into the grid circuit a signal - cancelled the signal coupled through the grid to plate capacitance. **Circuit Diagram**: (3M)  **Tuned RF amplifier with Hazeltine neutralization** **Working** (3M) • The primary and secondary windings - Rf transformer must be properly polarized -allow neutralization. • Primary - frequently inter wound - ground end portion of the secondary coil - tight coupling.
3	**The bandwidth of a double-tuned amplifier is 10 KHz. Calculate the number of such stages to be connected to obtain the bandwidth of 5.098 KHz. (7M)** BTL4

	Answer: Page 513- S. Salivahanan **Solution:** BWT = BW1 $(2^{1/n} - 1)^{1/4}$ (2M) 21/n = 1.0676. Taking log on both sides, 1/n log (2) = log(1.0676) n = 10 (5M)

UNIT IV– WAVE SHAPING AND MULTIVIBRATOR CIRCUITS	
Pulse circuits – attenuators – RC integrator and differentiator circuits – diode clampers and clippers –Multivibrators - Schmitt Trigger- UJT Oscillator.	
PART * A	
Q.No.	**Questions**
1	**What is High pass RC circuit? Why it is called high-pass filter?** BTL1 • A simple circuit consisting of a series capacitor and a shunt resistor is called high pass RC circuit. • At very high frequencies the capacitor acts as a short circuit and all the higher frequency components appear at the output with less attenuation than the lower frequency components. Hence this circuit is called high-pass circuit.
2	**Why high-pass RC circuit is called Differentiator? (Apr/May 2019)** BTL1 High-pass RC circuit gives an output waveform similar to the first derivative of the input waveform. Hence it is called Differentiator.
3	**What is Low pass RC circuit? Why it is called low-pass filter?** BTL1 • A simple circuit consisting of a series resistor and a shunt capacitor is called Low pass RC circuit. • At very high frequencies the capacitor acts as a virtual short circuit and output falls to zero. Hence this circuit is called low-pass filter
4	**Why low-pass RC circuit is called Integrator?** BTL1 Low pass RC circuit gives an output waveform similar to the time integral of the input waveform. Hence it is called Integrator.
5	**What is High pass RL circuit? Why it is called high-pass filter?** BTL1 • A simple circuit consisting of a series resistor and a shunt inductor is called high-pass RL circuit. • At very high frequencies, the inductor acts as an open circuit and all the higher frequency components appear at the output. Hence this circuit is called high-pass filter.
6	**What is Low pass RL circuit? Why it is called low-pass filter?** BTL1 • A simple circuit consisting of a series inductor and a shunt resistor is called low pass RL circuit. • At very high frequencies, the inductor acts as a virtual open circuit and the output falls to zero. Hence this circuit is called low pass filter.
7	**What is Delay time (td), Rise time (tr) , storage time (ts), fall time (tf) in transistor?** BTL1 The time needed for the collector current to rise to 10% of its maximum (saturation) value i.e. iC(Sat) = VCC/RC is called the delay time. The time required for the collector current to rise from 10% to 90% of the maximum value is called rise time (tr). The time when collector current (iC) dropped to 90% of its maximum value is called the storage time. The time required for the collector current to fall from 90% to 10% of its maximum value is called fall time (tf).
8	**What is Turn-ON time (t_{ON}), Turn-off time (t_{OFF}) in transistor?** BTL1 The sum of the delay time (td) and the rise time (tr) is called the turn-ON time (t_{ON}). t_{ON} = td + tr The sum of the storage time (ts) and the fall time (tf) is called the turn-OFF time (t_{OFF}).

	$(t_{OFF}) = (ts) + (tf)$
9	**List the applications of bistable multivibrator?** BTL1 • It is used as memory elements in shift registers, counters, and so on. • It is used to generate square waves of symmetrical shape by sending regular triggering pulse to the input. By adjusting the frequency of the trigger pulse, the width of the square wave can be altered. • It can also be used as a frequency divider.
10	**What are the two methods of triggering for bistable multivibrators?** BTL1 • Unsymmetrical triggering • Symmetrical triggering
11	**What are the other names of monostable Multivibrator?** BTL1 One-shot, Single-shot, a single-cycle, a single swing, a single step Multivibrator, Univibrator.
12	**What are the different names of bistable Multivibrator?** BTL1 Eccles Jordan circuit, trigger circuit, scale-of-2 toggle circuit, flip-flop and binary.
13	**What is clipper?** BTL1 The circuit with which the waveform is shaped by removing (or clipping) a portion of the input signal without distorting the remaining part of the alternating waveform is called a clipper.
14	**What are the four categories of clippers?** BTL1 • Positive clipper • Negative clipper • Biased clipper • Combination clipper
15	**What is comparator?** BTL1 • The nonlinear circuit which was used to perform the operation of clipping may also be used to perform the operation of comparison is called the comparator. • The comparator circuit compares an input signal with a reference voltage.
16	**What is clamper? (Apr/May 2019)** BTL1 A circuit which shifts (clamps) a signal to a different dc level, i.e. which introduces a dc level to an ac signal is called clamper. It is also called dc restorer.
17	**Which circuits are called multivibrators?** BTL1 • The electronic circuits which are used to generate no sinusoidal waveforms are called multivibrators. • They are two stage switching circuits in which the output of the first stage is fed to the input of the second stage and vice-versa.
18	**Which are the various types of multivibrators?** BTL1 • Astable multivibrator • Bistable multivibrator • Monostable multivibrator
19	**What is astable multivibrator?** BTL1 • A multivibrator which generates square wave without any external triggering pulse is called astable multivibrator. • It has both the states as quasi-stable states. None of the states is stable. • Due to this, the multivibrator automatically makes the successive transitions from one quasi-stable state to other, without any external triggering pulse. So, it called Free-running multivibrator. • The rate of transition from one quasi-stable state to other is determined by the

	discharging of a capacitive circuit.
20	**List the applications of Astable multivibrator?** BTL1 • Used as square wave generator, voltage to frequency convertor and in pulse synchronization, as clock for binary logic signals, and so on. • Since it produces square waves, it is a source of production of harmonic frequencies of higher order. • It is used in the construction of digital voltmeter and SMPS. • It can be operated as an oscillator over a wide range of audio and radio frequencies.
21	**State the basic action of monostable multivibrator.** BTL1 • It has only one stable state. The other state is unstable referred as quasi- stable state. • It is also known as one-short multivibrator or univibrator. • After some time, interval, the circuit automatically returns to its stable state. • The circuit does not require any external pulse to change from quasi- stable state. • The time interval for which the circuit remains in the quasi-stable state is determined by the circuit components and can be designed as per the requirement.
22	**Mention the applications of one short multivibrator?** BTL1 • It is used to function as an adjustable pulse width generator. • It is used to generate uniform width pulses from a variable width pulse train. • It is used to generate clean and sharp pulses from the distorted pulses. • It is used as a time delay unit since it produces a transition at a fixed time after the trigger signal.
23	**Which multivibrator would function as a time delay unit? Why?** BTL1 Monostable multivibrator would function as a time delay unit since it produces a transition at a fixed time after the trigger signal.
24	**What is Bistable multivibrator?** BTL1 • The Bistable multivibrator has two stable states. • The multivibrator can exist indefinitely in either of the two stable states. • It requires an external trigger pulse to change from one stable state to another. • The circuit remains in one stable state unless an external trigger pulse is applied.
25	**Why is monostable Multivibrator called gating circuit?** BTL1 The circuit is used to generate the rectangular waveform and hence can be used to gate other Circuits hence called gating circuit.
26	**What are the main characteristics of Astable Multivibrator?** BTL1 The Astable Multivibrator automatically makes the successive transitions from one quasi- stable State to other without any external triggering pulse.
27	**What is the self-biased Multivibrator?** BTL1 The need for the negative power supply in fixed bias bistable Multivibrator can be eliminated by raising a common emitter resistance RE. The resistance provides the necessary bias to keep one transistor ON and the other OFF in the stable state. Such type of biasing is called self-biasing and the circuit is called self-biased bistable Multivibrator.
28	**What is UTP of the Schmitt Trigger? What is the other name for UTP?** BTL1 The level of Vi at which Q1 becomes ON and Q2 OFF is called Upper Threshold Point. It is also called input turn on threshold level.
29	**What is LTP of the Schmitt trigger?** BTL1 The level of Vi at which Q1 becomes OFF and Q2 on is called Lower Threshold Point.

30	**List the applications of Schmitt trigger.** BTL1 • It is used for wave shaping circuits. • It can be used for generation of rectangular waveforms with sharp edges from a sine wave or any other waveform. • It can be used as a voltage comparator. • The Hysteresis in Schmitt trigger is valuable when conditioning noisy signals for using digital circuits. The noise does not cause false triggering and so the output will be free from noise.
31	**What is meant by Hysteresis voltage in a Schmitt trigger?** BTL1 The difference between UTP (Upper Threshold Point) and LTP (Lower Threshold Point) is called Hysteresis voltage (VH). It is also known as Dead Zone of the Schmitt trigger.
32	**How a Schmitt trigger is different from a multivibrator?** BTL1 A Schmitt trigger has an input and an output; the output is a squared-up version of the input. As long as the input is constant, the output of the Schmitt trigger is also constant. A multivibrator typically has no inputs (other than power), only an output - an oscillating signal.
33	**What is Schmitt trigger?** BTL1 • It is a wave shaping circuit, used for generation of a square wave from a sine wave input. • It is a bistable circuit in which two transistor switches are connected regeneratively.
34	**What is UJT?** BTL1 • UJT is a three terminal semiconductor switching device. • As it has only one PN junction and three leads, it is commonly called as Uni-junction transistor.
	PART*B
1	**Determine and explain a series clipper circuit with clipping above Bias voltage by showing the waveforms of input and output. Draw the transfer characteristics of it. (13M) (May2018)** BTL5 **Answer: Page 648- S. Salivahanan** **Definition**: (2M) **Types**: Positive, Negative (2M) **Circuit Diagram**: (3M)  **Waveforms** (6M) 

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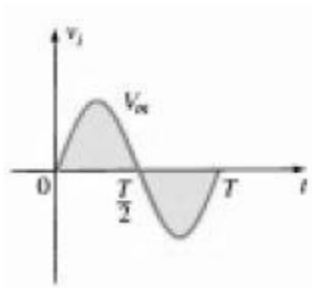

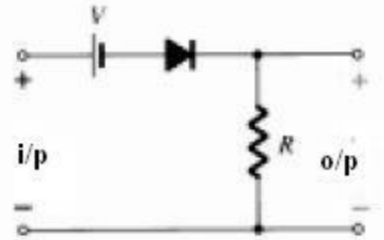

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Draw and explain the operation of Astable multivibrator, and give output waveforms. (13M) (May2018) BTL2

Answer: Page 663- S. Salivahanan

Introduction: (5M)

- A multivibrator - both stage - stable state - switched from one state to another -regular time intervals - any triggering.
- Collector – coupled astable multivibrator - two identical NPN transistors *Q1* and *Q2*.
- Rc1= Rc2 = Rc , R1 = R 2 = R and C1 = C2 = C- symmetrical astable multivibrator.
- The transistor *Q1* - forward biased by the Vcc supply through resistor R1.
- Transistor *Q2* - forward biased by the Vcc supply through resistor R2..
- Output of the transistor *Q1* - coupled - input of transistor *Q2* through the capacitor C1- Output of transistor *Q2* is coupled - input of transistor *Q1* through the capacitor C2.
- Both transistors - switch and connected back to back each other.
- R1C1 and R2C2 forms - charging - discharging network i.e., time constant network.
- RC1 and RC2 - load resistors - connected - biasing voltage VCC.
- Two outputs - 180^o out of phase.

Calculation of Time period: (3M)

- If Q1 is ON, then T1= R1C1ln2 = 0.693 R1C1
- If Q2 is ON, then T2= R2C2ln2 = 0.693 R2C2 Therefore, total Time period T=T1+ T2
- T= 0.693 (R1C1 + R2C2) ---- When R1 and R2 similarly C1 and C2 are not equal
  If both are equal then total time period is given as,

T= 1.386 RC
F = 1 / T

Circuit Diagram: (5M)

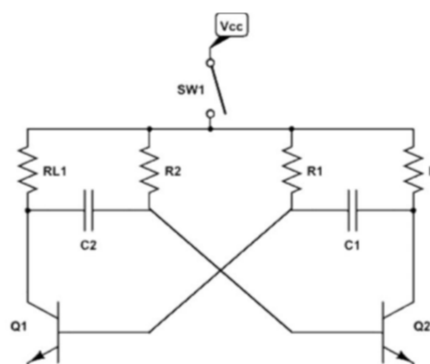

Figure (a)
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Explain the operation of UJT Sawtooth oscillator. (7M) (May2018) (Nov 2017) (May 2017) (Apr/May 2019) BTL2
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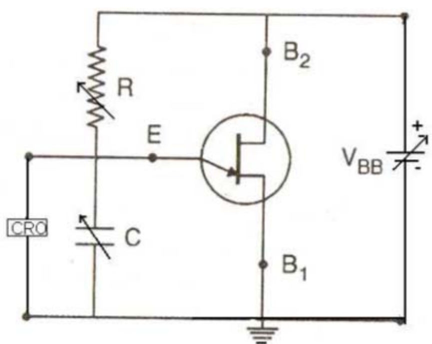
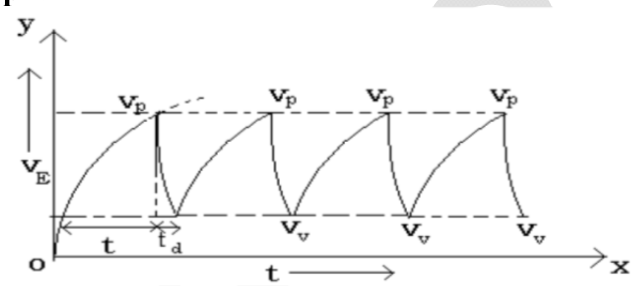
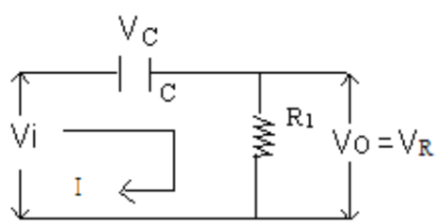
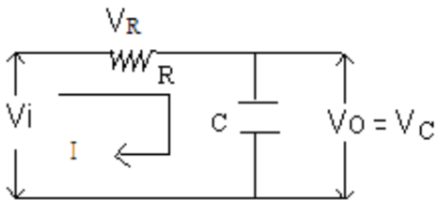
	Answer: Page 690- S. Salivahanan **Introduction**: (1M) • The UJT negative resistance characteristic, • Because -character the UJT - trigger pulse. • Any one - three terminals - triggering pulse. • The UJT - used - relaxation oscillator - produces non-sinusoidal waves. **Circuit Diagram**: (2M)  **Frequency of oscillation**: (2M) $$f = 1/(2.303RClog_{10}\frac{1}{1-\eta})$$ **Graph:** (2M) 
4	**Prove an HPF is a differentiator and also prove a LPF is a integrator. (8M) (Nov 2003, April 2005, April 2004) (Apr/May 2019)** BTL5 **Answer: Page 633- S. Salivahanan** **High Pass RC network as a differentiator: -** (4M) If the high pass RC network - very low time constant - circuit - differentiator. Under such conditions - drop across R is zero - the entire drop is across C.  $V_0 = RC\frac{dv_i}{dt}$ This proves the output is the differential of the input. **Low Pass RC circuit as a integrator:-** (4M)

If the resistor - capacitor of a high pass circuit - interchanged the circuit functions as a low pass circuit.

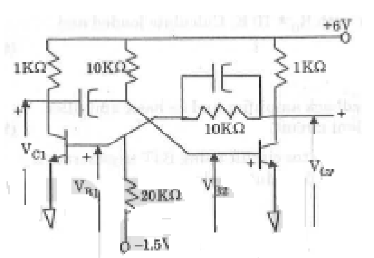


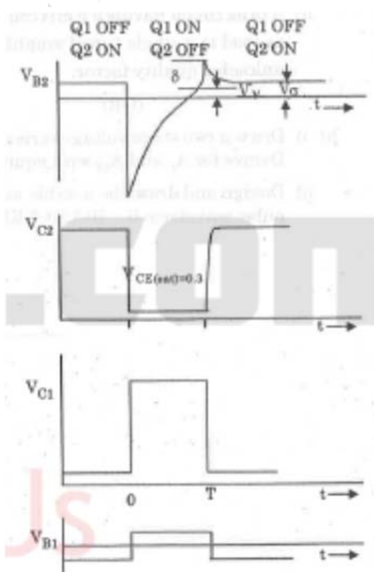
$$V_o = \frac{1}{RC}\int V_i\,dt$$

This implies that the output voltage is an integral of the input voltage.

5

Consider a collector coupled Monostable multivibrator, whose components and supply voltages are indicated in fig. Calculate the voltage levels (V_{B2}, V_{C1}, V_{C2}, V_{B1}) of the waveform during ($t=0^-$, 0, T) period in fig. Also find the overshoot voltage δ. Assume silicon transistor having hfe=50, V0=0.7V, V_γ=0.5V and input Resistance = 200Ω. (13M) (Nov 2017) BTL2





Answer: Page 674- S. Salivahanan

$V_{B2} = Vcc-(Vcc-V_\sigma+IcRc)e^{-t/Rc}$ (4M)

V_{B1} & V_{C1} Calculation (5M)

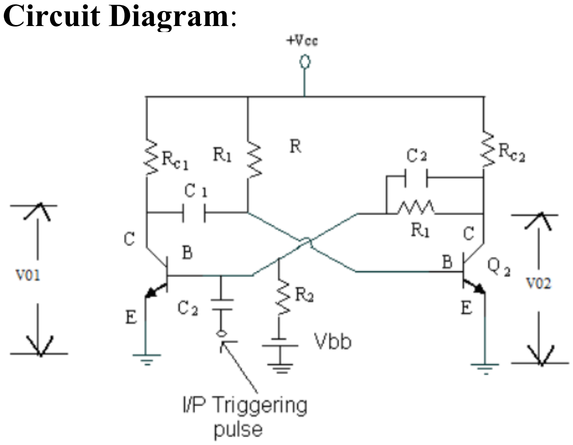
$V_{C2} =$ Vce(Sat) (4M)

6

With neat circuit diagram and necessary waveforms, explain the operation of a monostable multivibrator. (13M) BTL2

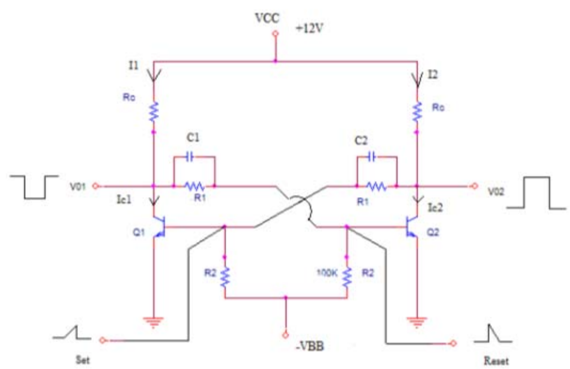
Answer: Page 670- S. Salivahanan

Multivibrator:- (3M)

	• Multivibrator -electronic circuit - used - generate a non-sinusoidal waveform. • Multivibrators - connected back to back - coupling circuits.i.e; output of first stage - connected with input of second stage - vice versa. Multivibrators are classified into three major types. 1. Astable multivibrator. 2. Monostable multivibrator. 3. Bistable multivibrator. **Monostable Multivibrator**:- (3M) **Construction: -** • It contains one stable state - one quasi stable state. • It needs - external pulse - change their permanent state to quasi-stable state - return back to permanent state - completing RC time constant. • Also called One short, single short, one swing multivibrator. • Two transistors Q1 and Q2 used - both - connected back to back. • R1C1 acts - a timing circuit. • RB Base resistance - biasing –VBB. • Trigger pulse applied - base of transistor Q1 - change the state. **Circuit Diagram**: (3M)  **Conditions**: (2M) **Stable state:** Q_1 = OFF; With $V_{C1} \sim V_{CC}$. Q_2 = ON; With $V_{C2} \sim V_{CE(sat)}$ **Quasi stable state:** Q_1 = ON; With $V_{C1} \sim V_{CE(sat)} \sim 0.2V$. . Q_2 = OFF; With $V_{C2} \sim V_{CC}$ **Time constant**: (2M) T1 = R1C1ln2 = 0.693 R1C1 T2 = R2C2ln2 = 0.693 R2C2
7	**With a neat circuit diagram and waveform, explain Bistable multivibrator operation. (13M) (May 2017)** BTL2 **Answer: Page 677- S. Salivahanan** **Introduction:** (6M) • It contains - two stable states - none of the quasi stable stable. • It needs two clock pulse change the states.It stays - one stable state - next trigger pulse appears.

- Two transistors Q1 - Q2 - connected back - back - feedback resistors R1 - R2 similar to asable multivibrator - no capacitors.
- Two transistor base - biased with –VBB.
- RC1 and RC2 acts - load resistor.
- Two trigger pulses(+ve) applied - change the states from 1 state - another in base of transistor
- R_E- used - emitter circuit - provide bias - keep one transistor ON and another OFF.

Circuit Diagram: (7M)



If a positive pulse - applied at S or R, drives Q_1- saturation - Q_2goes - cut-off.

8

Explain Clipper circuits. (10M) BTL2

Answer: Page 648- S. Salivahanan

Clipper: (2M)

- A circuit - removes the peak of a waveform - *clipper*.
- Clipper- device -to prevent the output - circuit - exceeding - predetermined voltage level - distorting - remaining part - applied waveform.
- The basic components - ideal diode - resistor.
- To fix - clipping level - the desired amount, a dc battery - included.

Types: (2M)

Depending - features - diode, the positive or negative region of the input signal is "clipped" off and accordingly the diode clippers may be ,

- Positive clippers.
- Negative clippers.

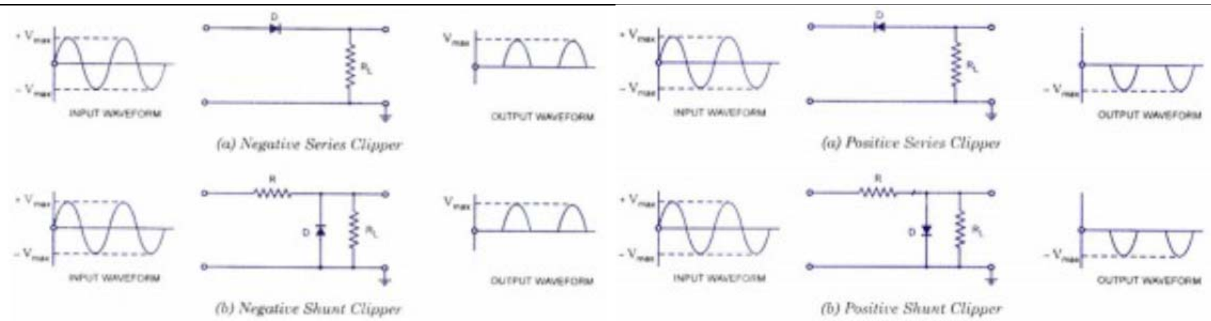
There are two general categories of clippers:

- Series clippers
- Parallel (or shunt) clippers.

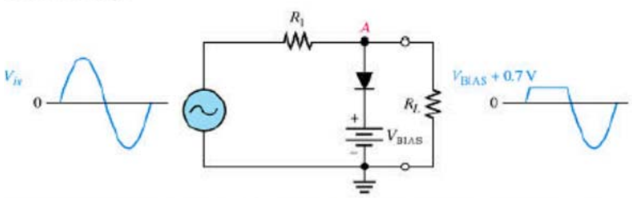
The series configuration is defined - diode - series - load,

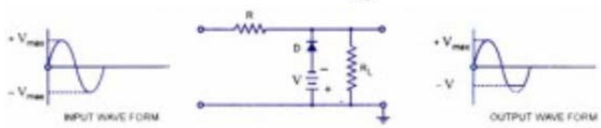
Shunt clipper - diode - branch parallel to the load.

Positive & Negative Clipper: (4M)



Biased Positive & Negative Clipper: (2M)





Biased Negative Clipper

9

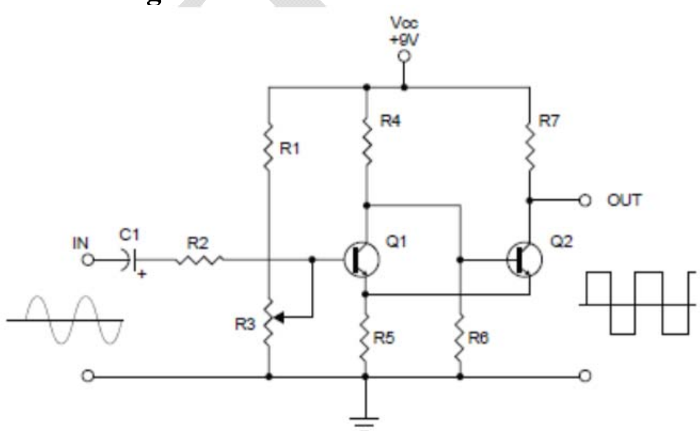
Explain Schmitt trigger circuit. (6M) BTL2

Answer: Page 682- S. Salivahanan

Schmitt trigger: (2M)

- Wave squaring circuit - to convert - sinusoidal - irregular input wave - square or rectangular output wave.
- Two-stage electronic gate.
- Gate is comprised - two dc coupled transistors - employ regenerative feedback - a common emitter resistor (R5).
- Regenerative feedback - necessary - produce - positive switching action.

Circuit Diagram: (2M)



Graph: (2M)

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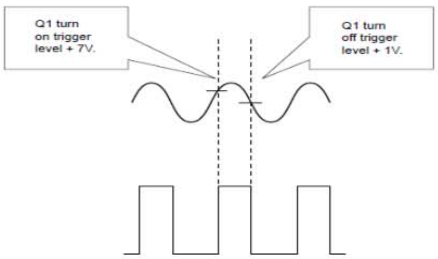

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PART *C

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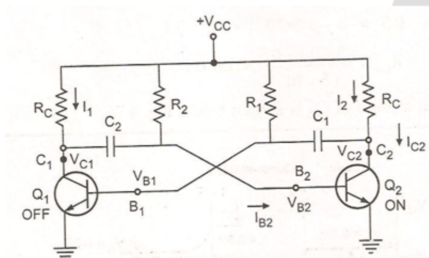
Design and draw the Astable multivibrator circuit using BJT, to generate a pulse waveform 0-10V at 5KHz, with 50% duty cycle. (6M) (Nov 2017) BTL6

Answer: Page 668- S. Salivahanan

$I_2 = \frac{V_{CC}-V_{C2}}{R_C} \approx I_{C2}$ (3M)

$$I_{B2} = \frac{V_{CC} - V_{B2}}{R_2}$$
$$T_2 = 0.69R_2C_2$$
$$T_1 = 0.69R_1\,C_1$$

(3M)



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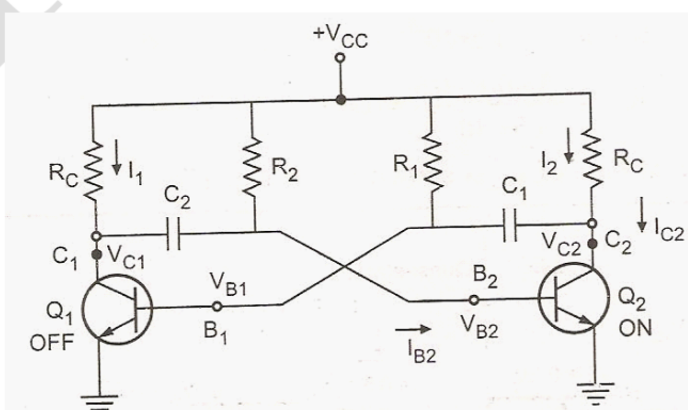
Design and draw the Astable multivibrator circuit to generate a pulse wave format 40% duty cycle, at 20KHz, using V_α=10V, hfe=220, I, sat=2mA. (15M) (May 2017) BTL6

Answer: Page 668- S. Salivahanan

$I_2 = \frac{V_{CC}-V_{C2}}{R_C} \approx I_{C2}$ (10M)

$$I_{B2} = \frac{V_{CC} - V_{B2}}{R_2}$$
$$T_2 = 0.69R_2C_2$$
$$T_1 = 0.69R_1C_1$$

Diagram: (5M)



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Illustrate an astable multivibrator to meet the following specifications; $V_{cc} = 10\ V$; $I_c =$

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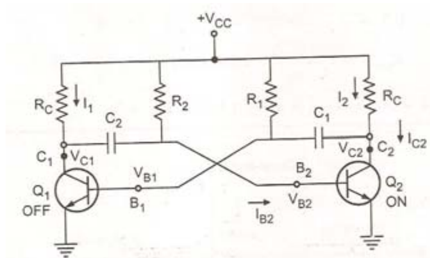
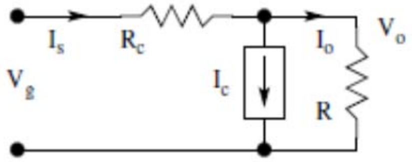
	$2\ mA$; $h_{fe} = 30$. (The output should be a square-wave of frequency 1 kHz with 60 % duty cycle). (15M) BTL2 **Answer: Page 668- S. Salivahanan** $I_2 = \frac{V_{CC}-V_{C2}}{R_C} \approx I_{C2}\ \therefore\ R_C = 4.85\ k\Omega$ (10M) $$I_{B2} = \frac{V_{CC} - V_{B2}}{R_2}\ \therefore\ R_2 = 93\ k\Omega$$ $$T_2 = 0.69R_2C_2\ \rightarrow C_2 = 9.39\ nF;\text{ but } C_2 = C_1$$ $$T_1 = 0.69R_1C_1\ \rightarrow R_1 = 62\ k\Omega$$  (5M)

UNIT V–POWER AMPLIFIERS AND DC CONVERTERS	
Power amplifiers- class A-Class B-Class AB-Class C-Power MOSFET-Temperature Effect- Class AB Power amplifier using MOSFET –DC/DC convertors – Buck, Boost, Buck-Boost analysis and design	
PART * A	
Q.No.	**Questions**
1.	**State the difference between voltage and power amplifier.** BTL1 Voltage Amplifier: The input given to the transistor is in millivolts. The transistor used is a small signal transistor. Power Amplifier: The input given to the transistor is in volts. The transistor used is a power transistor.
2	**Why power amplifier is also known as large signal amplifier?** BTL1 Since the output obtained from the power amplifier is very large, it is known as large signal amplifier.
3	**Define class A power amplifier. How do you bias class A amplifier?** BTL1 It is an amplifier in which the input signal and the biasing is such that the output current flows for full cycle of the input signal. The Q point should be kept at the center of the DC load line to bias the Class A amplifier.
4	**Define class B power amplifier.** BTL1 It is an amplifier in which the input signal and the biasing is such that the output current flows for half cycle of the input signal.
5	**Define class C power amplifier.** BTL1 It is an amplifier in which the input signal and the biasing is such that the output current flows for less than half cycle of the input signal
6	**Define class AB power amplifier.** BTL1 It is an amplifier in which the input signal and the biasing is such that the output current flows for more than half cycle but less than full cycle of the input signal
7	**What is a push pull amplifier?** BTL1 Class B amplifier is used as a push pull amplifier which uses two transistors. Both the transistors work as a push pull arrangement. i.e one transistor will be on at a time.
8	**What is cross over distortion? How it can be eliminated?** BTL1 There is a 0.7V delay in between every half cycle. Due to this the sine wave will not be a continues wave. This is called cross over distortion. It can be eliminated by class AB amplifier.
9	**An amplifier has an efficiency of 32% and a collector dissipation of 0.8W. Calculate the d.c. power input and a.c.power output of the circuit.** BTL1 Pin(d.c) = 2Pc(d.c) + Po(a.c) = 2.35W Po(a.c) = Pin(d.c)(.32) 0.752W
10	**Define DC DC Converters.** BTL1 DC-to-DC converters convert electrical power provided from a source at a certain voltage to electrical power at a different dc voltage.
11	**List the features of DC DC Converters.** BTL1 • DC-to-DC power converters form a subset of electrical power converters. • Both the output and input power specifications of dc-to-dc converters are in dc. Most dc loads require a well-stabilized dc voltage capable of supplying a range of required current, or

	a variable dc current or pulsating dc current rich in harmonics. • The dc-to-dc converter has to provide a stable dc voltage with low output impedance over a wide frequency range.
12	**Draw the simple DC DC Converter.** BTL1 
13	**List the different types of simple DC DC Converters. (Apr/ May 2019)** BTL1 • Series controlled • Shunt Controlled • Switch Mode Converters
14	**What are the different modes of DC Converters in Switch mode?** BTL1 • Buck Converter • Boost Converter • Buck-Boost Converter
15	**Give the important features of Buck Converters.** BTL1 • Gain less than unity • Gain is independent of switching frequency as long as Ts<To • Output voltage ripple percentage of independent of the load on the converter • Output ripple have second order roll off with the switching frequency. • Ideal efficiency is unity. • The input current is discontinuous and pulsating.
16	**Write the important features of Boost Converters.** BTL1 • Gain more than unity • Gain is independent of switching frequency as long as Ts<RC • Output voltage ripple percentage of dependent of the load on the converter • Parasitic resistance degrades the gain • Ideal efficiency is unity. • The input current is continuous.
17	**List the important features of Buck-Boost Converters.** BTL1 • Gain can be set below or above unity. • Gain is independent of switching frequency as long as Ts<RC • Output voltage ripple percentage of independent of the load on the converter & Output ripple have second order roll off with the switching frequency. • Parasitic resistance degrades the gain • Ideal efficiency is unity. • The input current is discontinuous and pulsating.
18	**What is theoretical maximum conversion efficiency of class A power amplifier? (Nov 2009)** BTL1 25% and it can be increased to 50% by using inductors or transformers.
19	**What is 'distortion' in power amplifiers? (Nov 2009)** BTL1 It is non-linear or harmonic distortion and is caused by the non-linear characteristic curve of an active devices.

20 **A BJT has a maximum power dissipation of 2W at ambient temperature of 25°C and maximum junction temperature of 150°C, find its thermal resistance. (Nov 2010)** BTL1

Thermal resistance = (TJ - TA)/ PD

= (150-25)/2

= 62.5 °C/W

21 **List the disadvantages of push pull amplifier. (Nov 2011)** BTL1

- The circuit needs two separate voltage suppliers
- The ouput is distorted due o the crss over distortion

22 **Define Harmonic distortion and intermodulation distortion. (Nov 2011)** BTL1

Harmonic distortion is caused by the nonlinear dynamic characteristics curve of an active device. Here new frequencies are produced in the output which are not present in the input. Intermodulation distortion is also a nonlinear distortion which occurs when the input signal consists of more than one frequency

23 **Define thermal resistance in the context of power amplifier?** BTL1

The resistance offered by the bipolar junction transistor to the flow of heat is called thermal resistance. The thermal resistance measured in °C/W = (TJ - TA)/ PD

24 **What is meant by second order harmonic distortion? (Nov 2012) (Apr/May 2019)** BTL1

The second harmonic distortion is defined as |B2|/|B1| X100 % Where B1-amplitude of the desired signal the fundamental frequency ω B2- amplitude of the second harmonic frequency 2ω

25 **List the applications of MOSFET power amplifier. (Nov 2012)** BTL1

- Large switches
- Line drivers for digital switching circuits
- Switched mode voltage regulators

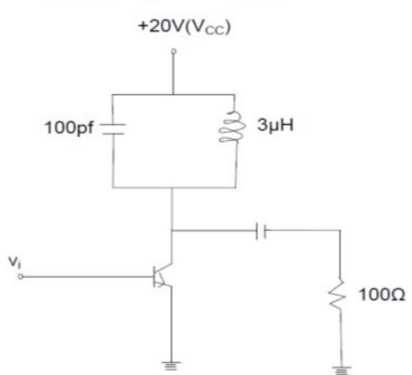
26 **Distinguish between class A and class B operation. (April 2011)** BTL2

Parameter	**Class A**	**Class B**
Conduction angle	100 % of the input signal	50 % of the input signal
Theoretical efficiency	25%	78.5%

PART *B

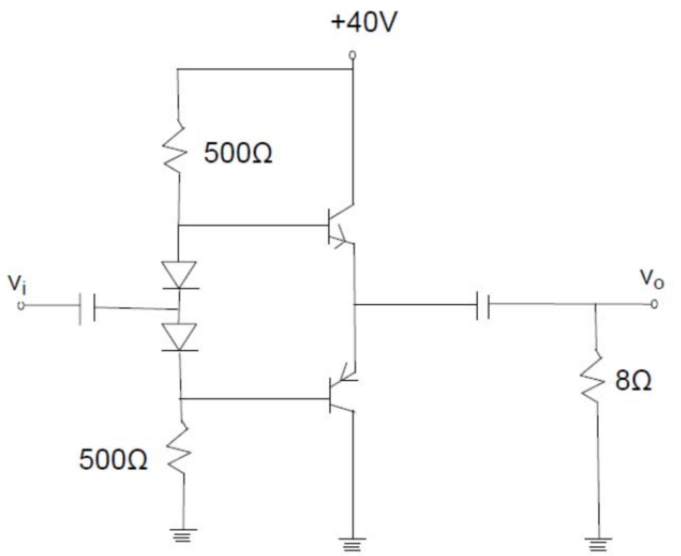
1 **In fig. a basic Class C-amplifier is shown. It uses supply voltage of + 20V and load resistance of 100Ω. The operating frequency is 3MHZ and VCE(sat) = 0.3 V. Calculate and efficiency. If peak current is 500 mA, find the conduction angle also. (13M)** BTL2

Answer: Page 484- S. Salivahanan



Solution:

	$V_p = V_{CC} - V_{CE(sat)} = 20 - 0.3$ Or, $V_p = 19.7V$ (2M) $P_0 = \frac{V_p^2}{2R_L} = \frac{1.97^{\ 2}}{2 \times 100}$ $or, P_0 = 1.69W$ $P_{dc} = 20 \text{ X } 0.0857$ or, $P_{dc} = 1.714$ W (2M) $P_{dc} = V_{CC} \times I_{dc}$ Where, $I_{dc} = \frac{P_0}{V_p} = \frac{1.69W}{19.7V} = 0.0857A$ (2M) $\eta = \frac{P_0}{P_{dc}} = \frac{1.69W}{1.714W} \times 100 = 98.5\%$ For the frequency of 3MHz, the period of the wave, T, is $T = \frac{1}{3 \times 10^6} = 0.33\mu s$ (2M) $t = \frac{P_0 \times T}{I_p \times V_p}$ $= \frac{1.69W \times 0.33 \times 10^{-6}}{500 \times 10^{-3} \times 19.7V}$ $or, t = 56.6 \times 10^{-9} s$ $or, t = 56.6 ns$ And, the conduction angle, θ, is $\theta = \frac{t}{T} \times 360 = \frac{56.6 \times 10^{-9}}{0.33 \times 10^{-6}} \times 360$ $or, \theta = 61.7^{\circ}$ (5M)
2	**Calculate maximum ac output power and the minimum power rating of the transistors in the push-pull amplifier shown in fig.(10M)** BTL2 **Answer: Page 682- S. Salivahanan**



$$P_{0(\max)} = \frac{V_{CEQ} \times i_{c(sat)}}{2}$$
(2M)

$$V_{CEQ} = \frac{1}{2}V_{CC} = \frac{1}{2} \times 40V = 20V$$
(2M)

$$i_{c(sat)} = \frac{V_{CEQ}}{r_C + r_E} = \frac{20V}{0 + 8\Omega} = 2.5A$$
(2M)

$$P_{0(\max)} \frac{V_{CEQ} \times i_{C(sat)}}{2} = \frac{20 \times 2.5}{2} = 25\ W$$
(2M)

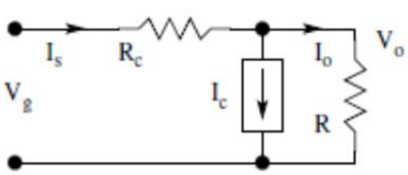
$$P_{D(\max)} = \frac{1}{5} \cdot P_{0(\max)} = \frac{25W}{5}$$
$$or,\ P_{D(\max)} = 5W$$
(2M)

3 **Explain DC DC Converter and its basic types. (Apr/May 2019) (13M)** BTL2

Answer: Page 119- Notes

DC-to-DC converters : convert electrical power - provided - source - certain voltage - electrical power - different dc voltage. (2M)

General Dc Dc Converetr. (3M)

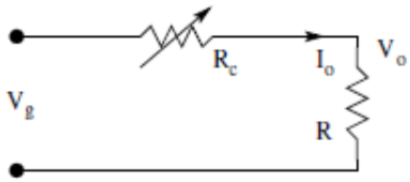


Types (2M)

- Series controlled
- Shunt Controlled

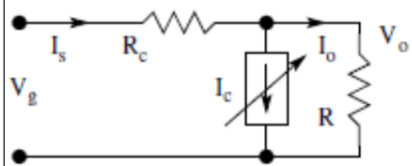
- Switch Mode Converters

Series controlled (2M)



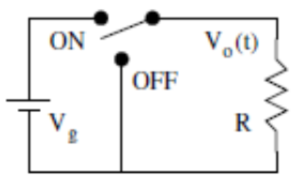
$$V_o = \frac{V_g R}{R + R_c}$$
$$P_l = \frac{V_g^2 R_c}{(R + R_c)^2}$$
$$\eta = \frac{V_o}{V_g}$$

Shunt controlled (2M)



$$V_o = \frac{V_g R}{R + R_c} - \frac{I_c R R_c}{R + R_c}$$
$$P_l = V_o I_c + (I_c + I_o)^2 R_c$$
$$\eta = \frac{V_o}{V_g} \frac{I_o}{I_o + I_c}$$

Switch Mode Converter (2M)



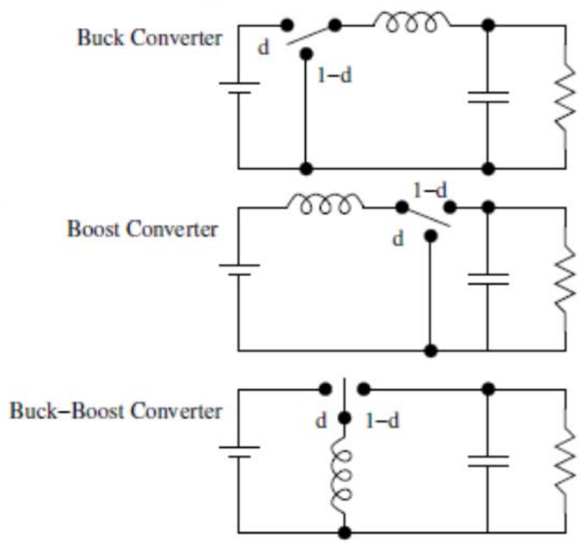
$$V_o = \frac{1}{T_s} \int_0^{T_s} V_o(t)\, dt \;=\; d\, V_g$$

4

Compare various modes of Switch mode DC DC Converters in details. (10M) BTL2

Answer: Page 119-notes

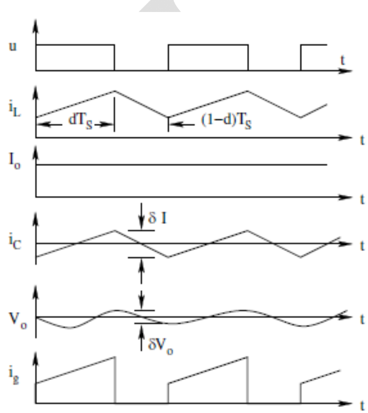
Circuit Diagram: (3M)



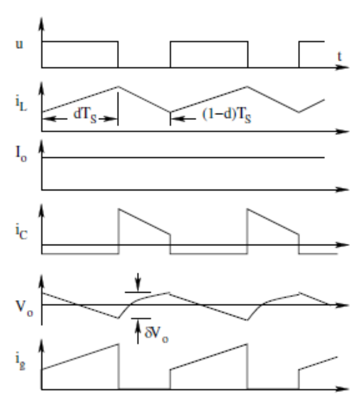
General Parameters: (4M)

	Buck	Boost	Buck-Boost
Ideal Gain	d	$\frac{1}{1-d}$	$-\frac{d}{1-d}$
Current Ripple	$\frac{(1-d)RT_S}{L}$	$\frac{d(1-d)^2RT_S}{L}$	$\frac{(1-d)^2RT_S}{L}$
Voltage Ripple	$\frac{(1-d)T_S^2}{8LC}$	$\frac{dT_S}{RC}$	$\frac{dT_S}{RC}$
Duty Ratio	$\frac{2}{3} \leq d \leq 1$	$0 \leq d \leq \frac{2}{3}$	$0 \leq d \leq \frac{2}{3}$
Efficiency degradation on account of different non-idealities Note: $\alpha = \frac{R_l}{R}; \beta = \frac{R_g}{R};$			
R_l and R_g	$\frac{1}{1+\alpha+\beta d}$	$\frac{1}{1+\frac{\alpha+\beta}{(1-d)^2}}$	$\frac{1}{1+\frac{\alpha+\beta d}{(1-d)^2}}$
V_{sn} and V_{sf}	$1-\frac{V_{sf}}{V_g}-\frac{V_{sf}}{dV_g}$	$1-\frac{V_{sn}}{V_g}-\frac{(1-d)V_{sf}}{V_g}$	$1-\frac{V_{sn}}{V_g}-\frac{(1-d)V_{sf}}{dV_g}$

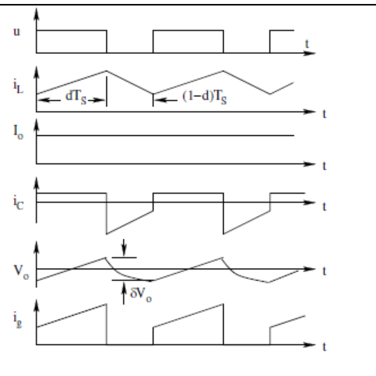
Wave form Comparison: (3M)



Steady State Waveforms of the Buck Converter



Steady State Waveforms of the Boost Converter



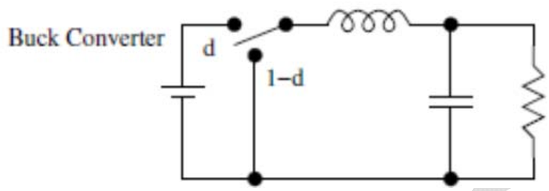
Steady State Waveforms of the Boost Converter

5

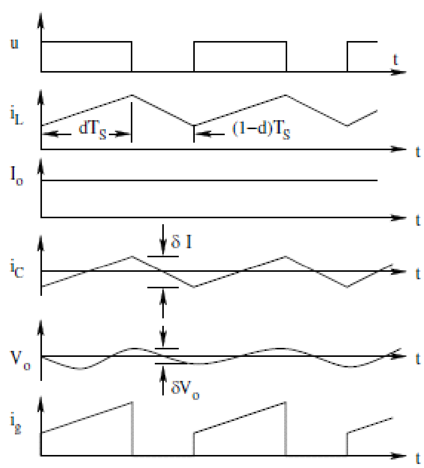
Derive the efficiency of Buck Converter with neat sketch. (10M) BTL4

Answer: Page 119- Notes

Diagram: (2M)



Waveform: (2M)



Steady State Waveforms of the Buck Converter

Voltage Gain: (4M)

$$V_o = dV_g$$

Current Ripple:

$$\delta I_o = \frac{V_g d(1-d)T_S}{L} = \frac{V_o(1-d)T_S}{L}$$

$$\frac{\delta I_o}{I_o} = \delta_i = \frac{(1-d)RT_S}{L}$$

Voltage Ripple:

$$\delta V_o = \frac{\delta Q}{C} = \frac{1}{C}\frac{1}{2}\frac{\delta I_o}{2}\frac{T_S}{2}$$

$$\delta V_o = \frac{V_o(1-d)T_S^2}{8LC}$$

$$\frac{\delta V_o}{V_o} = \delta_v = \frac{(1-d)T_S^2}{8LC}$$

Input Current:

$$I_g = dI_o$$

Validity of Results:

$$\frac{\delta V_o}{V_o} = \delta_v = \frac{5(1-d)T_S^2}{T_o^2} << 1$$

Efficiency:

$$\eta = \left[1 - \frac{V_{sn}}{V_g} - \frac{V_{sf}(1-d)}{dV_g}\right]\left[\frac{R}{R + R_l + dR_g}\right]$$

Features: (2M)

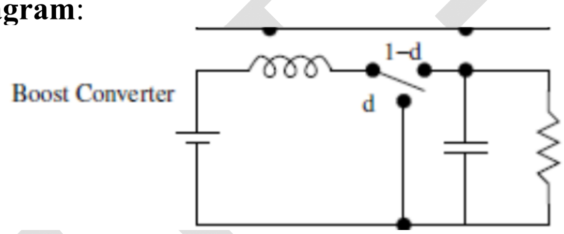
- Gain less than unity
- Gain is independent of switching frequency as long as Ts<To
- Output voltage ripple percentage of independent of the load on the converter
- Output ripple have second order roll off with the switching frequency.
- Ideal efficiency is unity.
- The input current is discontinuous and pulsating.

6

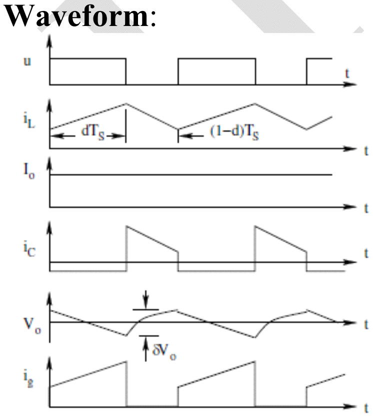
Explain the operation of Boost Converter with neat sketch. (10M) BTL2

Answer: Page 119- Notes

Diagram: (2M)



Waveform: (2M)



Steady State Waveforms of the Boost Converter

Voltage Gain: (4M)

$$V_o = \frac{V_g}{1-d}$$

Current Ripple:

$$\delta I_L = \frac{V_g d T_S}{L}$$

$$\frac{\delta I_L}{I_L} = \delta_i = \frac{d(1-d)^2 R T_S}{L}$$

Voltage Ripple:

$$\delta V_o = \frac{\delta Q}{C} = \frac{I_o d T_S}{C}$$

$$\frac{\delta V_o}{V_o} = \delta_v = \frac{d T_S}{RC}$$

Input Current:

$$I_g = \frac{I_o}{1-d}$$

Validity of Results:

$$\frac{\delta V_o}{V_o} = \delta_v = \frac{d T_S}{RC} << 1$$

Efficiency:

$$\eta = \left[1 - \frac{dV_{sn}}{V_g} - \frac{V_{sf}(1-d)}{V_g}\right]\left[\frac{1}{1+\frac{\alpha}{(1-d)^2}}\right]$$

Features: (2M)

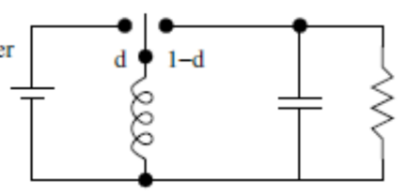
- Gain more than unity
- Gain is independent of switching frequency as long as Ts<RC
- Output voltage ripple percentage of dependent of the load on the converter
- Parasitic resistance degrades the gain
- Ideal efficiency is unity.
- The input current is continuous.

7 **Derive and draw the steady state waveform of Buck- Boost Converters. (10M)** BTL2

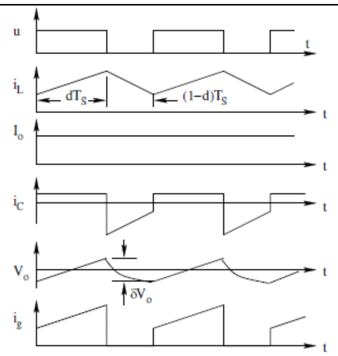
Answer: Page 119- Notes

Diagram: (2M)

Buck–Boost Converter



Steady state waveform: (2M)



Steady State Waveforms of the Boost Converter

Voltage Gain: (4M)

$$V_o = -\frac{dV_g}{1-d}$$

Current Ripple:

$$\delta I_L = \frac{V_g d T_S}{L}$$

$$\frac{\delta I_L}{I_L} = \delta_i = \frac{(1-d)^2 R T_S}{L}$$

Voltage Ripple:

$$\delta V_o = \frac{\delta Q}{C} = \frac{I_o d T_S}{C}$$

$$\frac{\delta V_o}{V_o} = \delta_v = \frac{dT_S}{RC}$$

Input Current:

$$I_g = \frac{dI_o}{1-d}$$

Validity of Results:

$$\frac{\delta V_o}{V_o} = \delta_v = \frac{dT_S}{RC} << 1$$

Efficiency:

$$\eta = \left[1 - \frac{V_{sn}}{V_g} - \frac{V_{sf}(1-d)}{dV_g}\right]\left[\frac{1}{1+\frac{\alpha+\beta d}{(1-d)^2}}\right]$$

Features: (2M)

- Gain can be set below or above unity.
- Gain is independent of switching frequency as long as Ts<RC
- Output voltage ripple percentage of independent of the load on the converter & Output ripple have second order roll off with the switching frequency.
- Parasitic resistance degrades the gain
- Ideal efficiency is unity.
- The input current is discontinuous and pulsating.

8 **Describe the distortion in power amplifier and the methods to eliminate the same. (6M)**

	(NOV/DEC 2009) (Apr/ May 2019) BTL1

Answer: Page 479- S. Salivahanan

Amplifier Distortion: (2M)

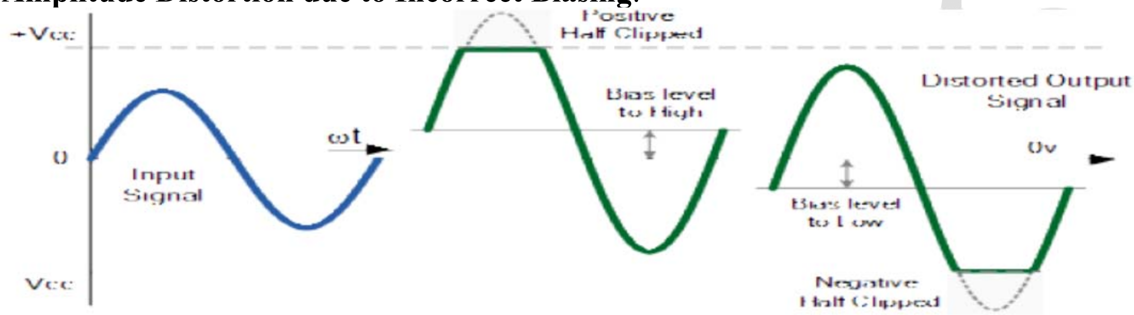
Distortion - output signal waveform may occur because:

1. Amplification may not be taking place over - whole signal cycle due - incorrect biasing levels.
2. The input signal - too large, causing - amplifiers transistors - limited by the supply voltage.
3. The amplification - not - a linear signal over - entire frequency range of inputs.

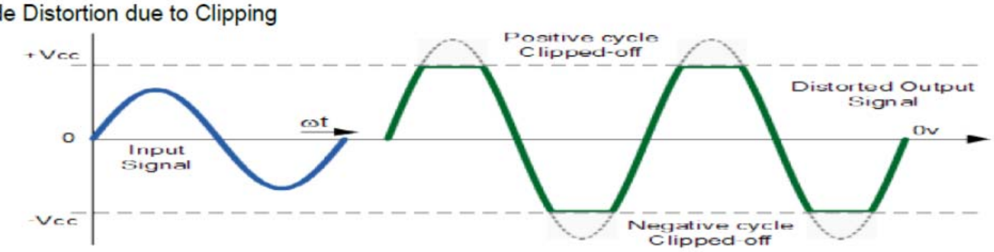
Amplitude Distortion

Amplitude distortion occurs - peak values of the frequency waveform - attenuated causing distortion - shift - Q-point and amplification may not take place over the whole signal cycle.

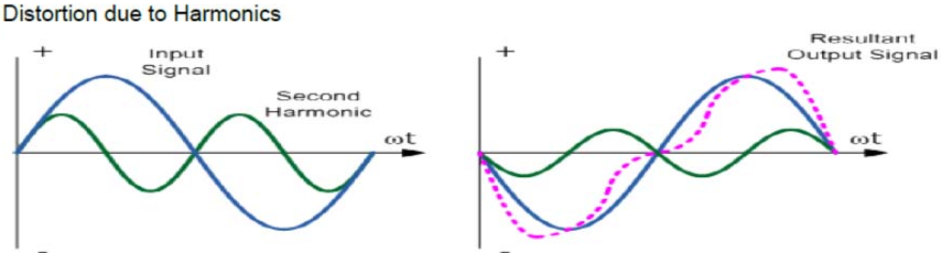
Amplitude Distortion due to Incorrect Biasing: (4M)



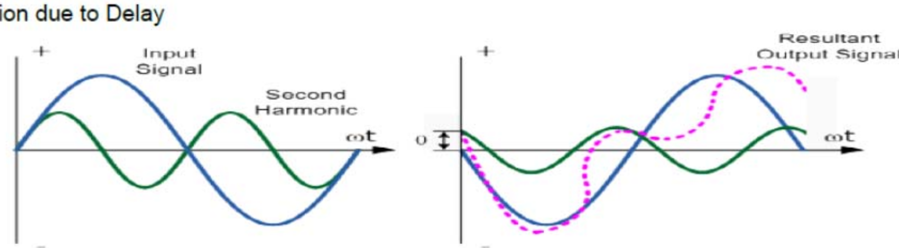
Amplitude Distortion due to Clipping



Frequency Distortion due to Harmonics



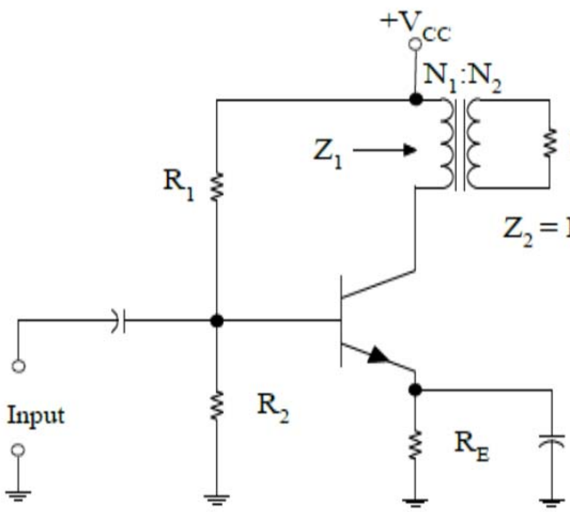
Phase Distortion due to Delay



9	**Explain the operation of the transformer coupled class A audio power amplifier. (8M) (April 2010) or Explain class A power amplifier with circuit diagram and derive for its efficiency. (8M) (Nov 2010)(Nov 12)** BTL2 **Answer: Page 671- S. Salivahanan**

Introduction: (2M)

Circuit Diagram: (2M)



Operation; (2M)

N1, N2 = the number of turns in the primary and secondary

V1, V2 = the primary and secondary voltages

I1, I2 = the primary and secondary currents

Z1, Z2 = the primary and seconadary impedance (Z2 = RL)

Ptot = P1 + P2 + PC + PT + PE (2M)

$$\eta_{(max)} = \frac{P_{ac}}{P_{dc}} = \frac{2V_{CC}\,2I_C}{8V_{CC}I_C} \times 100\%$$

10

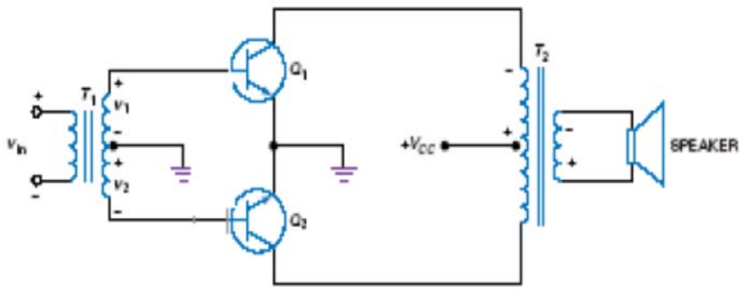
Draw the circuit diagram of class B push pull amplifier and discuss its merits. (13M) (NOV/DEC 2011) (APR/MAY 2010)(NOV/DEC'12) BTL2

Answer: Page 478- S. Salivahanan

Introduction: (2M)

- Push-pull - one transistor conducts - half a cycle - other -off, and vice versa.
- On - positive half cycle - input voltage, the secondary winding of T1 has voltage v1 and v2, as shown.
- The upper transistor conducts - lower one cuts off.
- The collector current through Q1flows - upper half of the output primary winding.
- This produces - amplified - inverted voltage, - transformer-coupled - loud speaker.
- On - next half cycle - input voltage, - polarities reverse. -lower transistor turns on - upper transistor turns off - lower transistor amplifies - signal, - alternate half cycle appears across the loudspeaker.
- Since each transistor amplifies one-half of the input cycle, the loud speaker receives - complete cycle - amplified signal.

Circuit Diagram: (4M)

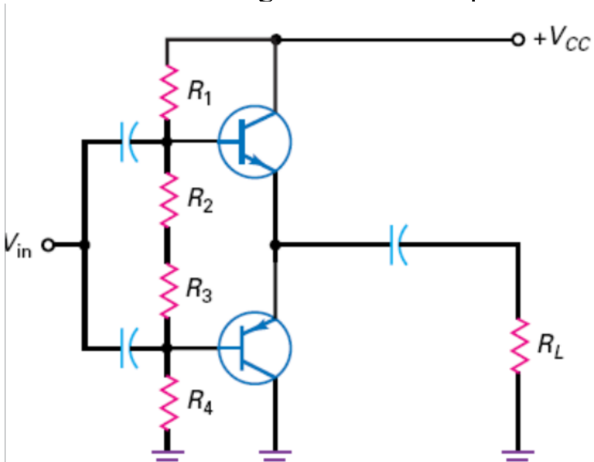


Class B advantages: (3M)

1. Much higher power conversion efficiency - class A - large signal amplitudes.
2. Zero power dissipation with zero input.

Class B Push-Pull Emitter Follower: (4M)

- Class B operation - collector current flows - only 180° -cycle.
- Q point - located - cutoff on both the dc and the ac load lines.
- The advantage of class B amplifiers is lower current drain – higher stage efficiency.



11 **Compare class A, class B and class C power amplifier in their performance and efficiency. (10M)** BTL2

Answer: Page 471- S. Salivahanan

Class A (4M)

- The Class A topology - one of the transistors - dc current source.
- capable of supplying the maximum audio current required by the speaker.
- Good sound quality - possible - Class A output stage
- power dissipation - excessive

Class B (4M)

- The Class B topology eliminates - dc bias current
- dissipates significantly less power.
- Its output transistors - individually controlled - push-pull manner
- This reduces -output stage power dissipation,
- The Class B circuit - inferior sound quality (2M)

Class	A	B	C
Conduction Angle in degrees	360	180	Less than 90
Position of Q point	Middle of DC load line	On X axis	Below X axis
Overall Efficiency	25 to 30%	70 to 80%	>80%
Signal Distortion	None if correctly biased	At X axis cross over point	Large amounts

12

Describe the operation of class c amplifier and derive the efficiency. (13M) BTL1

Answer: Page 484- S. Salivahanan

Introduction: (3M)

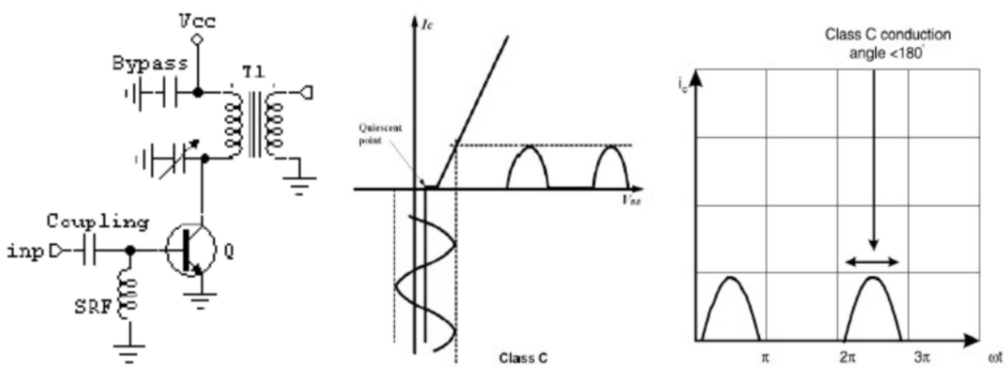
Less than 90-Conduction angle

Q point – On X axis

Efficiency - >80%

Circuit Diagram:

(4M)



It is an amplifier - conduction angle for the transistor is significantly less than 180°.

Operation: (6M)

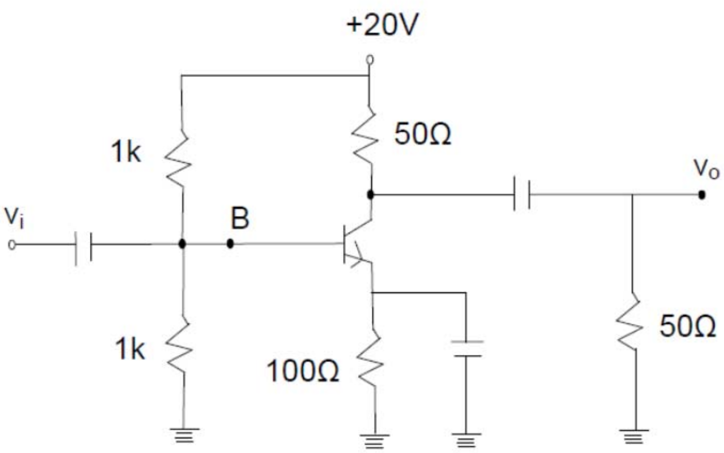
- The transistor - biased - under steady-state conditions - no collector current flows.
- The transistor idles - cut-off.
- linearity of the Class-C amplifier - poorest of the classes of amplifiers.
- The Efficiency of Class-C can approach 85 %, - much better - either the Class-B or the Class-A amplifier.
- To bias a transistor for Class-C operation, - necessary to reverse bias of base-emitter
- junction.
- External biasing - not needed

PART *C

1

Calculate maximum ac output power in the amplifier shown in fig. (Assume VBE = 0) (10M) BTL4

Answer: Page 474- S. Salivahanan



The ac power in class A-operation, P0 is given by the relation, (2M)

$$P_0 = \frac{V_{CEQ} \cdot I_{CQ}}{2}$$

$$I_{CQ} = I_E = \frac{V_{BB} - V_{BE}}{R_E} = \frac{V_{BB}}{R_E} = \frac{10V}{100\Omega} = 100\,mA$$

(3M)

$$V_{CC} = V_{CEQ} + I_E(R_C + R_E)$$

$$\text{Or, } V_{CEQ} = V_{CC} - I_E(R_C + R_E)$$

$$= 20 - 100\text{mA}\ (50 + 100)\Omega$$

$$= 20 - 15$$

$$\text{Or, } V_{CEQ} = 5V$$

(3M)

Therefore, maximum ac power, P_O,

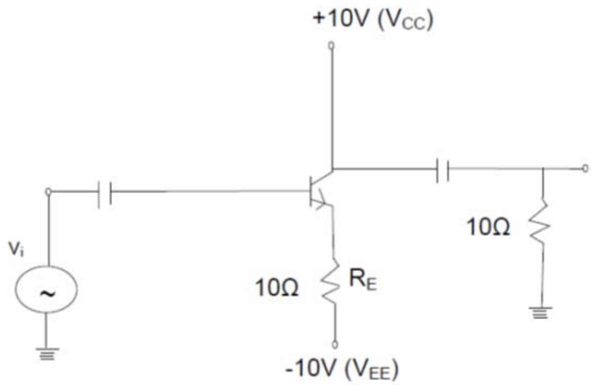
$$P_0 = \frac{V_{CEQ} \cdot I_{CQ}}{2} = \frac{5 \times 100\,mA}{2}$$

$$or\ \ P_0 = 250\,mW$$

(2M)

2 **Calculate maximum ac output power and efficiency of the amplifier shown in fig. VBE may be assumed negligibly small. (8M)** BTL4

Answer: Page 474- S. Salivahanan



$$I_{CQ} = I_E = \frac{|V_{EE}|}{R_E} = \frac{10V}{10\Omega} = 1A$$

(2M)

$V_{CEQ} = V_{CC} = 10V$

$$P_{0(max)} = \frac{V_{CEQ} . I_{CQ}}{2} = \frac{10 \times 1}{2} = 5W$$

(2M)

$$P_{DC} = |V_{CC}| + |V_{EE}| \ I_{CQ}$$
$$= (10+10) \times 1 = 20W$$

(2M)

$$\eta = \frac{P_{0(max)}}{P_{DC}} = \frac{5W}{20W} \times 100$$
$$or \ \eta = 25\%$$

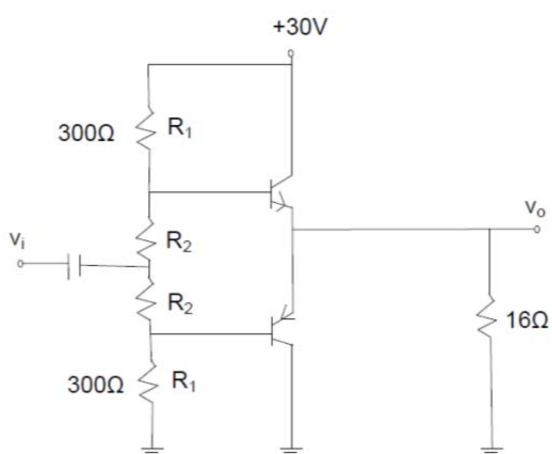
(2M)

3

Find out the value of resistor R2 to provide trickle current for distortion free output in the push pull amplifier shown in fig. VBE for each transistor is 0.7V. (8M) BTL4

Answer: Page 474- S. Salivahanan

Circuit Diagram: (2M)



Trickle current which flows through resistors R2 - produces a voltage drop of 0.7 V across base – emitter junction over comes cross – over distortion in push – pull amplifier.

For analysis purposes, - sufficient - consider only half of the circuit for reasons of symmetry, and

	VCC of half (= VCC/2 = 30/2 = 15V) is to be taken for one transistor. (2M) The current through resistors R1 and R2 is, $I = \frac{15V}{R_1 + R_2} = \frac{15V}{300\Omega + R_2}$ ....(A) (2M) I X R_2 = 0.7V (desired voltage) $or, I = 0.7V / R_2$ ....(B) (1M) $\frac{0.7V}{R_2} = \frac{15V}{300\Omega + R_2}$ $or, R_2 = 14.7\Omega$ (1M)

EC8491 COMMUNICATION THEORY L T P C
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OBJECTIVES:

The student should be made to:

- To introduce the concepts of various analog modulations and their spectral characteristics
- To understand the properties of random process
- To know the effect of noise on communication systems
- To study the limits set by Information Theory

UNIT I AMPLITUDE MODULATION 9

Amplitude Modulation- DSBSC, DSBFC, SSB, VSB - Modulation index, Spectra, Power relations and Bandwidth – AM Generation – Square law and Switching modulator, DSBSC Generation – Balanced and Ring Modulator, SSB Generation – Filter, Phase Shift and Third Methods, VSB Generation – Filter Method, Hilbert Transform, Pre-envelope & complex envelope –comparison of different AM techniques, Superheterodyne Receiver.

UNIT II ANGLE MODULATION 9

Phase and frequency modulation, Narrow Band and Wide band FM – Modulation index, Spectra, Power relations and Transmission Bandwidth - FM modulation –Direct and Indirect methods, FM Demodulation – FM to AM conversion, FM Discriminator - PLL as FM Demodulator.

UNIT III RANDOM PROCESS 9

Random variables, Random Process, Stationary Processes, Mean, Correlation & Covariance functions, Power Spectral Density, Ergodic Processes, Gaussian Process, Transmission of a Random Process Through a LTI filter.

UNIT IV NOISE CHARACTERIZATION 9

Noise sources – Noise figure, noise temperature and noise bandwidth – Noise in cascaded systems. Representation of Narrow band noise –In-phase and quadrature, Envelope and Phase – Noise performance analysis in AM & FM systems – Threshold effect, Pre-emphasis and de-emphasis for FM.

UNIT V SAMPLING & QUANTIZATION 9

Low pass sampling – Aliasing- Signal Reconstruction-Quantization - Uniform & non-uniform quantization - quantization noise - Logarithmic Companding –PAM, PPM, PWM, PCM – TDM, FDM.

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course, the student should be able to:

- Design AM communication systems
- Design Angle modulated communication systems
- Apply the concepts of Random Process to the design of Communication systems
- Analyze the noise performance of AM and FM systems
- Gain knowledge in sampling and quantization

TEXT BOOK:

1. J.G.Proakis, M.Salehi, ―Fundamentals of Communication Systems‖, Pearson Education 2014. (UNIT I-IV).
2. Simon Haykin, ―Communication Systems‖, 4th Edition, Wiley, 2014.(UNIT I-V).

REFERENCES:

1. B.P.Lathi, ―Modern Digital and Analog Communication Systems‖, 3rd Edition, Oxford University Press, 2007.
2. D.Roody, J.Coolen, ―Electronic Communications, 4th edition PHI 2006.
3. A.Papoulis, ―Probability, Random variables and Stochastic Processes‖, McGraw Hill, 3rd edition, 1991.
4. B.Sklar, ―Digital Communications Fundamentals and Applications‖, 2nd Edition Pearson Education 2007.
5. H P Hsu, Schaum Outline Series - ―Analog and Digital Communications‖ TMH 2006
6. Couch.L., "Modern Communication Systems", Pearson, 2001.

Subject Code: EC8491 **Year/Semester: II /04**
Subject Name: COMMUNICATION THEORY **Subject Handler: Mrs. M.Benisha**

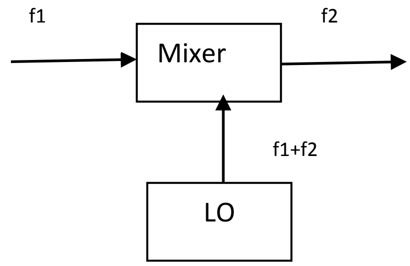
UNIT I - AMPLITUDE MODULATION

Amplitude Modulation- DSBSC, DSBFC, SSB, VSB - Modulation index, Spectra, Power relations and Bandwidth – AM Generation – Square law and Switching modulator, DSBSC Generation – Balanced and Ring Modulator, SSB Generation – Filter, Phase Shift and Third Methods, VSB Generation – Filter Method, Hilbert Transform, Pre-envelope & complex envelope –comparison of different AM techniques, Superheterodyne Receiver.

PART * A

Q.No	Questions
1	**Why DSB-SC AM is bandwidth inefficient when compared with side band AM? (April/May 2019)** BTL2 • In DSB-FC AM (Contains 2 side bands USB & LSB and the carrier) requires 2fm bandwidth. • In SSB SC AM (Contains One side band and suppressed carrier and other side band) requires only fm bandwidth, which is half compared to the DSB FC. Hence it is more efficient than DSB- FC. • Thus DSB-SC AM is bandwidth inefficient when compared with side band AM.
2	**Mention any four advantages of having RF Amplifier at AM Receiver. (April/May 2019)** BTL2 It is more advantageous of having RF Amplifier at AM Receiver because, • The RF amplifiers have greater gain that is they have better sensitivity. • They have better ability to amplify weak signals received by the receiver. • The RF amplifiers have better selectivity i.e., better ability to select the wanted signals among the various incoming signals. • Better Signal to Noise Ratio. (SNR)
3	**What are the advantages of converting the low frequency signal into high frequency signal? Does the modulation technique decide the antenna height? (Nov/Dec 2016) (Apr/May 2017) (Nov/Dec2018)** BTL2 • The antenna needed for transmitting signals should have size at least λ/4, where, λ is the wavelength. The information signal, also known as baseband signal is of low frequency (and therefore the wavelength is high). If we need to transmit such a signal directly, the size of the antenna will be very large and impossible to build. Hence direct transmission is not practical. • The radiated power by an antenna is inversely proportional to the square of the wavelength. So, if we use high frequency signals, the power radiated will be increased. • If we transmit the baseband signals directly, the signals from different transmitters will get mixed up and the information will be lost.
4	**An amplitude modulation transmitter radiates 100 watts of unmodulated power. If the carrier is modulated power. If the carrier is modulated simultaneously by two tons of 40% and 60% respectively, calculate the total power radiated.** BTL2 $m_t = \sqrt{m_1^2 + m_2^2} = \sqrt{0.6^2 + 0.4^2} = 0.73$ $P_t = P_c\left(1 + \frac{m^2}{2}\right) = 127$ watts $P_c = unmodulated\ carrierpower,\ p_t = total\ power, m = modulation\,index$

5 **Calculate the local oscillator frequency if incoming frequency is f_1 and translated carrier frequency is f_2.** BTL2



6 **Define modulation and what is the need for modulation?** BTL1

Modulation:

Modulation is a process by which some characteristics of high frequency carrier signal is varied in accordance with the instantaneous value of the modulating signal.

Need for modulation:

Ease of transmission, Multiplexing, Reduced noise, Narrow bandwidth, Frequency assignment, Reduce the equipments limitations.

7 **What are the types of analog modulation?** BTL1

Amplitude modulation, Angle Modulation- Frequency modulation, Phase modulation.

8 **Define depth of modulation and list what are the degrees of modulation?** BTL1

Depth of modulation:

It is defined as the ratio between message amplitude to that of carrier amplitude. $m=E_m/E_c$.

Degrees of modulation:

- Under modulation. $m<1$,
- Critical modulation $m=1$,
- Over modulation $m>1$

9 **What is single tone and multi tone modulation?** BTL1

If modulation is performed for a message signal with more than one frequency component then the modulation is called multi tone modulation. If modulation is performed for a message signal with one frequency component then the modulation is called single tone modulation.

10 **Compare AM with DSB-SC and SSB-SC.(MAY2014) (Ap/May 2018)** BTL2

S.No	AM	DSB-SC	SSB-SC
1	Transmission Bandwidth $B_T = 2f_m$	Transmission Bandwidth $B_T = 2f_m$	Transmission Bandwidth $B_T = f_m$
2	Contains two sidebands	Contains two sidebands	Contains only one sideband
3	Consumes large power $P_T = P_C + P_{USB} + P_{LSB}$	Consumes less power than AM $P_T = P_{USB} + P_{LSB}$	Consumes less power than AM,DSB-SC , $P_T = P_{USB}$

11 **What are the advantages of VSB-AM?** BTL2

It has bandwidth greater than SSB but less than DSB system. Power transmission greater than DSB but less than SSB system. No low frequency component lost. Hence it avoids phase distortion.

12 **Compare linear and non-linear modulators.** BTL2

Linear modulators	Nonlinear modulators
Heavy filtering is not required	Heavy filtering is required
These modulators are used in high level modulation.	These modulators are used in low level modulation.

13 **How will you generate DSBSC-AM?** BTL1

There are two ways of generating DSBSC-AM such as balanced modulator, ring modulators.

14 **What are advantages of ring modulator?** BTL2

Its output is stable. It requires no external power source to activate the diodes. Virtually no maintenance. Long life.

15 **Define demodulation.** BTL1

Demodulation or detection is the process by which modulating voltage is recovered from the modulated signal. It is the reverse process of modulation.

16 **What are the types of AM detectors?** BTL1

Nonlinear detectors, Linear detectors

17 **What are the types of linear detectors?** BTL1

Synchronous or coherent detector, Envelope or non-coherent detector.

18 **Define multiplexing.** BTL1

Multiplexing is defined as the process of transmitting several message signals simultaneously over a single channel.

19 **A broadcast radio transmitter radiates 5 kW power when the modulation percentage is 60%. How much is the carrier power?** BTL2

$$P_t = P_c\left(1+\frac{m^2}{2}\right)$$

$$P_c = \frac{P_t}{\left(1+\frac{m^2}{2}\right)} = \frac{5000}{\left(1+\frac{0.6^2}{2}\right)} = 4237.28W$$

20 **What is the relationship between total power in AM wave and unmodulated carrier power?** BTL2

$$P_t = P_c\left(1+\frac{m^2}{2}\right)$$

$P_c = unmodulated\ carrier\ power,\ p_t = total\ power,\ m = modulation\ index$

21 **What is the relationship between total current in AM wave and unmodulated carrier current?** BTL2

$$I_t = I_c\sqrt{\left(1+\frac{m^2}{2}\right)}$$

$I_t = total\ current,\ I_c = unmodulated\ carrier\ cuurent,\ m = modulation\ index$

22 **What are the two major limitations of the of amplitude modulation (DSBFC) ?** BTL2

Total power in the DSBFC AM signal is more. Bandwidth required for DSBFC AM signal is more. If carrier and one of the side band is suppressed, we will have considerable power saving and reduction in bandwidth requirement.

23 **An unmodulated carrier is modulated simultaneously by three modulating signals with coefficients of modulation m1 = 0.2, m2 = 0.4, m3 = 0.5. Determine the total coefficient of modulation.** BTL2

$$m_t = \sqrt{m_1^2 + m_2^2 + m_3^2} = \sqrt{0.2^2 + 0.4^2 + 0.5^2} = 0.67$$

24	**What is frequency translation?** BTL1 Suppose that a signal is band limited to the frequency range extending from a frequency f1 to a frequency f2. The process of frequency translation is one in which the original signal is replaced with a new signal whose spectral range extends from f1' to f2'and which new signal bears, in recoverable form the same information as was borne by the original signal.
25	**What are the two situations identified in frequency translations?** BTL1 The two situations identified in frequency translation are Up conversion and down conversion .In up conversion; the translated carrier frequency is greater than the incoming carrier frequency. In Down conversion, the translated carrier frequency is smaller than the incoming carrier frequency. Thus, a narrowband FM signal requires essentially the same transmission bandwidth as the AM signal.
26	**What is Hilbert transform?** BTL1 It is a peculiar sort of filter that changes the phase of the spectral components depending on the sign of their frequency. It only effects the phase of the signal. It has no effect on the amplitude at all The **Hilbert transform** $\hat{x}(t)$ of a signal $x(t)$ is defined by the equation $$\hat{x}(t) = \frac{1}{\pi}\int_{-\infty}^{\infty} \frac{x(s)}{t-s}\,ds,$$
27	**Mention the properties of Hilbert transform? BTL1** A signal $x(t)$ and its Hilbert transform $\hat{x}(t)$ have 1).the same amplitude spectrum 2).the same autocorrelation function 3). $x(t)$ and $\hat{x}(t)$ are orthogonal 4).The Hilbert transform of $\hat{x}(t)$ is $-x(t)$
28	**What is pre envelope? (May/June 2016).** BTL1 The **pre envelope** of a real signal $x(t)$ is the complex function $\boldsymbol{x_{+}(t) = x(t) + j\,\hat{x}(t)}$. The pre envelope is useful in treating band pass signals and systems.
29	**What is complex envelope? (May/June 2016).** BTL1 The complex envelope of a band pass signal $x(t)$ is $\mathrm{x}(t) = x(t)\ e^{-j2\pi fct}$
30	**What are the advantages of super heterodyne receiver over TRF?** BTL2 The advantages of super heterodyne receiver over TRF are high selectivity, improved sensitivity throughout the carrier frequency band. It eliminates image frequency.
31	**Define selectivity and sensitivity of a radio receiver.** BTL1 **Selectivity:** It is the ability of the receiver to accept a given band of frequencies and reject all others. **Sensitivity:** It is the ability of the receiver to pick up weak signals and amplify them. It is defined in terms of the voltage that must be applied to the receiver input terminals to give the standard output power. It is usually expressed in micro volts.
32	**Mention the drawbacks of coherent detector. (April/May 2018)** BTL01
33	**Define the term fidelity of a radio receiver.** BTL21Fidelity is a measure of the ability of a receiver to reproduce an exact replica of the original source information .i.e., fidelity is the ability of a receiver to reproduce faithfully all frequency components present in the base band signal
34	**For an AM system the instantaneous values of carrier & modulating signal are 60 sin ($2\pi f_c$t) & 40 sin($2\pi f_m$t), Determine the modulation index**? BTL2 $m_a = \frac{E_m}{E_c} = \frac{40}{60}$=0.66
35	**A carrier of 6KV is amplitude modulated by an audio signal of 3KV. Find Modulation Index. (Nov/Dec 2018)** BTL2 $m_a = \frac{E_m}{E_c} = \frac{6}{3} = 2$

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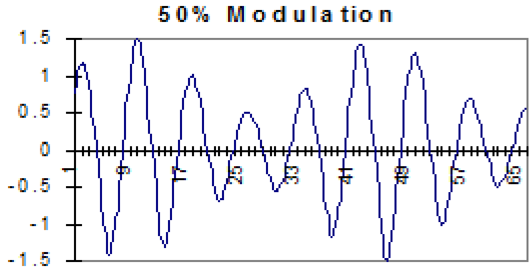
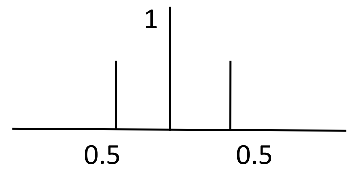
Draw the AM wave for modulation index =0.5 and its spectra. (May 2015). BTL2





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Define heterodyning (May 2015) (Nov/Dec 2018). BTL1
Heterodyning -To combine a radiofrequency wave with a locally generated wave of different frequency. Inorder to produce a new frequency equal to the sum or difference of the two, also called as frequency conversion, is used very widely in communications engineering to generate new frequencies and move information from one frequency channel to another.

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What is the advantage of conventional DSB-AM over DSB-SC and SSB-SC AM? (Nov/Dec 2015) BTL2
The receivers for conventional DSB-AM are simple and detection is easier.

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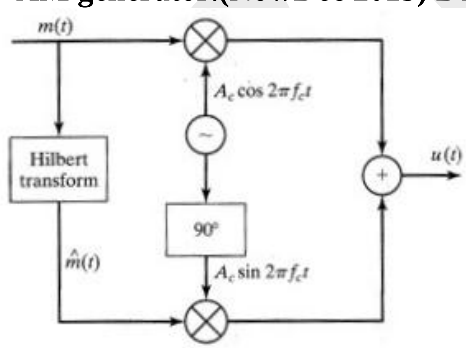
Draw the block diagram of SSB-AM generator.(Nov/Dec 2015) BTL2



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What theorem is used to calculate the ave age power of a periodic signal $g_p(t)$? State the theorem. (May/June 2016). BTL2
Parseval's theorem represents the average power P of the function $x(t)$ given by

$$P = \int_{-\infty}^{\infty} \lim_{\tau\to\infty} \frac{|X_t(\omega)|^2}{\tau} df$$

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Suggest a modulation scheme for the broadcast video transmission and justify.(Nov2016) BTL2
VSB is preferred for TV transmission because of reduced bandwidth of modulation system and most of the required data present after modulation occupy the space near the carrier frequency Fc.

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PART * B

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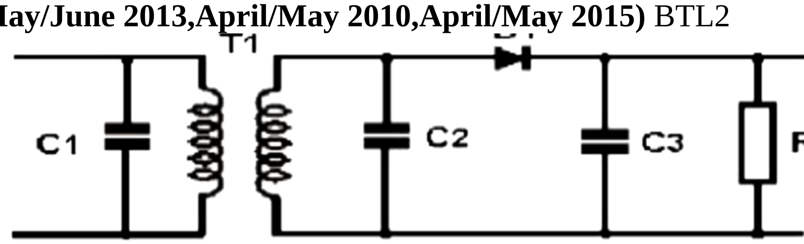
Draw an envelope detector circuit used for demodulation of AM and explain its operation (May/June2012,May/June 2013,April/May 2010,April/May 2015) BTL2



Diode Detector or Envelope Detector

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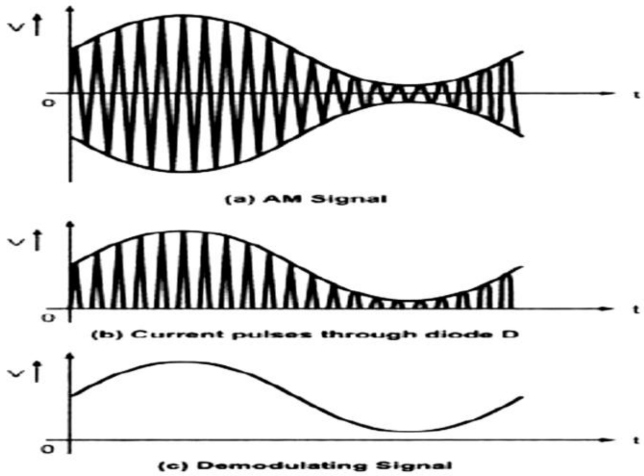
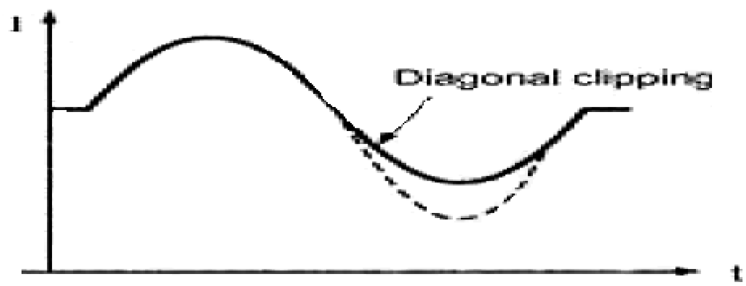
half wave rectified - detector diode
capacitor reconstructs - original modulating signal, high frequency carrier removed

Negative peak clipping in diode detector

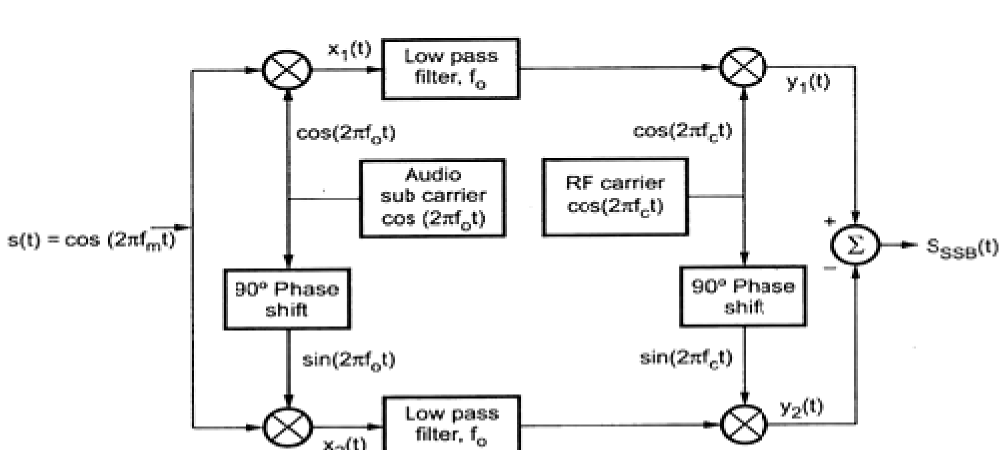


modulation index - E***m*** /E***c.***
I_m = E***m*** /Z***m***, I_c = E***c*** /R***c***
over modulation effect

Diagonal Clipping in Diode Detector
Zm - purely resistive
distortion - detected signal



2 **How SSB can be generator using Weavers method? Illustrate with a neat block diagram**. **(May/June2012) or Third Method of SSB Generation.** BTL2
Principle: two carriers - audio subcarrier at fo – RF carrier at fc
Block diagram and operation



	Input s(t) = cos(2пfmt)

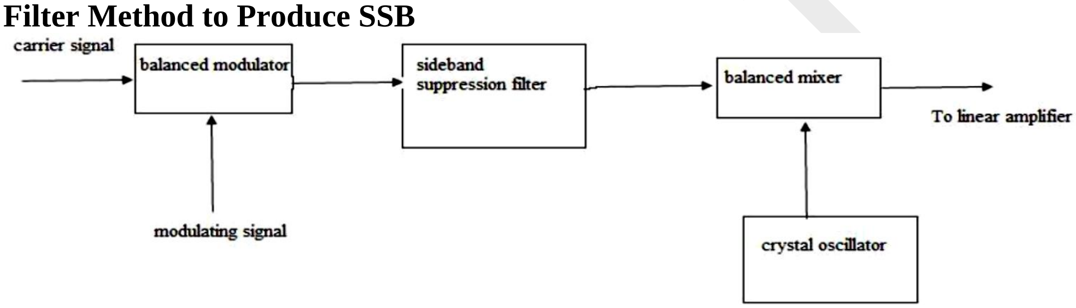
Explain The Filter Method And Phase Shift Method To Produce SSB. (Or)
Explain the working of a SSB transmitter and receiver. (or) Name the methods used for the suppression of unwanted side band in AM transmission? Discuss the working of any one BTL2

SSB – SC – AM waves can by generate - two ways.
1. Frequency discrimination (or) Filler method
2. Phase discrimination method.

Phase discrimination method
1. Phase shift method.
2. Modified phase shift (or) weaver's method.

Suppression of Unwanted Sideband
(i) filter method,
(ii) phase shift method and
(iii) The 'third' method.

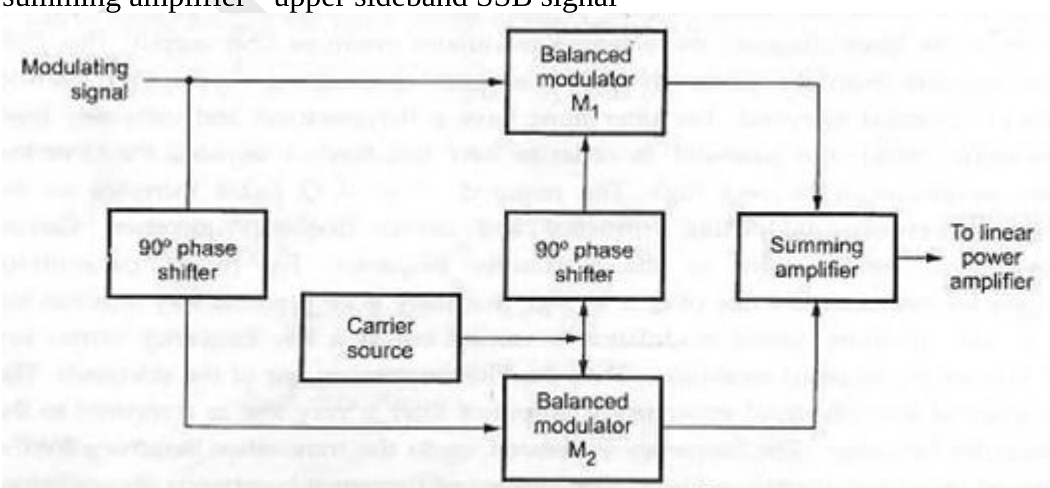
Filter Method to Produce SSB



DSB output - both the sideband
balanced modulator - frequency booting – up conversion
SSB signal - frequency equal to - transmitter frequency - amplified by linear amplifiers

Phase Shift Method to Generate SSB
balanced modulators - (+90, -90)

summing amplifier - upper sideband SSB signal



3

Compare various Amplitude modulation System (May/june2012) BTL2

Description	**AM with carrier**	**DSB – SC – AM**	**SSB – SC- AM**	**VSB – AM**
Band width	2fm	2fm	fm	fm <BW<2fm
Power Saving for Sinusoidal	33.33%	66.66%	83.3%	75%
Power Saving for non - Sinusoidal	33.33%	50%	75%	75%
Generation methods	Easier to generate	Not difficult	More difficult to generate	Difficult. But to easier generate than SSB-SC
Detection methods	Simple & Inexpensive	Difficult	More difficult	Difficult

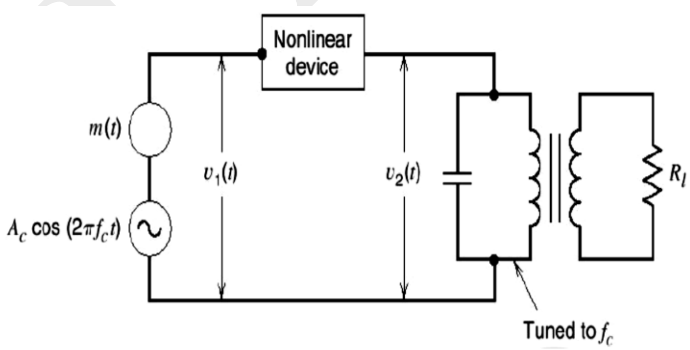
4

Define Amplitude modulation. How an amplitude modulated signal can be generated using a nonlinear modulated circuit (Nov/Dec 2012, NOV/DEC 2016) BTL2

Amplitude modulation - amplitude - carrier signal - varied - instantaneous value -modulating signal, frequency, phase remains - constant

Non linear modulator circuits:
Types: square law modulator - Balance modulator
Square law modulators:
operated - nonlinear region - output characteristics
capable - amplitude modulated waves - carrier and modulating signals - fed input.
Eg: transistor, a triode tube,a diode

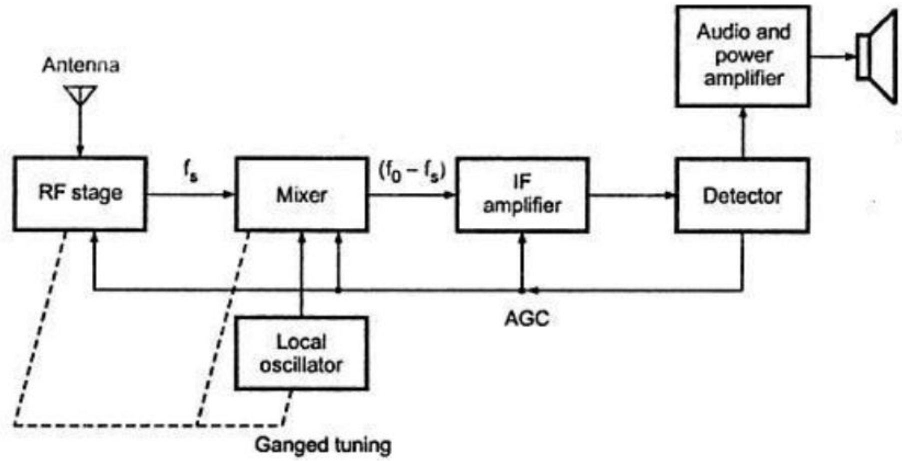
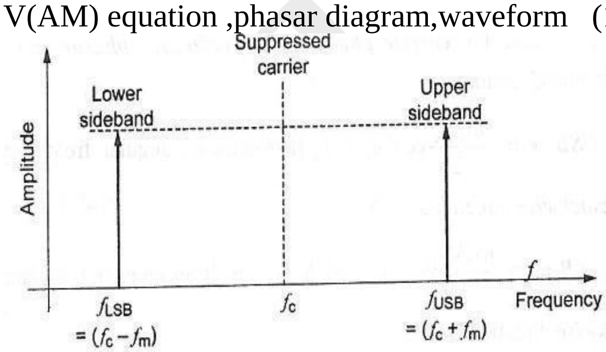
(i) A non linear device
(ii) A bandpass filter
(iii)A carrier source and modulating signal

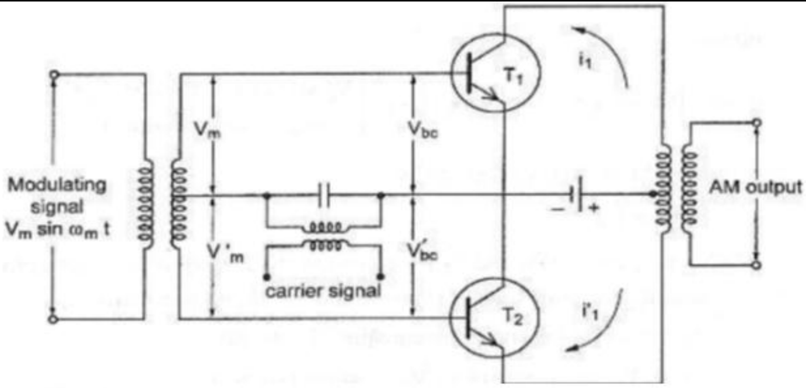


Carrier : c(t)= A **cos(2Π *fct*)**

$$V_{in} = c(t) + m(t)$$
$$V_{in} = A_c \cos 2\pi f_c t + m(t)$$
$$V_0 = a_O + a_1 V_{in} + a_2 V_{in}^2$$

8	$V_0 = a_O + a_1 V_{in} + a_2 V_{in}^2$ $V_0(f) = (a_0 + \frac{a_2 A_c^2}{2})\delta(f) + \frac{a_1 A_c}{2}[\delta(f - f_c) + \delta(f + f_c)] + a_1 M(f) +$ $\frac{a_2 A_c^2}{4}[\delta(f - 2f_c) + \delta(f + 2f_c)] + a_2 M(f) + a_2 A_c [M(f - f_c) + M(f + f_c)]$ square law device lower cutoff frequency - 2W and (fc - W) Upper cut-off frequency - (fc+W) and 2fc $V_0 = a_0 + a_1[A_c \cos 2\pi f_c t + m(t)] + a_2[A_c \cos 2\pi f_c t + m(t)]^2$ $V_0 = a_0 + a_1 A_c \cos 2\pi f_c t + a_1 m(t) + \frac{a_2 A_c^2}{2}(1 + \cos 4\pi f_c t) + a_2[m(t)]^2 + 2a_2 m(t) A_c \cos 2\pi f_c t$ $V_0 = a_0 + a_1 A_c \cos 2\pi f_c t + a_1 m(t) + \frac{a_2 A_c^2}{2} \cos 4\pi f_c t + a_2 m^2(t) + 2a_2 m(t) A_c \cos 2\pi f_c t$
6	**Explain in details the generation and demodulation of DSB-SC with simple diagram. (April/May 2019)**
7	**A 10KW carrier power is amplitude modulated at 80% depth of modulation by a sinusoidal signal. Calculate the side band power, total power and transmission efficiency of the AM Wave. (April/May 2019)**
8	**A Transmitter radiates 1200w of power under carrier conditions. If this carrier is modulated simultaneously by two tones of 35% and 50% respectively. Determine the total power radiated?** BTL5 Depth of modulation m1=0.35, m2=0.50 $$P_{mod} = P_c \left[1 + \frac{m_1{}^2}{2} + \frac{m_2{}^2}{2}\right]$$ $$P_{mod} = 1423.5\ w$$
9	**A signal is transmitted through a 10 km co-axial line channel which exhibits a loss of 2 dB/km. The transmitted signal power is P1 dB = -30 dBw means 30 db below 1 Watts or simply one milliwatt). Determine the received signal power and the power at the output of an amplifier that has an gain of Gdb = 15 dB.** BTL5 $$P_R = P_T\ dB - L\ dB = -50\ dbW$$ $$P_o dB = P_R dB + G\ dB = -35\ dbW$$
10	**Explain With Block Diagram Super Heterodyne Receiver? (April/May 2015, May/June 2016, April/May 2019)** BTL2

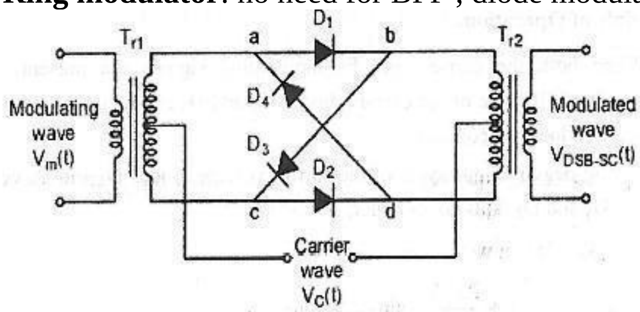
	 (2M) **Definition:** process of mixing two signals - different frequencies - produce new frequency (2M) **RF** - tuned carrier frequency - incoming wave. (preselector & amplifier) (2M) **MIXER** -hetrodyning function (455kHz) (2M) **CONVERTER**-Local oscillator frequency, signal frequency,image signal frequency (1M) IFRR=$\frac{Gain\ at\ the\ signal\ frequency}{Gain\ at\ the\ image\ frequency}$ (1M) **IF/DEMODULATOR**—the output is only audio frequencies (1M) **Advantages** (2M) o variation in BW, high sesitivitiy and selectivity, high adjacent channel variations, improved stabitlity, higher gain, uniform BW
11	**With The Help Of Neat Diagram Explain The Generation Of DSB-SC Using Balanced Modulator And Ring Modulator. (Nov/Dec 2010, MAY/JUNE 2016,NOV/DEC 2016)** BTL2 **DSB-SC :** BW=2fm (only upper and lower sidebands) (1M) **DSB-SC generation diagram** (1M) V(AM) equation ,phasar diagram,waveform (1M)  **Types** : balanced modulator ,Ring modulator (1M) **Balanced Modulator** – Two transistor are identical and the circuit is symmetrical (2M)



$V_{bc} = V_{c\,(t)} + V_{m(t)}$ ---- inphase , $V_{bc}" = V_{c\,(t)} + V"_{m(t)}$ ---- outphase

Output voltage V_0 = 2Ka_1 V_m [1+ m_a Cos ω_ct] Cos ω_mt (2M)

Ring modulator: no need for BPF , diode modulator (1M)

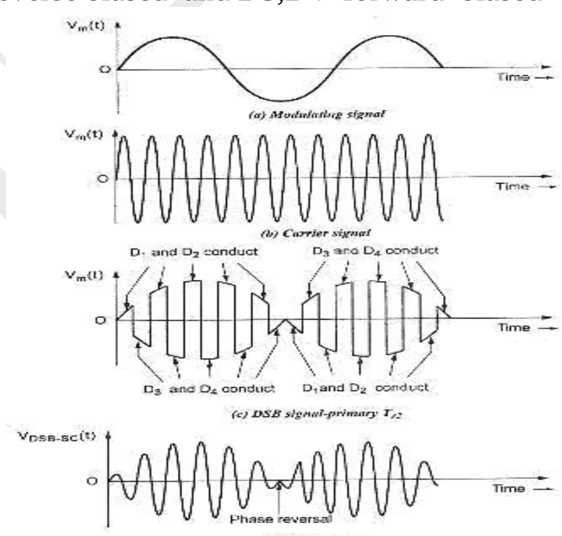


Positive Half Cycle of Carrier

positive halfcycle-D1,D2-Forward device and D3,D4- reverse biased -magnetic field cancel each other

Negative Half Cycle of Carrier

Negative half cycle ,D1,D2-reverse biased and D3,D4- forward biased -opposite magnetic field. (1M)



Advantages – more efficient , better SNR (1M)

Disadvantages- BW of DSB-SC remain same as AM (2M)

PART * C

1 **A signal with the bandwidth 4 KHz is to be transmitted distance of 200 km over a wideline channel that has an attenuation of 2 dB/km.**

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a) Determine the transmitter power PT required to active an SNR of (S/N) = 30 dB at the output of the receiver amplifier that has a noise figure Fa dB = 5 dB

b) Repeat the calculation when a repeater is inserted every 10 km is wireline channel. Where the repeater has a gain of 20 db and noise figure Fa=5dB. Assume that the noise equivalent bandwidth of each repeater Bneq = 4 kHz and that N0 = 4 *10^-21 W/Hz BTL5

a)

$$P_T = \left(\frac{S}{N}\right) dB + F_a\, dB + 10\log L + \left(N_0\, B_{req}\right) dB$$

$$P_T = 30 + 5 + 400 - 168 = 267\, dB = 5 * 10^{26}\, Watts$$

b)

$$\left(\frac{S}{N}\right) dB = -10\log k + 10\, log\, P_T - 10\, log\, F_a - 10\log L - 10\, log\, \left(N_0\, B_{req}\right) dB$$

$$30 = -13 - 20 - 5 + 168 + P_T\, dB = 10^{-10}\, Watts$$

$$P_T\ must\ be\ incresed\ by\ 3\ dB$$

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Draw the VSB spectrum and explain the significance (May/June2013) (April/May 2019) BTL2

compromise between DSB and SSB

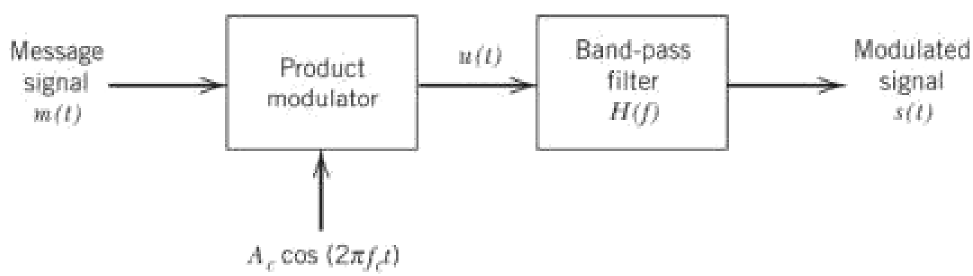
bandwidth - slightly 25 percent

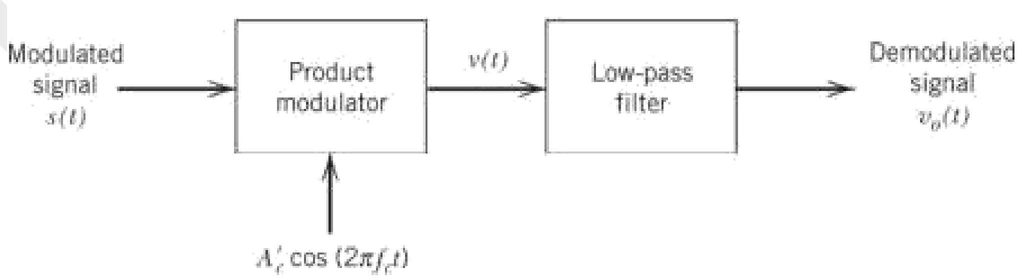
Greater than - SSB signals.

roll-off characteristic – partial transmission of the corresponding part of the suppressed sideband

S(f) = U(f) H(f)

$$\mathrm{S(f)} = \frac{A_c}{2}\left[M\,(f - f_c) + M\,(f + f_c)\right] H(f)$$





Filtering scheme of the generation of VSB modulated wave Spectrum of VSB SC

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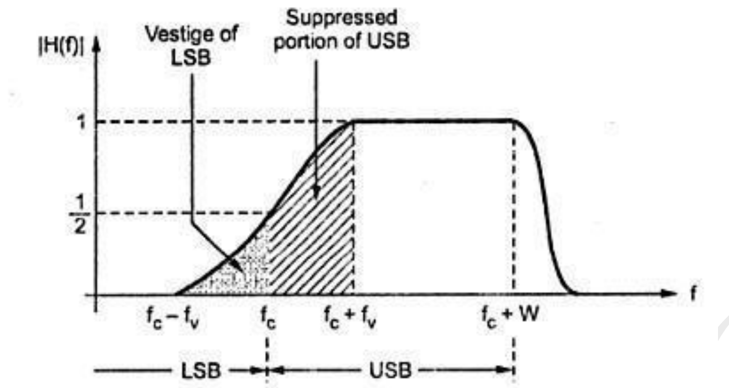


Amplitude response of VSB filter:

$$H\,(f - f_c) + H\,(f + f_c) = 1, -W \le f \le W$$

3

What is DSB_SC signal? Write the working of a synchronous detector used to detect the DSB_SC signal with the output amplitude spectrum of each block (Nov/Dec2012) BTL2

DSB-SC : -BW=2fm (only upper and lower sidebands) (1M)

DSB-SC generation diagram (1M)

V(AM) equation ,phosar diagram,waveform (1M)

Types : balanced modulator ,Ring modulator (1M)

Balanced Modulator – Two transistor are identical and the circuit is symmetrical (2M)

$V_{bc} = V_{c\,(t)} + V_{m(t)}$ ---- inphase , $V_{bc}" = V_{c\,(t)} + V"_{m(t)}$ ---- outphase

Output voltage V_0 = 2Ka$_1$ V_m [1+ m$_a$ Cos ω_{c}t] Cos ω_{m}t (2M)

Ring modulator: no need for BPF , diode modulator (1M)

positive halfcycle-D1,D2-Forward device and D3,D4- reverse biased -magnetic field cancel each other and negative half cycle ,D1,D2-reverse biased and D3,D4- forward biased -opposite magnetic field (1M)

Advantages – more efficient , better SNR (1M)

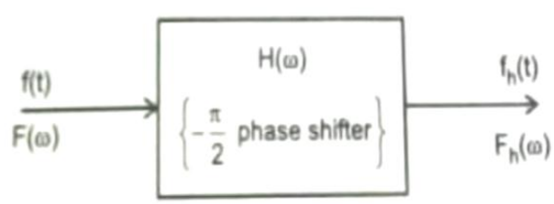
Disadvantages- BW of DSB-SC remain same as AM
(2M)

4

Explain Hilbert Transform With An Example. (APRIL/MAY 2015) BTL2

Hilbert Transform

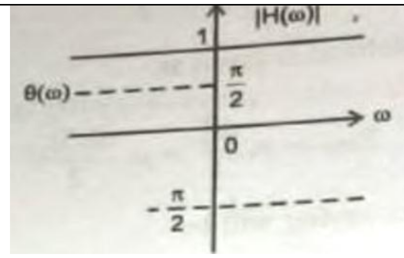
f(t) is shifted by (-π/2)



Characteristics

i. H(ω) = 1

ii. phase of the positive frequency components if shifted by -π/2



Properties:

1. Signal f(t) - Hilbert transform - same magnitude spectrum.
2 Signal f(t) - Hilbert transform - same energy density spectrum.
3 Hilbert transform fh(t) is –f(t)

$$H[f(t)] = f_H(t)$$
$$H[f_H(t)] = -f(t)$$

4. Signal f(t) - Hilbert transform fh(t) - orthogonal interval (-∞,∞)

$$\int_{-\infty}^{\infty} f(t)\, f_H(t)\, dt = 0$$

5. Signal f(t) - Hilbert transform fh(t) - same auto correlation function.

Application

Generation of SSB signal

- Design of minimum phase type filters
- Representation of band pass signals
  1. $\cos \omega_c t \rightarrow \sin \omega_c t$
  2. $\sin \omega_c t \rightarrow \cos \omega_c t$
  3. $\sin(\omega_c t + \theta) \rightarrow \cos\left(\omega_c t + \theta - \frac{\pi}{2}\right)$
  4. $\mathrm{m(t)c(t)} \rightarrow \mathrm{m(t)}^n\ \mathrm{c(t)}$

5 **A message signal m(t) =cos2000□ t+2cos4000□ t modulates the carrier c(t)=100cos 2□ fct, where fc=1KHz to produce DSB signal m(t)*c(t).**

1. **Determine the expression for USB Signal**
2. **Determine and sketch the spectrum of USB Signal. (April/May 2019)**

UNIT II - ANGLE MODULATION

Phase and frequency modulation, Narrow Band and Wide band FM – Modulation index, Spectra, Power relations and Transmission Bandwidth - FM modulation –Direct and Indirect methods, FM Demodulation – FM to AM conversion, FM Discriminator - PLL as FM Demodulator

PART * A

Q.No	Questions
1.	**Define modulation index, with reference to FM and PM. (MAY 2013)(Nov2017)** Modulation index is the ratio of frequency deviation and modulating signal frequency. $m = \frac{\Delta f}{f_m}$ Δf = frequency deviation (Hz), f_m = modulating signal frequency (Hz)
2	**Why FM is preferable for voice Transmission?(MAY 2014)** In FM modulation the amplitude components do not get affected, so preferable for voice transmission.
3	**How is the Narrow band FM converted into Wideband FM?** The narrowband FM is converted to wideband FM with the help of frequency multiplier. The frequency multiplier increases the frequency deviation as well as carrier frequency. It is called indirect method because FM is generated from PM. Advantages: 1) FM is generated from PM indirectly. 2) Modulation takes place at low carrier frequency.
4	**Define deviation ratio.** It is the **worst-case modulation index** which is the ratio of maximum permitted frequency deviation and maximum modulating signal frequency. Deviation ratio = $m = \frac{\Delta f_{max}}{f_{m_{max}}}$
5	**State Carson's rule for determining approximate Band Width of FM signal. (Nov/Dec 2015)** $Bandwidth = 2(\Delta f + f_{m\,max})$Hz, Δf = frequency deviation (Hz),$f_{m(max)}$ = highest modulating signal frequency (Hz)
6	**A carrier frequency is frequency modulated with a sinusoidal signal of 2 KHz resulting in a maximum frequency deviation of 5 KHz. Find the approximate band width of the modulated signal. (NOV 2013)(May 2015)** Δf = frequency deviation (Hz) = 5 KHz, $f_{m(max)}$ = highest modulating signal frequency(Hz) = 2 KHz,$Bandwidth = 2(\Delta f + f_{m\,max})$Hz =2(5KHz + 2KHz)=14 KHz
7	**Determine the modulation index of a FM system with a maximum frequency deviation of 75 KHz and maximum modulating frequency of 10 KHz.** $m = \frac{\Delta f_{max}}{f_{m_{max}}} = \frac{75KHz}{10KHz}$ =7.5
8	**Distinguish between narrow band FM and wide band FM. (April May 2019) (April May 2018)**

Narrow band FM	Wide band FM
Frequency deviation in car ier frequency is small	Frequency eviation in carrier frequency is large
Bandwidth is twice the highest modulating frequency	Band width is calculated as per Carson's rule

Q.No	Questions
9	**What are the advantages of FM over AM?**

S.No	AM	FM

	<table><tr><td>**1**</td><td>The modulation is directly proportional to modulation voltage AM and inversely proportional to frequency</td><td>The modulation index is proportional to amplitude as well as phase</td></tr><tr><td>**2**</td><td>There are three components in AM. They are carrier USB, LSB.</td><td>They are many frequency components in FM signal.</td></tr><tr><td>**3**</td><td>Power depends on the sideband</td><td>Total power remains constant.</td></tr><tr><td>**4**</td><td>The bandwidth required is less compared to FM signal and is equal to 2fm.B.W=2fm</td><td>Theoretically bandwidth of FM signal is infinite</td></tr></table>
10	**Define phase modulation**. Phase modulation is defined as the process of changing the phase of the carrier signal in accordance with the instantaneous amplitude of the message signal.
11	**What are the types of Frequency Modulation?.** Based on the modulation index FM can be divided into types. They are Narrow band FM and Wide band FM. If the modulation index is greater than one then it is wide band FM and if the modulation index is less than one then it is Narrowband FM
12	**What is the basic difference between an AM signal and a narrowband FM signal?** In the case of sinusoidal modulation, the basic difference between an AM signal and a narrowband FM signal is that the algebraic sign of the lower side frequency in the narrow band FM is reversed.
13	**What are the two methods of producing an FM wave?** Basically there are two methods of producing an FM wave. They are i) Direct method - In this method the transmitter originates a wave whose frequency varies as function of the modulating source. It is used for the generation of NBFM ii) Indirect method-In this method the transmitter originates a wave whose phase is a function of the modulation. Normally it is used for the generation of WBFM where WBFM is generated from NBFM.
14	**Give the average power of an FM signal.** The amplitude of the frequency modulated signal is constant .The power of the FM signal is same as that of the carrier power.$P = \frac{1}{2}E_c^2$.
15	**Define phase deviation.** The maximum phase deviation of the total angle from the carrier angle is called phase deviation.
16	**Define frequency Deviation.** The maximum departure of the instantaneous frequency from the carrier frequency is called frequency deviation.
17	**What is the use of crystal controlled oscillator?** The crystal-controlled oscillator always produces a constant carrier frequency thereby enhancing frequency stability.
18	**What are the disadvantages of FM system?** A much wider channel is required by FM. FM transmitting and receiving equipments tend to be more complex and hence it is expensive
19	**How will you generate message from frequency-modulated signals?** First the frequency-modulated signals are converted into corresponding amplitude modulated signal using frequency dependent circuits. Then the original signal is recovered from this AM signal.
20	**What are the types of FM detectors?** Slope detector and phase discriminator
21	**What are the types of phase discriminator?** Foster seely discriminator and ratio detector.
22	**What are the disadvantages of balanced slope detector?** Amplitude limiting cannot be provided, Linearity is not sufficient; It is difficult to align because of

	three different frequency to which various tuned circuits to be tuned. The tuned circuit is not purely band limited.
23	**What are components in a frequency discriminator?** Frequency discriminator has got two components .Slope detector or differentiator with a purely imaginary frequency response that varies linearly with frequency. It produces output where the amplitude and frequency vary with the message signal. Envelope detector recovers the amplitude variations and reproduces message signal.
24	**What are the applications of PLL?** i) Frequency Multiplier ii) FM Demodulator
25	**How is a Narrowband FM converted into a Wideband FM?** FM signal is given by $S(t) = A_c \cos(2\pi f_c t + \beta \sin(2\pi f_m t))$, If β is very small compared to one radian, it is called NBFM. If β is very large compared to one radian, it is called WBFM
26	**What are the advantages of ratio detector?** i) It is not affected by amplitude variations on the FM wave, ii) Ratio detector can operate with as little as100mv of inputs.
27	**Define Lock in range and dynamic range of PLL. (May 2015)** Lock Range: Range of input signal frequencies over which the loop remains locked once it has captured the input signal. This can be limited either by the phase detector or the VCO frequency range. Capture range: Range of input frequencies around the VCO center frequency onto which the loop will lock when starting from an unlocked condition.
28	**Compare amplitude and angle modulation schemes (Nov/Dec 2015)**

PARAMETERS	AM	FM
Channel Bandwidth	Each channel bandwidth = 15KHz . In a given frequency space, AM accommodates more number of channels.	Each channel bandwidth = 150KHz . In a given frequency space, FM accommodates less number of channels.
Noise Immunity	AM reception is less immune to noise	FM reception is more immune to noise
Amplitude limiters	AM receivers are not fitted with amplitude limiters	FM receivers can be fitted with amplitude limiters to remove amplitude variations caused by noise.
Amplitude of modulated wave	Amplitude of AM wave varies and is dependent on the modulation index.	Amplitude of FM wave is constant and is independent of modulation index.

29	**A carrier signal is frequency modulated by a sinusoidal signal of 5 Vpp and 10KHz. If the frequency deviation constant is 1 kHz/V, determine the maximum frequency deviation and state whether the scheme is narrow band FM or wide band FM. (May/June 2016)** $\frac{\partial}{f_m}$= 1 kHz /v $\partial =$ 1*5 V =5 KHz. $$m_f = \frac{\partial}{f_m} = \frac{5KHz}{10KHz} = 0.5$$ Whenm_f=0.5, spectrum consists of 1 USB, 1 LSB. Hence it's a narrow band FM.
30	**What is the need for pre-emphasis? (May/June 2016)(Nov2016)** The boosting of higher modulating frequencies is called Pre-emphasis. By artificially emphasizing high frequency components of message signal prior to modulation in the transmitter i.e., before

noise is introduced in the receiver, the low frequency and high frequency positions of the PSD of the message signal are equalized in such a way that message fully occupies the frequency band allotted to it.

31 **Define carrier swing. (April/May2017)**
The total variation in frequency from the lowest to the highest is referred as carrier swing. The carrier swing is equal to twice the frequency deviation .Carrier swing = 2X frequency deviation.

32 **State the carson's rule. (April/May2017)**
used for bandwidth calculation of FM modulation, **$BW=2(\Delta f + f_m)$**, Δf = frequency deviation
f_m =modulating frequency.

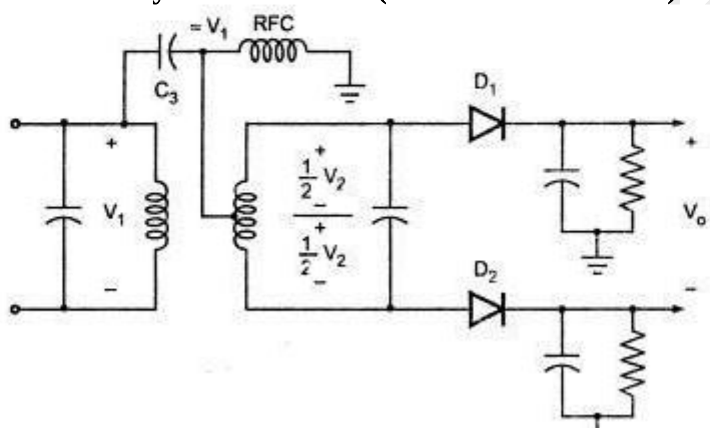
33 **Distinguish between narrow band FM (NBFM) and Amplitude modulation(AM). (Apr/May2017)**

AM	Narrow band FM
AM accommodates more number of channels.	Only a single message is allowed
AM reception is less immune to noise	NBFM is more immune to noise
AM frequency deviation is relatively higher	Frequency deviation in carrier frequency is small
Amplitude of AM wave varies and is dependent on the modulation index.	frequency of carrier signal varies according to message signal amplitude

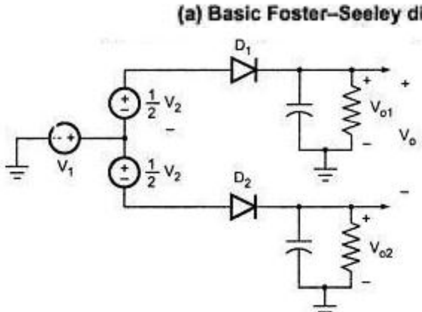
PART * B

1 **Draw the circuit diagram of foster Seeley Discriminator And Ratio Detector. Explain its working principle with relevant Phasor Diagram (APRIL/MAY 2015,MAY/JUN 2016, NOV/DEC 2016)**

Foster-Seeley Discriminator (Phase Discriminator)



(a) Basic Foster–Seeley discriminator

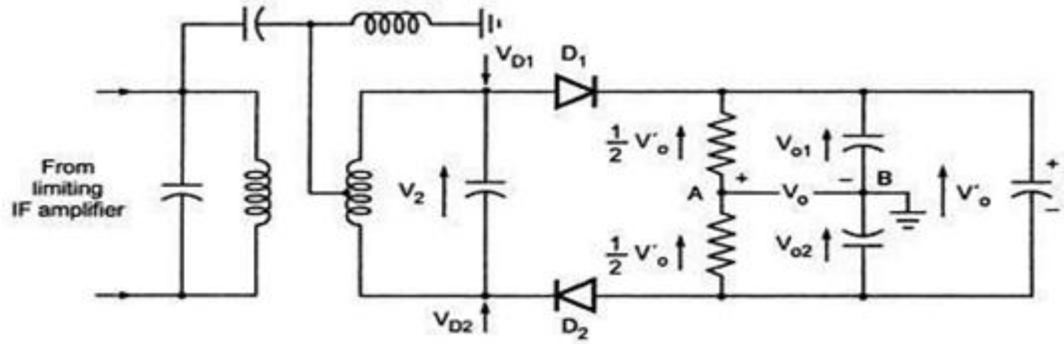


(b) Voltage generator equivalent circuit

phase shift - primary and secondary voltages - tuned transformer
Function - frequency.
principle - FM detection

output V0=V01-V02
|VD1|=|VD2|. output of the discriminator - zero
|VD1| is greater than |VD2| output V0=V01-V02 will be positive
|VD1| less than |VD2| V0=V01-V02 will be negative
Foster- Seeley discriminator - produces output depending upon the phase shift

Ratio Detector:



slight modifications - Foster - Seeley discriminator
D2 is reversed - output - different points
voltages V01 and V02 across two capacitors add

Advantages:
1) Circuit does not respond - amplitude variations.
2) The output- bipolar (positive & negative).

Disadvantages:
1) Ratio detector - tolerate variation in signal strength over performed period.
2) Requires - ACC signal.

2 **Derive the expression for wide band FM in terms of Bessel functions (Nov/Dec2012)**

Modulation Index (2)
Definition (2)

$$s(t) = A_c \cos[2\pi f_c t + \beta \sin(2\pi f_m t)]$$

complex envelope

$$\tilde{s}(t) = A_c \exp\left[j\beta \sin(2\pi f_m t)\right]$$

$$\tilde{s}(t) = \sum_{n=-\infty}^{\infty} c_n \exp(j2\pi n f_m t)$$

Bessel function

$$J_n(\beta) = \frac{1}{2\pi}\int_{-\pi}^{\pi} \exp[j(\beta \sin x - nx)]\, dx$$

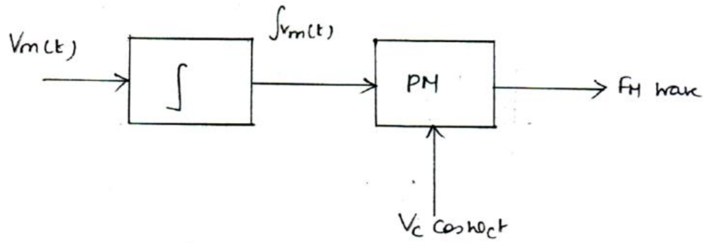
Fourier transform

$$S(f) = \frac{A_c}{2}\sum_{n=-\infty}^{\infty} J_n(\beta)\left[\delta(f - f_c - nf_m) + \delta(f + f_c + nf_m)\right]$$

3 **How can FM be derived from PM and vice versa? Explain in details (Nov/Dec2012)**

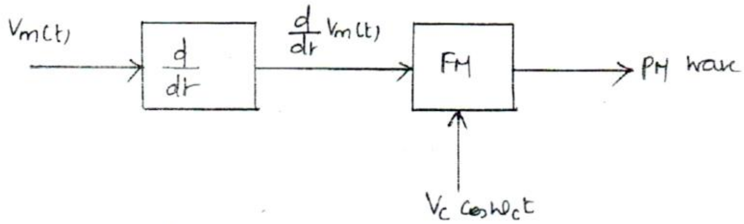
How the phase and frequency modulation is are related? Explain (May/June2013)

FM from PM Diagram, Derivation and Explanation (6)



$$V_{FM}(t) = \overset{E_c}{V_c} \cos\left[\omega_c t + \frac{k_f \overset{E_m}{V_m}}{\omega_m} \sin\omega_m t\right]$$

PM from FM diagram, Derivation and explanation (6)



$$V_{PM}(t) = \overset{E_c}{V_c} \cos\left[\omega_c t + k_p \overset{E_m}{V_m} \cos\omega_m t\right]$$

4

Derive the mathematical representation of FM signal (May/June2013)

FM Defn. (2)

$$E_{FM}(t) = E_c \cos f_i(t)$$

$$E_{FM}(t) = E_c \cos\left[\omega_c t + m_f \sin\omega_m t\right]$$

FM Wave (2)

$$m_f = \frac{k_f E_m}{f_m} = \frac{\Delta f}{f_m}$$

Wave Equation (2)

Derivation (5)

$$DR = \frac{\text{Maximum frequency deviation}}{\text{Maximum modulating index}}$$

$$\%\text{ of modulation} = \frac{\Delta f\,(\text{actual})}{\Delta f\,(\text{max.})} \times 100$$

Final Answer (2)

5

When the frequency in an FM system is400Hz and the modulating voltage is 2.4V. The modulation indexis60.calculate the maximum deviation. What is the modulating index when the modulating frequency is reduced to250Hz and the modulating voltage is simultaneously. (May/June2013)

	Given data (3) Formula used (3) Solving (3) Answer with Unit (4)
6	**Make the atleast five comparisons of AM and FM system (May/June2014)**

	AM	**FM**
Stands for	AM stands for Amplitude Modulation	FM stands for Frequency Modulation
Origin	AM method of audio transmission was first successfully carried out in the mid 1870s	FM radio was developed in the United states in the 1930s, mainly by Edwin Armstrong.
Modulating differences	In AM, a radio wave known as the "carrier" or "carrier wave" is modulated in amplitude by the signal that is to be transmitted. The frequency and phase remain the same.	In FM, a radio wave known as the "carrier" or "carrier wave" is modulated in frequency by the signal that is to be transmitted. The amplitude and phase remain the same.
Pros and cons	AM has poorer sound quality compared with FM, but is cheaper and can be transmitted over long distances. It has a lower bandwidth so it can have more stations available in any frequency range.	FM is less prone to interference than AM. However, FM signals are impacted by physical barriers. FM has better sound quality due to higher bandwidth.
Frequency Range	AM radio ranges from 535 to 1705 KHz (OR) Up to 1200 bits per second.	FM radio ranges in a higher spectrum from 88 to 108 MHz. (OR) 1200 to 2400 bits per second.
Bandwidth Requirements	Twice the highest modulating frequency. In AM radio broadcasting, the modulating signal has bandwidth of 15kHz, and hence the bandwidth of an amplitude-modulated signal is 30kHz.	Twice the sum of the modulating signal frequency and the frequency deviation. If the frequency deviation is 75kHz and the modulating signal frequency is 15kHz, the bandwidth required is 180kHz.
Zero crossing in modulated signal	Equidistant	Not equidistant
Complexity	Transmitter and receiver are simple but syncronization is needed in case of SSBSC AM carrier.	Transmitter and receiver are more complex as variation of modulating signal has to beconverted and detected from corresponding variation in frequencies.(i.e. voltage to frequency and frequency to voltage conversion has to be done).
Noise	AM is more susceptible to noise	FM is less susceptible to noise

			because noise affects amplitude, which is where information is "stored" in an AM signal.	because information in an FM signal is transmitted through varying the frequency, and not the amplitude.

7

Derive the single tone frequency modulation and draw it is frequency response (MAY/JUNE 2016, NOV/DEC 2016)

modulating signal x(t)
amplitude E_m and frequency f_m
$x(t) = Em \cos(2\pi fmt)$
$ec = Ec \sin(\omega ct + \varphi)$.

Instantaneous frequency of an FM wave

$$f_i(t) = f_c + k_f x(t) = f_c + k_f . E_m \cos(2\pi f_m t)$$

$$or \qquad f_i(t) = f_c + \Delta f \cos(2\pi f_m t)$$

frequency deviation

maximum departure of the instantaneous
frequency fi(t) of the FM wave from the carrier frequency fc
$\Delta f = k_f E_m$

Maximum frequency of FM Wave

$\Delta f = k_f E_m$

Mathematical Expression for FM

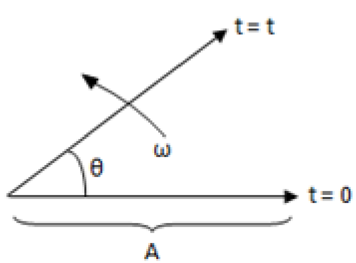
constant amplitude and a variable instantaneous frequency
FM wave is represented

$$s(t) = E_c \sin[F(\omega_c, \omega_m)]$$

$$s(t) = E_c \sin\theta(t)$$

$$\theta(t) = F(\omega_c, \omega_m)$$

Phasor of single tone



$$\theta(t) = \omega_c t + \frac{kE_m sin\omega_m t}{f_m}$$

Modulation Index

$$m_f = \frac{Frequency\ deviation}{Modulating\ frequency}$$

$$or \qquad m_f = \frac{\Delta f}{f_m}$$

AM - maximum value of the modulation index m is 1.
FM - modulation index can be greater than 1

Deviation Ratio

$$Deviation\ Ratio = \frac{Maximum\ deviation}{Maximum\ Modulating\ frequency}$$

Percentage Modulation of FM Wave

$$\%\ Modulation = \frac{Actual\ Frequency\ deviation}{Maximum\ allowed\ Deviation}$$

8 **An angle modulated wave is described by the equation V(t)=10Cos(2*10t+10Cos200t) Find 1. Power of the modulated signal, 2. Maximum frequency deviation & 3.Band width**

Given data (3)
Formula used (3)
Solving (3)
Answer with Unit (4)

9 **Write The Comparison Of Wideband And Narrowband FM (NOV/DEC 2011, MAY/JUNE 2013)**

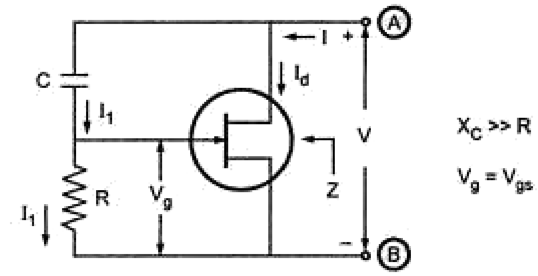
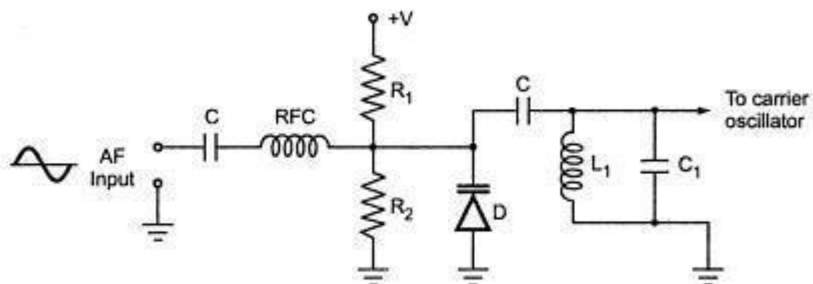
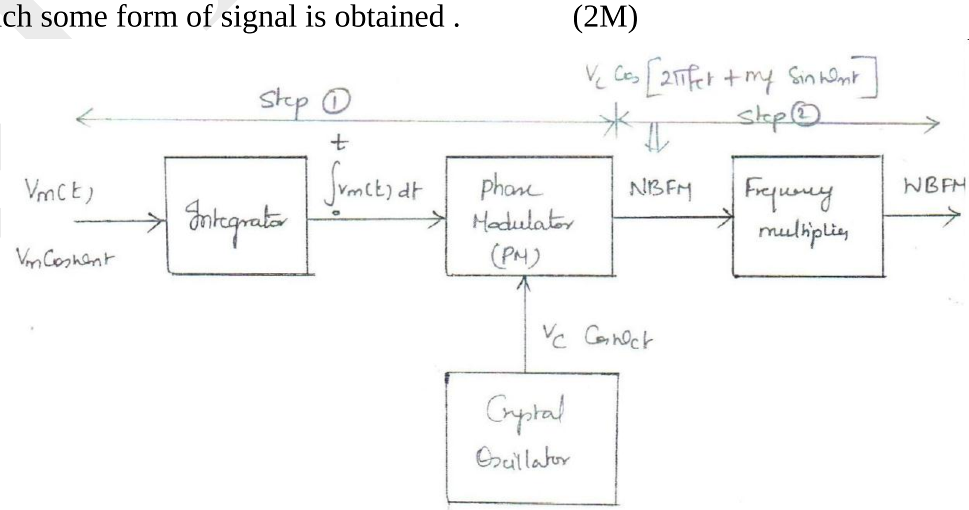
SI. No	Parameter Characteristics	Wideband FM	Narrowband FM
1	Modulation index	Greater than 1	Less than (or) slightly greater than 1
2	Maximum deviation	75 KHz	5 KHz
3	Range of modulating Frequency	30 Hz to 15 KHz	30 Hz to 3 KHz
4	Bandwidth	Large, about 15 times higher than BW of narrow band FM. BM=2(ΔF+Fm)	Small. Approximately same as that of AM. BW=2fm
5	Maximum modulation	5 to 2500	Slightly greater than 1
6	Pre-emphasis and De-emphasis	Needed	Needed
7	Noise	Noise is more suppressed	Less suppressing of noise
8	Applications	Entertainment bro dcasting	FM mobile communication
9	Side bands	Spectrum contains infinite number of side bands	Spectrum contains two sidebands and carrier.

10 **Explain With Diagram The Generation Of FM Using Direct Method. (APRIL/MAY 2015, NOV/DEC 2016)**

Direct FM - FET and varactor diode

FET Reactance Modulator

reactance across terminals A-B

	modulating voltage V reactance - inductive or capacitive  **Frequency Modulation using varactor Diode** reverse biased condition - varactor diodes - optimize this characteristic capacitance - 1 to 200 pF Radio Frequency Choke (RFC) - high reactance - carrier frequency - prevent the carrier signal from getting into the modulating signal circuits A negative going modulating signal subtracts from bias, increasing the capacitance, which decreases the carrier frequency  frequency - LC oscillator - changes due to temperature effects crystals - FM generators to provide frequency stability
	PART * C
1	**Explain the Armstrong method to generate FM signal (May/June2013)** **Definition** : The modulating signal is integrated and the phase modulated with the carrier signal,as a result of which some form of signal is obtained . (2M) 

Generation of FM and PM: (2M)

$\Delta f = V_{m\,\&}$ fm (The frequency deviation at the output of the phase modulator will be effectively proportional to the modulating voltage and we obtain FM wave at the output of the phase modulator)

Phase modulator circuit (2M)

phasor diagram (2M)

$V\ fm = v_c \cos w_{c\ -m_f}\ \ v_c \sin w_c t \sin w_m t$ (2M)

Explanation: (when the phase of carrier is modulated by information signal by using PM and multiplier circuits) (3M)

2

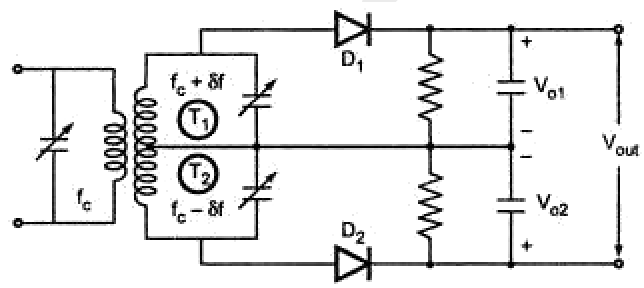
Explain the function of any FM detector circuit MAY/JUNE 2014, NOV/DEC 2016)

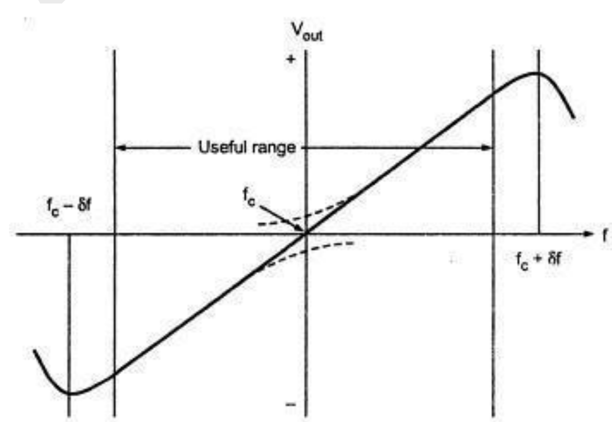
Super heterodyne receivers – different types of demodulators or detectors.
The AGC system - FM receivers is different than that of AM receivers.
FM receivers - RF amplifiers, mixers, local oscillators IF amplifiers, audio amplifiers etc.
FM detector - produce the signal whose amplitude is proportional to the deviation in the frequency of signal
Frequency to voltage convertor these types of FM detectors - Slope detectors, phase discriminator and ratio detector.

Round – Travis detector or balanced slope detector (frequency Discriminator)

two identical circuit connected back to back
Two turned LC circuits are connected in series
LC circuit - turned transformer
T1 and T2 180° out of phase

$V_{out} = V_{01} - V_{02}$

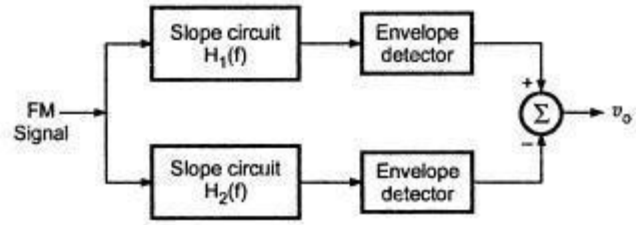
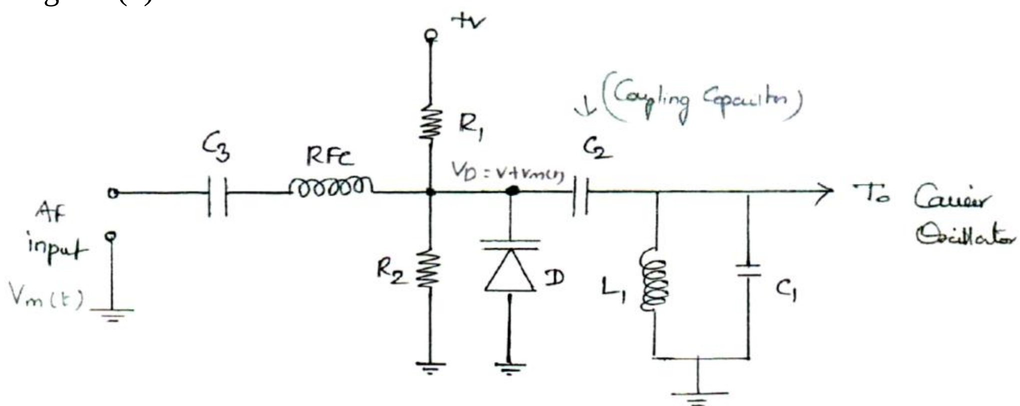




Characteristic of balanced slope detector, or 'S' curve

Frequency Discriminator

principle - slope detection.

	
3	**Explain how FM is achieved using Varactor diodes (May/June2014)** Diagram (3)  $C_d = \frac{k}{\sqrt{V_D}}$ $\omega_i = \frac{1}{\sqrt{L_0\left(C_0 + \frac{k}{\sqrt{V_D}}\right)}}$ Application: Automatic Frequency Control, Remote Tuning

UNIT III - RANDOM PROCESS	
Random variables, Random Process, Stationary Processes, Mean, Correlation & Covariance functions, Power Spectral Density, Ergodic Processes, Gaussian Process, Transmission of a Random Process Through a LTI filter.	
PART * A	
Q.No.	**Questions**
1.	**Define probability**. The probability of occurrence of an event A is defined as, P(A)= number of possible favorable outcomes Total number of equal likely outcomes.
2	**What are mutually exclusive events?** Two possible outcomes of an experiment are defined as being mutually exclusiveif the occurrence of one outcome precludes the occurrence of the other.
3	**What are the types of Correlation**? The types of Correlation are Cross Correlation and Auto Correlation
4	**What is the difference between Correlation and Convolution?** In Correlation physical time 't' is dummy variable and it disappears after solution of an integral. Convolution is a function of delay parameter 't. Convolution is commutative but correlation is non-commutative.
5	**Define Signal.** A signal is defined as any physical quantity carrying information that varies with time. The value of signal may be real or complex. The types of signal are continuous signal and discrete time signal**.**
6	**Define probability density function.** Probability density function is defined as $f_x(x)$ is defined in terms of cumulative distribution function F_x (x) as $f_x(x)$ = d F_x (x)dx.
7	**Define random variable. Specify the sample space and the random variable for a coin tossing experiment.** Random variable is defined as a rule or mapping from the original sample space to a numerical sample space subjected to certain constraints. Random variable is also defined as a function where domain is the set of outcomes and whose range is R, is the real line.
8	**Define Random process**. A Random process X (t) is defined as an ensemble of time functions together with a probability rule that assigns a probability to any meaningful event associated with an observation of one of the sample functions of the random process.
9	**What is meant by sample space?** The set of all possible outcome of a random experiment is called sample space and is represented by an alphabet's'.
10	**What is joint probability?** The probability of an event such as A,B that is intersection of events from sub experiments is called the joint probability of the event.$P(AB) = \lim(\frac{N_{AB}}{N})$
11	**What is meant by conditional probability?** If $A_1,A_2,A_3,$…….. and $B_1,B_2,B_3,$….. are the results of two experiments A and B respectively then probability of occurrence of both A_i and B_j in single experiment is written as P[A_i and B_j] with the probability of A is known , then the probability and written as P(B_j / A_i). If N times there is joint occurrence in large N times experiment then

	$$P\left(\frac{B_j}{A_i}\right) = \frac{N_{ij}}{N} = \frac{P(A_i, B_j)}{P(A_i)}$$
12	**What is meant by statistical independence?** A_i and B_j are events associated with the outcome of two experiments. The event B_j is independent of A_i so that occurrence of A_i does not influence the occurrence of B_j and vice versa. Then we say that the events are statistically independent. $P(A_i, B_j) = P(A_i).P(B_j)$
13	**Express Random process as a function of random variables.** A random process defined as a function of one or more random variables as X(t) = $g(Y_1,Y_2,\ldots.Y_n;t)$ where X(t) is a random process and $Y_1,Y_2,\ldots..Y_n$ are n random variables and g is an ordinary function.
14	**Express mean $\mu_x(t)$ of a statistical average in terms of random process.** The statistical average of a random processes mean $\mu_x(t)$ is defined as $\mu_x(t) = E(X(t))$ The expected values are taken with respect to the appropriate probability density function.
15	**Express auto correlation function in terms of random process./ Define autocorrelation function. (May/June 2016)** The statistical average of a random processes auto correlation function $R_{xx}(t_1,t_2)$ is defined as the expected values of the random processes with respect to the appropriate probability density function. $R_{xx}(t_1,t_2) = E(X(t_1),X(t_2))$
16	**When a random process is said to be Ergodic?** A random process is said to be Ergodic if the time average equal to ensemble average if 1)$E((\mu_x)) = E(X(t))$ is said to be ergodic and the variance $(\mu_x)\rightarrow 0$ as $T\rightarrow\alpha$ 2) In the auto correlation function if $E(R_{xx}(\tau)) = R_{xx}(\tau)$ and the variance $(R_{xx}(\tau)) \rightarrow 0$ as $T\rightarrow\alpha$
17	**Define power spectral density of stationary random process.** The auto correlation function $R_{xx}(\tau)$ of a stationary random process is such that $\mathbf{G_x(f)} = \int_{-\alpha}^{\alpha} Rxx\,(\tau)\, e^{-2\pi jf\tau}\, d\tau$
18	**When a random process is said to be deterministic? (Nov/Dec 2018)** A process is called deterministic, if the future values of any sample function can be predicted from past values. Eg. Consider the random process $x(t) = A\cos(w_o t)$. In this case, the knowledge of the sample function prior to any time instant automatically allows prediction of the future values of the sample function since its form is known.
19	**Define distribution function.** Let X be a one dimensional random variable. The function F is defined for all real x ε $(-\alpha,\alpha)$ by the equation $F(x) = P(X \leq x)$ is called the distribution function of the random variable X.
20	**Mention any two properties of power spectral density.** i) The PSD of a stationary process is always Non- Negative. ii) The PSD of a real valued random process is an even function of frequency**.**
21	**Mention any two properties of Gaussian Process.** i) If a Gaussian process X(t) is applied to a stable filter, then the random process Y(t) developed at the output of the filter is also Gaussian. ii) If a Gaussian process is stationary, then process is strictly Stationary.

22	**Explain the types of random variable with suitable examples.** A random variable may be discrete or continuous. A discrete random variable can take on only a countable number of distinct values. A continuous random variable can assume any value within one or more intervals on the real line**.**
23	**What is meant by Random experiment?** The mathematical technique for dealing with the result of an experiment whose outcomes are not known in advance is called random experiment.
24	**Define Cross correlation function.** Consider a random process X(t) and Y(t) with auto correlation function $R_x(t,u)$ and $R_y(t,u)$. the two cross correlation of X(t) and Y(t) are $R_{xy}(t,u) = E\lvert X(t),Y(u)\rvert$ and $R_{yx}(t,u) = E\lvert Y(t),X(u)\rvert$
25	**Mention any two properties of auto correlation function.** i) The mean square value of the process may be obtained from $R_x(\tau)$ simply by putting $\tau = 0$ ii) The auto correlation function $R_x(\tau)$ is an even function of τ (i.e) $R_x(\tau) = R_x(-\tau)$
26	**Define Q factor of a receiver.(May 2015)** Q is defined as the ratio of the energy stored in the resonator to the energy supplied to it, per cycle, to keep signal amplitude constant, at a frequency where the stored energy is constant with time. It can also be defined for an inductor as the ratio of its inductive reactance to its resistance at a particular frequency, and it is a measure of its efficiency.
27	**Write the equation for the mean square value of thermal noise voltage in a resister. (May 2015)** $P = V_n^2 / R = 4kbT\Delta f$
28	**State the central limit theorem. (May/June 2016) (Nov/Dec 2016)** The central limit theorem states that the distribution of the sum (or average) of a large number of independent, identically distributed variables will be approximately normal, regardless of the underlying distribution
29	**Define a random variable. (Nov/Dec 2015)** A function which can take on any value from the sample space and it's range is some set of real numbers is called a random variable of the experiment.
30	**State Bayes rule. (Nov/Dec 2015)** Bayes rule states that $$P\left(\frac{A}{B}\right) = \frac{P(B/A)P(A)}{P(B)}$$
31	**Write Einstein-Wiener – khintchine theorem. (Nov/Dec 2016) (April/May2017)** For continuous time, the Wiener–Khinchin theorem says that if x is a wide-sense stationary process such that its autocorrelation function (sometimes called auto covariance) defined in terms of statistical expected value $r_{xx}(\tau)=E[x(t)\ x^*(t-\tau)]$, (the asterisk denotes complex conjugate, and of course it can be omitted if the random process is real-valued), exists and is finite at every lag τ, then there exists a monotone function F(f) in the frequency domain $-\infty < f < \infty$ *such that* $$rxx(\tau) = \left[\int_{-\infty}^{\infty} e^{-2\pi i r f} df(f)\right]$$
32	**List the sufficient and Necessary conditions for the process to be WSS.(April/May2017)** If it satisfies the following conditions (i).the mean value of the process is a constant **E[X(t)]=m=**constant. (ii).it's autocorrelation function depends only on **τ : $E[X(t)X(t+\tau)]=R_{xx}(\tau)$.**
	PART * B

1	**Write the definition, power spectral density and autocorrelation function for white noise and narrow band noise (May/June2012)** Communication system - preprocessing the received signal. Preprocessing - narrowband filter - narrow band noise. Wideband noise - bandlimited noise. Bandlimited noise - small - carrier frequency - narrowband noise. Power spectral density Gn(f) Auto-correlation function Rnn(τ) narrowband noise as n(t) = x(t) cos 2πfct - y(t) sin2πfct. Hibert transform n^ (t) = H[n(t)] = x(t) sin 2πfct + y(t) cos 2πfct. properties 1. E[x(t) y(t)] = 0. 2. x(t) and y(t) - same means and variances asn(t). 3. If n(t) is Gaussian, then x(t) and y(t) - Gaussian. 4. x(t) and y(t) have identical power spectral densities, 5. power spectral density -Gx(f) = Gy(f) = Gn(f- fc) + Gn(f+ fc)(28.5) for fc - 0.5B < | f | < fc + 0.5B and B is the bandwidth of n(t).
2	**A mixer stage has a noise fig of 20 db and this is preceded by an amplifier that has a noise fig of 9db and an amplifier gain of 15db.calculate the overall noise figure referred to the input (Nov/Dec2012)** Given data (3) Formula used (3) Solving (3) Answer with Unit (4)
3	**Write short noise and thermal noise (May/June2013)** Shot Noise Defn. (2) PSD (2) Thermal Noise Defn. (2) PSD (2)
4	**Derive the equation for finding the power spectral density of a one to one differential function of a given random variable. (Nov/Dec 2013)** Random process *Z* (*t*) - sum of two real jointly WSS random processes *X(t)* and *Y(t)*. Cross correlation functions - R_{XY} and R_{YX}. **Definition of Power Spectral Density** $$S_{XY\,(\omega)} = \lim_{T\to\infty} E\,\frac{FTX_T^*(\omega)\,FTY_T(\omega)}{2T}$$ $$S_{YX\,(\omega)} = \lim_{T\to\infty} E\,\frac{FTY_T^*(\omega)\,FTX_T(\omega)}{2T}$$ Wiener-Khinchin-Einstein theorem cross-power spectral density $$R_{XY}(\tau) = \int_{-\infty}^{\infty} S_{XY}(\omega) e^{i\omega\tau}\, d\omega$$

	$$R_{YX}(\tau) = \int_{-\infty}^{\infty} S_{YX}(\omega) e^{i\omega\tau}\, d\omega$$ **Properties of the PSD** 1. CPSD of two jointly WSS processes *X(t)* and *Y(t)* 2. Re (S_{XY}) - even function, Im (S_{XY}) - odd function 3. *X(t)* and *Y(t)* - uncorrelated and constant means 4. If *X(t)* and *Y(t)* are orthogonal 5. cross power P_{XY} between X(t) and Y(t)
5	**Write Short Notes On Covariance Function** covariance or kernel - spatial covariance of a random variable process or field covariance function $C\ (x, y) := cov\ (Z(x), Z(y))$ Auto covariance function - time series - multivariate random fields ✓ **Mean & Variance of covariance functions:** For locations $x_1, x_2, \ldots, x_N \in D$ the variance of every linear combination $$X = \sum_{i=1}^{N} w_i Z(x_i)$$ can be computed as $$\operatorname{var}(X) = \sum_{i=1}^{N} \sum_{j=1}^{N} w_i C(x_i, x_j) w_j.$$ Covariance function - non negative for all possible choices Function - positive definite
6	**Write Short Notes On Auto Correlation Function.** Statistical relationship - two random variables or two sets of data. Correlation - statistical relationships involving dependence. Examples: electrical utility may produce less power on a mild day based on the correlation between electricity demand and weather. Correlation coefficients - ρ or r, measuring the degree of correlation. Pearson correlation coefficient - linear relationship between two variables. **Pearson's correlation coefficient**: commonly called - correlation coefficient $$\rho = corr\ (X, Y) = \frac{cov\ (X, Y)}{\sigma_X \sigma_Y} = \frac{E[(X - \mu_x)(Y - \mu_Y)]}{\sigma_X \sigma_Y}$$ Correlation coefficient corr(X,Y) = corr(Y,X). Pearson correlation +1 - perfect direct (increasing) linear relationship (correlation), Pearson correlation −1 - perfect decreasing (inverse) linear relationship (autocorrelation) $$r_{xy} = \frac{\sum x_i y_i - n\bar{x}\bar{y}}{(n-1) s_x s_y} = \frac{n \sum x_i y_i - \sum x_i \sum y_i}{\sqrt{n \sum x_i^2 - (\sum x_i)^2}\ \sqrt{n \sum y_i^2 - (\sum y_i)^2}}.$$

6	**Explain in detail about Ergodicity Principle** time-average computed from a large realization - corresponding ensemble average **Example** $\int_{-2T}^{2T} \lvert C_X(\tau)\rvert \, d\tau = 2\int_{0}^{2T} C_X(\lvert\tau\rvert)\, d\tau$ $= \frac{2T_p}{3}$ $\therefore \int_{-\infty}^{\infty} \lvert C_X(\tau)\rvert \, d\tau < \infty$ **Autocorrelation ergodicity** $\langle R_X(\tau)\rangle = \frac{1}{2T}\int_{-T}^{T} X(t)\, X(t+\tau)\mathrm{d}t$
7	**Differentiate The Strict-Sense Stationary With That Of Wide Stationary Process. (APR/MAY 2015,MAY/JUN 2016)** stochastic process - joint probability distribution does not change when shifted in time parameters such as the mean and variance, if they are present, also do not change over time and do not follow any trends stationary process Example: time-homogeneous *strict-sense stationary* (SSS) $C_X(t_1, t_2) = C_X(t_1 - t_2)$ **Wide-sense stationary process** very difficult - process SSS - subclass of the SSS - *wide sense stationary process* $\mathbb{E}[x(t)] = m_x(t) = m_x(t+\tau) \quad \text{for all } \tau \in \mathbb{R}$
8	**What type of Gaussian noise follow or Demonstrate the advantages of Gaussian Modeling of a random process. (8)** Random process X(t) - Gaussian process if for all n and all (t1 ,t2 ,…,tn) - Gaussian density function. Gaussian processes - mean and autocorrelation mX (t) and Rx (t1 ,t2) - statistical description of the process. Gaussian process X(t) - LTI system - output process Y(t) - Gaussian process. Gaussian processes - WSS and strict stationary are equivalent. Two or multidimensional Gaussian process - Gaussian random field. ergodicity - stationary zero-mean Gaussian process Jointly Gaussian processes: Random processes X(t) and Y(t) - uncorrelatedness and independence are equivalent. Density function - one to one differential function of a given random variable.

	• X(t) – input, impulse response - h(t), Y (t) output Autocorrelation: function of the output random process Y (t). *RY (t, u) = E[Y (t)Y (u)]* Application : Bayesian inference. Wiener process - integral of a white noise Gaussian process.
	PART * C
1	**A receiver has a noise fig of12db and it is fade by allow noise amplifier that has again of 50db and a temperature of 90k.Calculate the noise temp. of the receiver and the overall noise temp. of the receiving system take room temp is290K (Nov/Dec2012)** Given data (3) Formula used (3) Solving (3) Answer with Unit (4)
2	**Explain Central limit theorem and its Convergence to the limit.** Central limit theorem - arithmetic mean of a sufficiently large number of iterates of independent Random variables - well-defined expected value and well- defined variance - Normally distributed, regardless of the underlying distribution. Example: if one flips coin many times, the probability of getting a given number of heads should follow a normal curve, with mean equal to half the total number of flips. **Classical Central limit theorem Sn=X1+…….+Xn/n** sample averages converge in probability and almost surely to the expected value μ as n → ∞. **Convergence to the limit** Asymptotic distribution - reasonable approximation only when close to the peak of the normal distribution - Very large number of observations to stretch into the tails. central limit theorem applies - sums of independent and identically distributed discrete random variables Moivre Laplace theorem - simple case of a discrete variable taking only two possible values.
3	**(i) Give a random process, X(t) = Acos(!t+μ), where A and ! Are constants and μ is a uniform random variable. Show that X(t) is ergodic in both mean and autocorrelation (ii) Write a short note on shot noise and also explain about power spectral density of shot noise. (April/may2010)** Given data (3) Formula used (3) Solving (3) Answer with Unit (4)

UNIT IV - NOISE CHARACTERIZATION

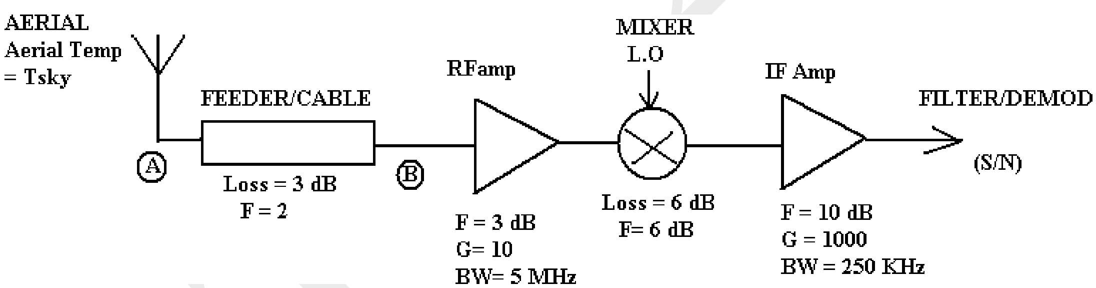
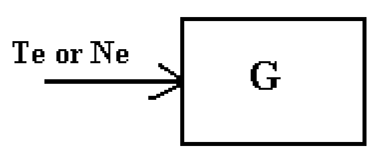
Noise sources – Noise figure, noise temperature and noise bandwidth – Noise in cascaded systems. Representation of Narrow band noise –In-phase and quadrature, Envelope and Phase – Noise performance analysis in AM & FM systems – Threshold effect, Pre-emphasis and de-emphasis for FM.

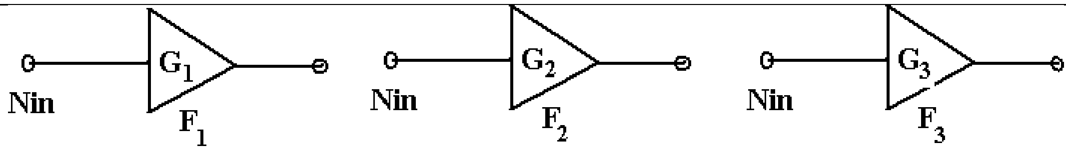
PART * A

Q.No.	Questions
1.	**What is pre emphasis? Why is it needed?(MAY 2015)** Pre-emphasis is the first part of a noise reduction technique in which a signal's weaker, higher frequencies are boosted before they are transmitted or recorded onto a storage medium.
2	**State the cause of threshold effect in AM systems? (MAY 2015) .(April/May2017)** When the carrier-to-noise ratio at the receiver input of a standard AM is small compared to unity, the noise term dominates and the performance of the envelope detector changes completely.
3	**What is coherent system? (MAY 2013)** If the carrier signal is synchronous (magnitude and phase) with that of the message signal then such system is called coherent system.
4	**Give the expression for noise voltage when several sources are cascaded.** Enr = √ (4 KTB (R1 + R2 + …..)) Where R1 , R2 --- are the resistances of the noise resistors. K – Boltzman constant T – absolute temperature B – Bandwidth.
5	**What is intermediate frequency?** Intermediate frequency (IF) is defined as the difference between the signal frequency and the oscillator frequency. IF = fs – fo when fs > fo (or)IF = fo –fs when fo > fs.
6	**State the reasons for higher noise in mixers.** Conversion trans conductance of mixers is much lower than the transconductance of amplifiers. If image frequency rejection is inadequate, the noise associated with the image frequency also gets accepted.
7	**Define signal to noise ratio.** Signal to noise ratio is the ratio of signal power to the noise power at the same point in a system.
8	**What is the need for pre emphasis? (MAY 2013,2014)** Pre-emphasis is the first part of a noise reduction technique in which a signal's weaker, higher frequencies are boosted before they are transmitted or recorded onto a storage medium.
9	**Define band width improvement factor and noise figure improvement. Give the formula for finding Noise figure (April May 2019)** Band width improvement factor (BI) is the ratio of RF bandwidth and IF bandwidth. $BI = \frac{RF - BandWidth}{IF - BandWidth}$ Noise figure improvement = 10 log (BI)
10	**Define Noise figure.(Nov/Dec 2015) (Nov/Dec 2016)** Noise figure is a parameter commonly used to indicate the quality of a receiver. Lower the Noise figure value, better is the performance.
11	**What is the figure of merit of DSBSC system?** The figure of merit of DSBSC signal is unity
12	**What is Capture effect? (May/June 2016)** When the interference signal and FM input are of equal strength, the receiver fluctuates back and

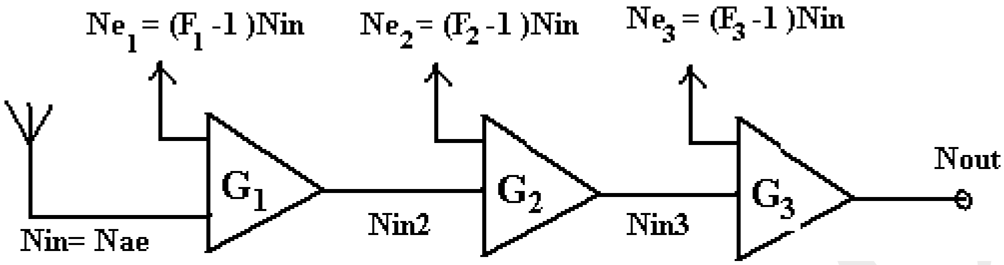
	forth between them .This phenomenon is known as the capture effect.
13	**What is threshold effect?(Nov/Dec 2015)** As the input noise power is increased the carrier to noise ratio is decreased the receiver breaks and as the carrier to noise ratio is reduced further crackling sound is heard and the output SNR cannot be predicted by the equation. This phenomenon is known as threshold effect.
14	**How is threshold reduction achieved in FM system? What are the methods to improve FM Threshed reduction? (Nov/Dec 2018)** Threshold reduction is achieved in FM system by using an FM demodulator with negative feedback or by using a phase locked loop demodulator.
15	**What is Pre-emphasis?** The pre-modulation filtering in the transistor, to raise the power spectral density of the base band signal in its upper-frequency range is called pre emphasis .Pre emphasis is particularly effective in FM systems which are used for transmission of audio signals.
16	**Comment the role of pre-emphasis and de-emphasis circuit in SNR improvement.(April/May2017)** **How does Pre- Emphasis and De- Emphasis process provide overall SNR improvement in FM Systems? (April May 2018)** Pre-emphasis is the first part of a noise reduction technique in which a signal's weaker, higher frequencies are boosted before they are transmitted or recorded onto a storage medium. The filtering at the receiver to undo the signal pre-emphasis and to suppress noise is called de-emphasis.
17	**What do you infer from the receiver output of a coherent detector?** The output indicates that the message signal and in-phase noise component of the filtered noise appear additively at the receiver output. The quadrature component of the narrow band noise is completely rejected by the coherent detector.
18	**When the figure of merit of SSBSC system is 1?** For the same average transmitted signal power and the same average noise power in the message bandwidth, an SSB receiver will have exactly the same output signal to noise ratio as a DSB-SC receiver when both receivers use coherent detection for the recovery of the message signal.
19	**Compare the noise performance of AM receiver with that of DSB-SC receiver.** The figure of merit of DSB-SC or SSB-SC receiver using coherent detection is always unity, the figure of merit of AM receiver using envelope detection is always less than unity. Therefore noise performance of AM receiver is always inferior to that of DSBSC due to the wastage of power for transmitting the carrier.
20	**What is the figure of merit of a AM system with 100 percent modulation?** The figure of merit of a AM system with 100 percent modulation is 1/3.This means that other factors being equal an AM system must transmit three times as much average power as a suppressed system in order to achieve the same quality of noise performance.
21	**What are the characteristics of a receiver?** The characteristics of a receiver are sensitivity, selectivity, fidelity, signal to noise ratio.
22	**Define noise.** Noise is defined as any unwanted form of energy, which tends to interfere withproper reception and reproduction of wanted signal.
23	**Give the classification of noise.**

	Noise is broadly classified into two types. They are External noise and internal noise.
24	**What are the types of External noise?** External noise can be classified into Atmospheric noise, Extraterrestrial noises, Man –made noises or industrial noises.
25	**What are types of internal noise? (Nov/Dec2018)** Internal noise can be classified into Thermal noise, Shot noise, Transit time noise, Miscellaneous internal noise.
26	**What are the types of extraterrestrial noise and write their origin?** The two type of extraterrestrial noise are solar noise and cosmic noise Solar noise is the electrical noise emanating from the sun. Cosmic noise is the noise received from the center part of our galaxy, other distant galaxies and other virtual point sources.
27	**Define transit time of a transistor.** Transit time is defined as the time taken by the electron to travel from emitter to the collector.
28	**Define flicker noise.** Flicker noise is the one appearing in transistors operating at low audio frequencies. Flicker noise is proportional to the emitter current and junction temperature and inversely proportional to the frequency.
29	**Explain thermal noise.** Thermal noise is the name given to the electrical noise arising from the random motion of electrons in a conductor.
30	**Give the expression for noise voltage in a resistor.** The mean –square value of thermal noise voltage is given by $Vn^2 = 4\ K\ T\ B\ R'$ K – Boltzmann constant, R – resistance – absolute temperature, B - Bandwidth
31	**Explain White Noise. (MAY 2013,2014)** Many types of noise sources are Gaussian and have flat spectral density over a wide frequency range. Such spectrum has all frequency components in equal portion, and is therefore called white noise. The power spectral density of white noise is independent of the operating frequency.
32	**What is narrowband noise? (April/May 2018)** The receiver of a communication system usually includes some provision for preprocessing the received signal. The preprocessing may take the form of a narrowband filter whose bandwidth is large enough to pass modulated component of the received signal essentially undistorted but not so large as to admit excessive noise through the receiver. The noise process appearing at the output of such filter is called narrow band noise.
33	**Define noiseless channel.** A channel is called noiseless if it is both lossless and deterministic. The channel matrix has only one element in each row and in each column and this element is unity. The input and output alphabets are of the same size.
34	**Give the expression for equivalent noise temperature in terms of hypothetical temperature./ Define noise equivalent temperature. (May/June 2016) (Nov/Dec 2016)** The expression for equivalent noise temperature in terms of hypothetical Temperature is $T_e = (F- 1)\ T_0$ where, F is the noise figure and T_0 absolute temperature.
35	**Give the Friss formula in terms of noise temperature.** The Friss formula in terms of noise temperature is $Te = T_1 + (T_2 / G_1) + (T_3 / G_1)G_2 + \ldots\ldots\ldots$ G_1 , G_2 ,… are the gain of amplifiers
36	**Define Partition noise.** In an electron tube having one or more positive grids, this noise is caused by erratic partition of

	the cathode current among the positive electrodes. In a transistor, the partition noise is created from the random fluctuation in the division of current between the collector and base.
37	**Two resistor of 20K,50K are at room temperature (290K) for a Bandwidth of 100Khz . Calculate the thermal noise voltage generated by two resistor in series. (Nov/Dec 2016)** Rs=R1+R2=20K+50K=70K En= $\sqrt{(4KTBR_S)}$ =$\sqrt{(4x1.38X10^{-23}x290x100x10^3x70x10^3)}$ =$(1.06x10^{-5})$V
	PART * B
1	**Determine the range of tuning of a local oscillator of a super Heterodyne receiver when flo>fc. The broad cast frequency range is 542Hz to 1600hz. Assume If=455Khz (May/June2012)** Given data (2) Formula used (3) Solving (3) Answer with Unit (4)
2	**Discuss how sine wave plus noise is represented. Obtain the joint PDF of such noise component.(7)** Consider two amplifiers - cascade. First stage amplifier - gain and noise figure as 10 dB and 2 dB. Second stage - noise figure of 3 dB. Estimate the total noise figure. Number of passive or active elements - connected in series Noise figure or noise temperature and bandwidth Elements - matched. **A typical receiver block diagram is shown below, with example**  (S/N) - overall receiver noise figure or noise temperature - determined. noise to the input of that specific element i.e.  **T_e or N_e is the noise referred to the input.** N_e = (L-1) N_{IN} T_e = (L-1)T_S **SYSTEM NOISE FIGURE**: Assume - system comprises - each element defined and specified separately



Gains - greater or less than 1 - symbols F - noise factor



Circuit Diagram of Cascade System

FRIIS Formula.

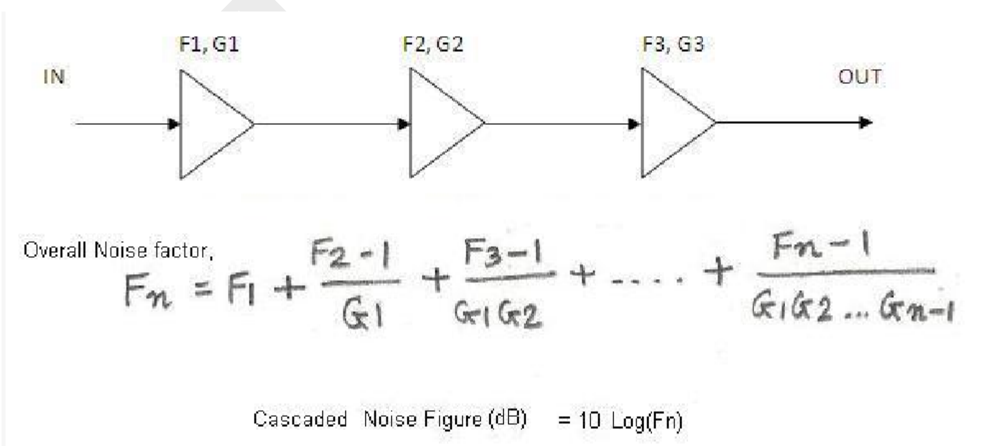
Gain - first stage is too large, large and unwanted signals are applied to the mixer - intermodulation distortion - Apply signals from the aerial directly to the mixer to avoid this problem.

first stage amplifier - good noise factor - gain - acceptable overall noisefigure.

Evaluate the effective noise temperature of a cascade amplifier. Assess how the various noises are generated in the method of representing them

Cascade Noise Figure – Gain and Noise Figure

Cascade Noise Figure – Magnitude of the total loss



3 **Define and explain the following: Gaussian noise and Gaussian distribution and thermal noise. What type of PDF**

Noise- unwanted signal that accompanies a wanted signal

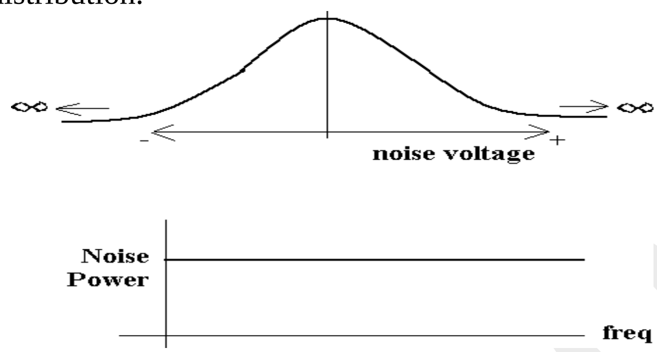
Common form is random (non-deterministic) thermal noise.

signal power to Noise power ratio - (S/N) ratio

S= signal power (mW) N = noise power (mW)

performance - error rate and fidelity

Noise - Additive White Gaussian Noise, AWGN
concepts - statistics and probability theory
Gaussian or Normal distribution.



Probability of noise voltage vs voltage

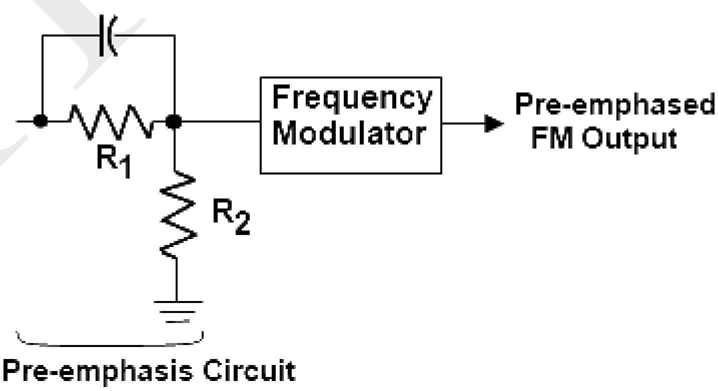
Gaussian distribution – Probability of noise voltage vs voltage –most probable noise voltage 0 volts (zero mean).

4

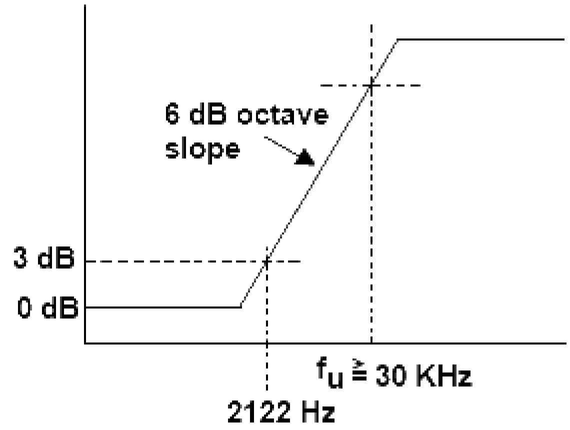
Point out the significance of pre-emphasis and de- emphasis in FM system (Nov/Dec2012)

Pre-emphasis - boosting the relative amplitudes of the modulating voltage for higher audio frequencies from 2 to approximately 15 KHz.
De-emphasis - attenuating those frequencies by the amount by which they are boosted.

Pre-emphasis – transmitter, de-emphasis - receiver.
Purpose - improve the signal-to-noise ratio for FM reception.
Pre-Emphasis Circuit:
High pass filter - fig (a).
pre- emphasis curve - Fig (b) - improves the signal to noise ratio and increases intelligibility and fidelity.

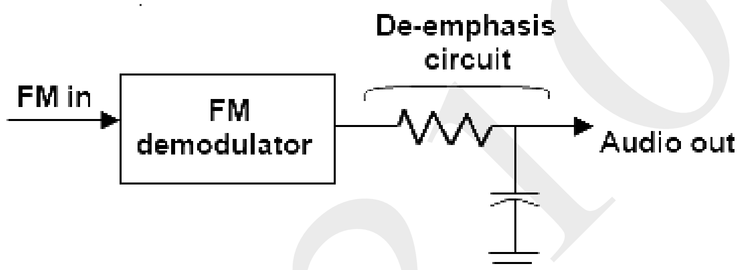


(a) Pre-emphasis Circuit

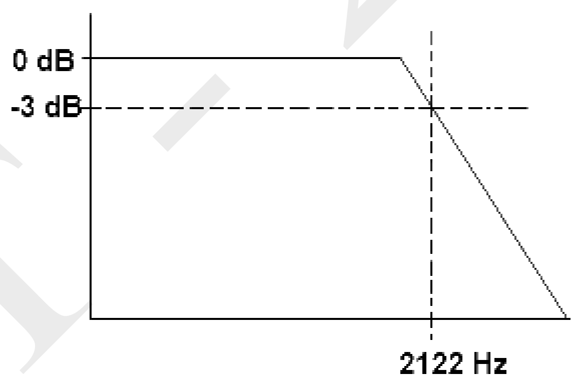


(b) Pre-emphasis Curve

De-EmphasisCircuit:



(c) De-emphasis circuit



(d) De-emphasis Curve

5

Write a short note on shot noise and also explain about power spectral density of shot noise.

Shot noise - noise due to random fluctuations in electron emission from cathodes in vacuum tubes.

semiconductors - pn junctions – Mean Square Noise

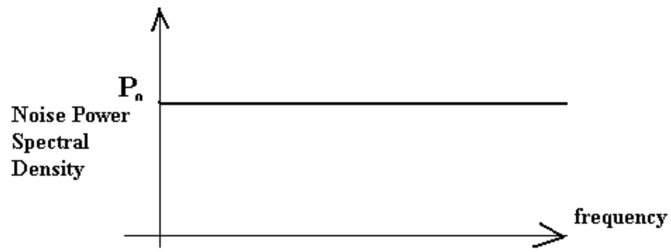
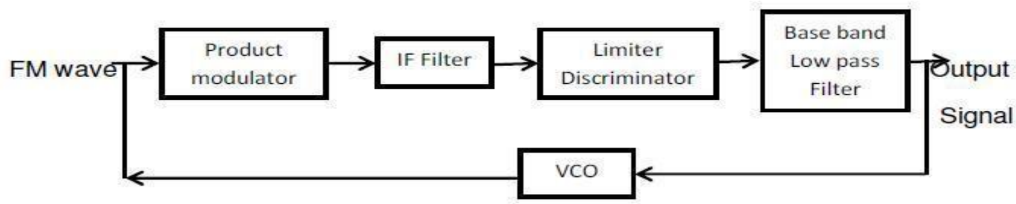
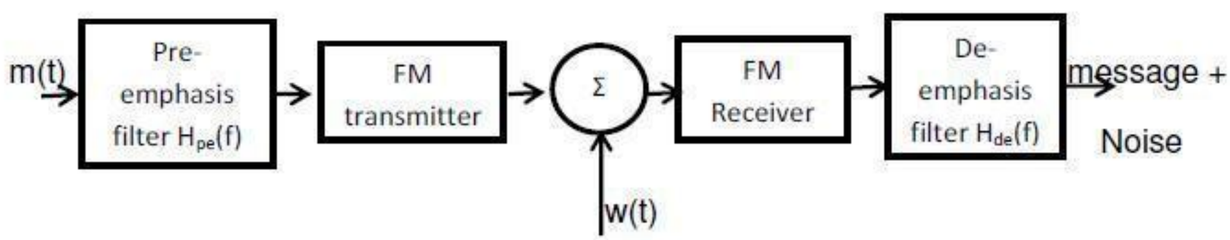
I_{DC} - direct current as the pn junction (amps)

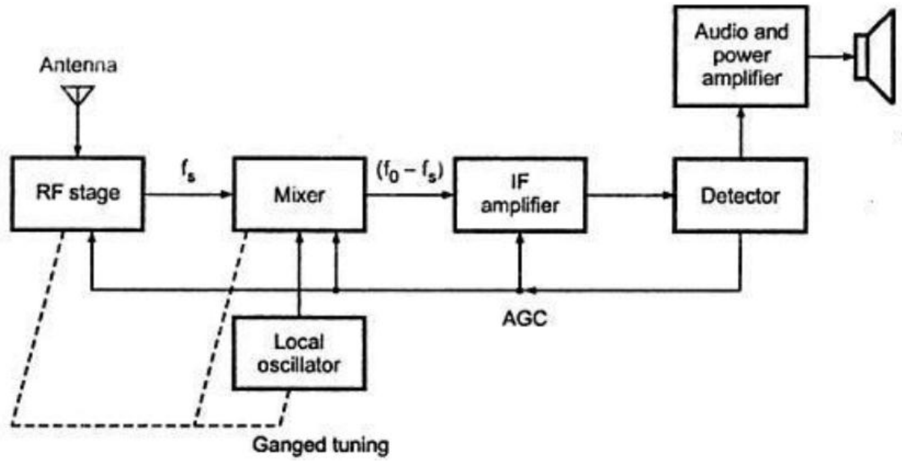
I_0 - reverse saturation current (amps)

q - electron charge = 1.6 x 10^{-19}coulombs

B - noise bandwidth (Hz)

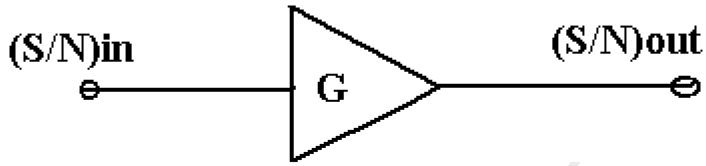
Shot noise- uniform spectral density - thermal noise.

	 **Uniform Noise Power Spectral Density**
6	**Explain the Capture effect, threshold effect Pre-emphasis and de-emphasis (APR/MAY-2013,NOV/DEC2015,MAY/JUNE 2016)** **Capture effect:** Desired signal = interference signal Receiver fluctuates back - receiver locks interference signal - randomly. **FM Threshold Effect:** Signal to noise ratio - discriminator input - high compared to unity. input noise - increased - carrier to noise ratio decreased Crackling or sputtering sound. **FM threshold reduction:** FM demodulator with negative feedback (FMFB) - phase locked loop demodulator.  Local oscillator - VCO. Modulation index - sum and difference frequency components. IF filter - difference frequency component. **Pre-Emphasis and De-Emphasis in an FM system**  high frequency noise - increasing the output SNR of the system.
7	**Explain With Block Diagram Super Heterodyne Receiver? (April/May 2015, MAY/JUNE 2016)**

	 (2M) **Definition:** process of mixing two signals - different frequencies - produce new frequency (2M) **RF** - tuned carrier frequency - incoming wave. (preselector & amplifier) (2M) **MIXER** -hetrodyning function (455kHz) (2M) **CONVERTER**-Local oscillator frequency, signal frequency,image signal frequency (1M) IFRR=$\frac{Gain\ at\ the\ signal\ frequency}{Gain\ at\ the\ image\ frequency}$ (1M) **IF/DEMODULATOR**—the output is only audio frequencies (1M) **Advantages** no variation in BW, high sesitivitiy and selectivity, high adjacent channel variations ,improved stabitlity ,higher gain , uniform BW (2M)
8	**Propose the PSD of in-phase and quadrature phase noise** Wideband noise - Bandlimited noise. Band limited noise - small compared to the carrier frequency - narrowband noise. power spectral density Gn(f), auto-correlation function Rnn(τ) - analyse the performance of linear systems. the narrowband noise n(t) = x(t) cos 2πfct - y(t) sin2πfct. Hibert transform n^ (t) = H[n(t)] = x(t) sin 2πfct + y(t) cos 2πfct. Properties: E[x(t) y(t)] = 0 - uncorrelated with each other. x(t) and y(t) - means and variances as n(t). n(t) is Gaussian, then x(t) and y(t) - Gaussian. Power spectral density n(t) by Gx(f) = Gy(f) = Gn(f- fc) + Gn(f+ fc) for fc - 0.5B < | f | < fc + 0.5B and B is the bandwidth of n(t). In-Phase & Quadrature Sinusoidal Components

$$\sin(A+B) = \sin(A)\cos(B) + \cos(A)\sin(B)$$

Active elements - power gain G>1



9

Compare the performances of AM and FM systems (April/May2010)

Standard AM wave - both sidebands and the carrier are transmitted.

AM wave may be written as

s(t) = Ac[1+ k_a m(t)] cos$2\pi fct$

n(t) = n_I(t) cos 2πft – n_Q(t) sin 2πft

Discriminator = n_Q(t)/A_c - carrier to noise ratio – removes variation in envelop

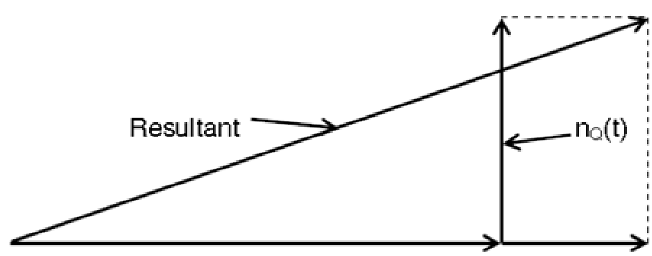
Signal to Noise Ratio

$$(\boldsymbol{SNR})_{\boldsymbol{C}} = \frac{\boldsymbol{A^2c}\,[\mathbf{1} + \boldsymbol{k^2aP}]}{\mathbf{2}\boldsymbol{WN_o}}$$

Received Signal

$$X\,(t) = [A_c + A_c\,K_a m(t) + n_I(t)\,]\cos 2\pi f_c t - n_Q(t)\sin 2\pi f_c t$$

Phasor Diagram



$$y\,(t) = A_c + A_c\,K_a m\,(t) + n_I(t)$$

$$\rho = \frac{A^2c}{4WN_o}$$

$$(\boldsymbol{SNR})_{\mathbf{0}} = \frac{\boldsymbol{A^2c}\,[\boldsymbol{k^2aP}]}{\mathbf{2}\boldsymbol{WN_o}}$$

PART * C

Show and discuss the causes and effects of various forms of noise created within a receiver? (or) Write Short Notes On Shot Noise, Thermal noise, White Noise .(APRIL/MAY 2015,MAY/JUNE 2013,NOV/DEC 2016)

1

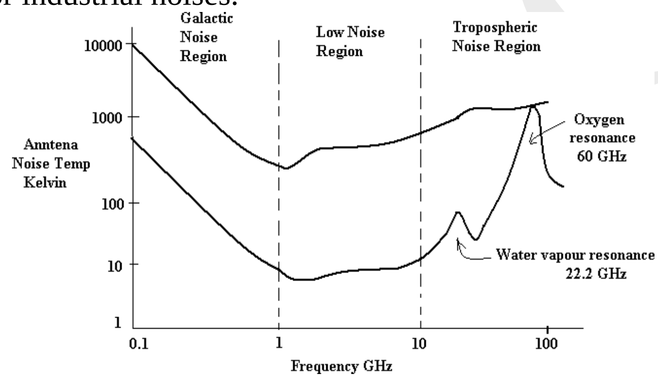
Noise – random - undesirable electrical energy - interferes with the transmitted message. (OR) Unwanted form of energy - interfere with proper reception and reproduction of wanted signal.

Noise - two categories.

External noises - noise whose sources are external.

External noise - classified into – three types:

- Atmospheric noises
- Extraterrestrial noises
- Man-made noises or industrial noises.



Internal noise - generated within the receiver or communication system.
Internal noise – four categories.

- Thermal noise or white noise or Johnson noise
- Shot noise.
- Transit time noise
- Miscellaneous internal noise.

Atmospheric Noise - thunderstorms, natural electrical disturbances

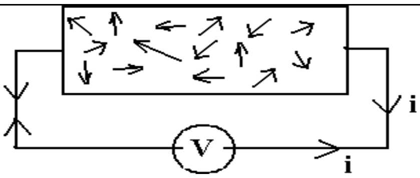
Extraterrestrial noise:

- Solar noise
- Cosmic noise

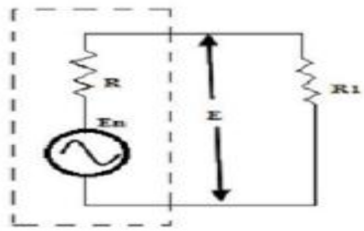
Solar noise: electrical noise emanating from the sun.
Cosmic noise: Distant stars are also suns and have high temperatures.

Man-Made Noise (Industrial Noise): electrical noise produced - automobiles and aircraft ignition, electrical motors and switch gears, leakage from high voltage lines, fluorescent lights, and numerous other heavy electrical machines.

Thermal Noise - movement of free electrons - long time averages zero - random motion of the electrons which give rise to noise voltage - white or Johnson noise.



N = k TB watts



$$P_n = \frac{E^2}{R_1} = \frac{E^2}{R} = \frac{(\frac{E_n}{2})^2}{R} = \frac{E_n^2}{4R}$$

$$[\therefore from\ Fig\ if\ R = R_2, E_n = \frac{E}{2}]$$

$$E_{n2} = 4RP_n$$

$$E_{n2} = 4R\,KTB$$

Transit Time Noise: kind of random noise within the device - directly proportional to the frequency of operation.

Miscellaneous Internal Noises Flicker Noise: transistors operating at low audio frequencies - proportional to the emitter current and junction temperature - inversely proportional to the frequency.

Transistor Thermal Noise: emitter, base and collector internal resistances.

Partition Noise: random fluctuations in the division.

Shot Noise: random movement of electrons or holes across a PN junction.

2

Analyze in detail about narrow band noise and the properties of in-phase and quadrature components of narrow band noise

In-Phase & Quadrature Sinusoidal Components

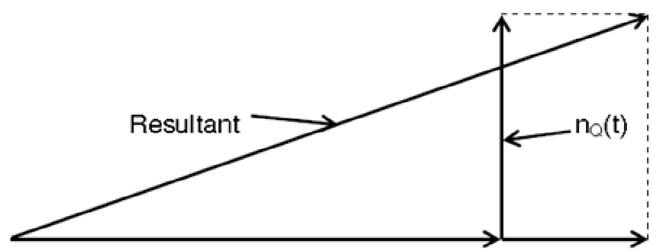
$$\mathbf{\sin(A+B) = \sin(A)\ \cos(B) + \ \cos(A)\ \sin(B)}$$

Trigonometry identity $\boldsymbol{x(t) \cong A_1 \cos(\omega t) + \ A_2 \sin(B)}$

in-phase component - single sinusoid at some amplitude and phase

phase-quadrature component - 90 degrees out of phase

Noise in AM receivers using Envelope detection:

	The AM wave may be written as s(t) = Ac[1+ kam(t)] cos2πfct n(t) = n_I(t) cos 2πft – n_Q(t) sin 2πft Discriminator = $n_Q(t)/A_c$ – carrier to noise ratio – removes variation in envelop Signal to Noise Ratio $$(\boldsymbol{SNR})_{\boldsymbol{C}} = \frac{\boldsymbol{A^2 c}\,[\boldsymbol{1 + k^2 aP}]}{\boldsymbol{2WN_o}}$$ **Received Signal** $$X\,(t) = [A_c + \; A_c\, K_a m(t) + n_I(t)\,]\cos 2\pi f_c t - n_Q(t)\sin 2\pi f_c t$$ **Phasor Diagram**  $$y\,(t) = \; A_c + \; A_c\, K_a m\,(t) + n_I(t)$$ $$\rho = \frac{A^2 c}{4WN_o}$$ $$(\boldsymbol{SNR})_{\boldsymbol{0}} = \frac{\boldsymbol{A^2 c}\,[\boldsymbol{k^2 aP}]}{\boldsymbol{2WN_o}}$$
3	**Derive the figure of merit of a FM system (may/june2013)** Ratio of output signals to noise ratio to channel signal to noise ratio is called figure of merit. FM receiver - desired-signal gain - limit the desired signal Signal to noise ratio - carrier to noise ratio - discriminator input - high compared to unity. input noise - increased - carrier to noise ratio decreased receiver output - carrier to noise ratio decreases - threshold effect. SNR - small noise power. x(t) = [Ac +nI(t)] cos2πfct – nQ(t) sin 2πfct Assumptions : output signal - absence of noise. 1. frequency deviation ΔI = 1/2.

2. Average output noise power - no signal present

Assumptions:

- Single-tone modulation, m(t) = Am cos(2Δfmt)
- Message bandwidth W =fm;
- AM system, μ =1;
- FM system, β = 5

4

i. Formulate the figure of merit for AM system for coherent system. (10)

ii. Create the formula to show the relationship between noise figure and equivalent noise temperature. (3)

The AM wave may be written as s(t) = Ac[1+ kam(t)] cos$2\pi fct$

$n(t) = n_I(t) \cos 2\pi ft - n_Q(t) \sin 2\pi ft$

Discriminator = $n_Q(t)/A_c$ – carrier to noise ratio – removes variation in envelop

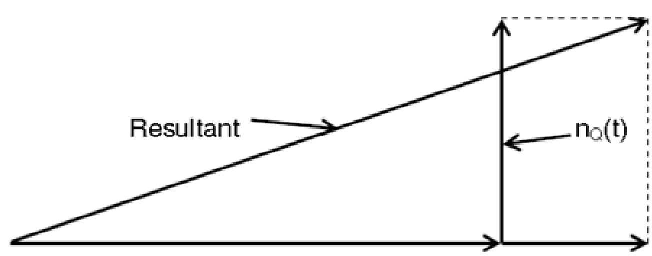
Signal to Noise Ratio

$$(\boldsymbol{SNR})_{\boldsymbol{C}} = \frac{\boldsymbol{A^2c}\,[\boldsymbol{1 + k^2aP}]}{\boldsymbol{2WN_o}}$$

Received Signal

$$X\,(t) = [A_c + A_c\,K_a m(t) + n_I(t)\,] \cos 2\pi f_c t - n_Q(t) \sin 2\pi f_c t$$

Phasor Diagram



$$y\,(t) = A_c + A_c\,K_a m\,(t) + n_I(t)$$

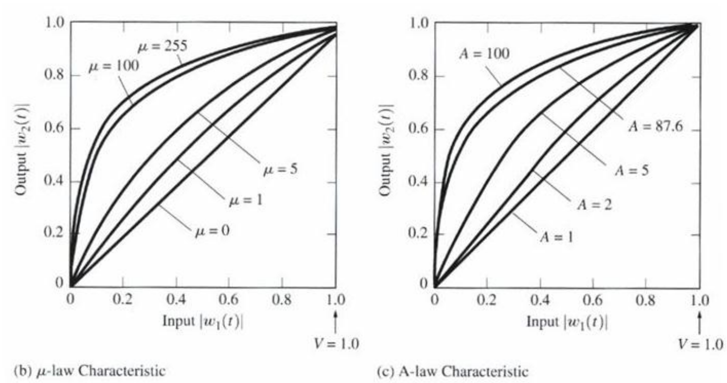
$$\rho = \frac{A^2c}{4WN_o}$$

$$(\boldsymbol{SNR})_{\boldsymbol{0}} = \frac{\boldsymbol{A^2c}\,[\boldsymbol{k^2aP}]}{\boldsymbol{2WN_o}}$$

UNIT V - SAMPLING & QUANTIZATION

Low pass sampling – Aliasing- Signal Reconstruction-Quantization - Uniform & non-uniform quantization - quantization noise - Logarithmic Companding –PAM, PPM, PWM, PCM – TDM, FDM.

PART * A

Q.No.	Questions
1.	**Define bandpass sampling. (April 2018) (or)** **State Sampling Theorem. (May 2006)** BTL1 If a finite energy signal g(t)contains no frequency components greater than W Hz, it is completely determined by specifying in ordinates at a sequence of points spaced 1/(2W) seconds apart. If a finite energy signal g(t)contains no frequency components greater than W Hz, it is completely recovered from its ordinates at a sequence of points spaced 1/(2W) seconds apart.
2	**In a PCM system the output of the transmitting quantizer is digital. Then why is it further encoded? (April 2018)** BTL 2 Further encoding is required to translate the discrete set of sample values to a more appropriate form of signal.
3	**Derive the expression for the quantization noise of a PCM system. (Nov 2017)** BTL 6 Quantization error or noise is produced by the quantizer by rounding off the sample values of an analog baseband signal to the nearest permissible representation levels of the quantizer. It is signal independent and uniformly distributed over the range -Δ/2 to +Δ/2. And it is denoted by 'q'. The distribution function is $$f_Q(q) = \begin{cases} 1/\Delta, & -\Delta/2 \le q \le \Delta/2 \\ 0, & otherwise \end{cases}$$ Quantization noise power $\sigma_Q^2 = \Delta^2/12$. Where σ_Q^2-Variance of Quantizer noise. Δ- Step size of uniform quantizer.
4	**What is Companding? Sketch the characteristics of compander. (April 2017)** BTL1 The combination of compressor at the input and expander at the output is called Companding. Compressor characteristics are defined by A-law and μ law Companding.  (b) μ-law Characteristic (c) A-law Characteristic
5	**A certain low pass bandlimited signal x(t) is sampled and the spectrum of the sampled version has the first guard band from 1500Hz to 1900 Hz. What is the sampling frequency? What is the maximum frequency of the signal? (April 2017)** BTL 3 F1 = 1500 Hz F2= 1900 Hz Guard bandwidth = f2-f1= 400Hz. Sampling frequency fs>=2*B = 800Hz. Maximum signal frequency = 400 Hz.

6	**What is meant by aliasing? (Nov 2016)** BTL1 Aliasing effect takes place when sampling frequency is less than Nyquist rate. Under such condition, the spectrum of the sampled signal overlaps with itself. Hence higher frequencies take the form of lower frequencies. This interference of the frequency components is called as aliasing effect.
7	**State Sampling theorem for band limited signals and the filter to avoid aliasing. (Dec 2015)** BTL1 If a finite energy signal g(t)contains no frequency components greater than W Hz, it is completely determined by specifying in ordinates at a sequence of points spaced 1/(2W) seconds apart. If a finite energy signal g(t)contains no frequency components greater than W Hz, it is completely recovered from its ordinates at a sequence of points spaced 1/(2W) seconds apart. Low pass anti-aliasing filter is used to avoid aliasing.
8	**Write the two-fold effects of Quantization Process. (Dec 2015)** BTL1. 1. The peak-to-peak range of input sample values subdivided into a finite set of decision levels or decision thresholds. 2. The output is assigned a discrete value selected from a finite set of representation levels are reconstruction values that are aligned with the treads of the staircase
9	**State 4 advantages of digital communication system. (April 2015)** BTL1 1. In digital Communication, the speech, video and other data may be merged and transmitted over a common channel using multiplexing technique. 2. The digital Communication system are simpler and cheaper because of advancement made in the IC technologies. 3. Channel Coding is used in digital Communication that why it reduces the amount of errors in the detector and correct them in the receivers. **4.** As the transmitted signals are digital in nature thus the amount of interference is controlled in this form of Communication.
10	**What are the major disadvantages of digital communication system. (April 2015)** BTL2 **State the demerit of digital communication. (May 2014)** **Disadvantages:** 1. Due to Analog to Digital Conversion the data rate become high. Therefore, more transmission bandwidth is required for digital communication. This is the major disadvantage of Digital communication. 2. Synchronization is required in digital communication during the process of synchronous modulation.
11	**Define Non-uniform Quantization. (April 2015)** BTL1 In uniform quantization, step or difference between two quantization levels remains constant over the complete amplitude range. So, the maximum quantization error also remains same, which causes problems at some amplitude levels. In such cases, non-uniform quantization is preferred with varying step size. This is achieved by compressor at the transmitter and uniform quantization and expander at the receiver collectively called as compander.
12	**What is the difference between natural and flat top sampling? (Nov 2014)** BTL 4 Flat top sampling is like natural sampling i.e.; practical in nature. In comparison to natural sampling flat top sampling can be easily obtained. In this sampling techniques, the top of the samples remains constant and is equal to the instantaneous value of the message signal x(t) at the start of sampling process. Sample and hold circuit are used in this type of sampling.
13	**Classify communication channels. (May 2014) (May 2013)** BTL 4 The communication medium between transmitter and receiver is called communication channel.

	Types: 1. Wired channel (Example. Coaxial cable, Fiber optic cable etc.) **2.** Wireless channel (Example. Air)
14	**What is the need for non-uniform quantization? (May 2014)** BTL 2 In uniform quantization, step size or the difference between two quantization levels remains constant over the complete amplitude range. So, the maximum quantization error also remains same, which causes problems at some amplitude levels. In such cases, non-uniform quantization is preferred.
15	**What is a channel? Give examples. (May 2014)** BTL1 The communication medium between transmitter and receiver is called communication channel. Types: 1. Wired channel (Example. Coaxial cable, Fiber optic cable etc.) 2. Wireless channel (Example. Air)
16	**What is natural sampling (May 2014) (May 2013)** BTL1 Natural Sampling is a practical method of sampling in which pulse(rectangular) have finite width equal to τ. Sampling is done in accordance with the carrier signal which is digital in nature.
17	**Write a law of compression (May 2014)** BTL1 A-law compression: $$\frac{c(\lvert x\rvert)}{x_{max}} = \begin{cases} \frac{A\lvert x\rvert/x_{max}}{1+lnA}, & 0 \le \frac{\lvert x\rvert}{x_{max}} \le 1/A \\ \frac{1+ln(A\lvert x\rvert/x_{max})}{1+lnA}, & 1/A \le \frac{\lvert x\rvert}{x_{max}} \le 1 \end{cases}$$ Typical Value of A= 87.56 Value for A giving Uniform Quantization A =1 M – law compression: $$\frac{c(\lvert x\rvert)}{x_{max}} = \frac{ln(1+\frac{\mu\lvert x\rvert}{x_{max}})}{ln(1+\mu)} \quad 0 \le \frac{\lvert x\rvert}{x_{max}} \le 1$$ Typical Value of μ= 255 Value for A giving Uniform Quantization μ =0
18	**State the advantages and disadvantage of digital communication systems over analog communication systems. (May 2013) (May 2011)** BTL 4 **Advantages:** 1. In digital Communication, the speech, video and other data may be merged and transmitted over a common channel using multiplexing technique. 2. The digital Communication system are simpler and cheaper because of advancement made in the IC technologies. 3. Channel Coding is used in digital Communication that why it reduces the amount of errors in the detector and correct them in the receivers. 4. As the transmitted signals are digital in nature thus the amount of interference is controlled in this form of Communication. **Disadvantages:** 1. Due to Analog to Digital Conversion the data rate become high. Therefore, more transmission bandwidth is required for digital communication. This is the major disadvantage of Digital communication. 2. Synchronization is required in digital communication during the process of synchronous modulation.

19

State any two non-uniform quantization rules. (May 2013) BTL1

A-law compression:

$$\frac{c(|x|)}{x_{max}} = \begin{cases} \dfrac{A|x|/x_{max}}{1+lnA}, & 0 \le \dfrac{|x|}{x_{max}} \le 1/A \\ \dfrac{1+ln(A|x|/x_{max})}{1+lnA}, & 1/A \le \dfrac{|x|}{x_{max}} \le 1 \end{cases}$$

Typical Value of A= 87.56

Value for A giving Uniform Quantization A =1

μ – law compression:

$$\frac{c(|x|)}{x_{max}} = \frac{ln(1+\frac{\mu|x|}{x_{max}})}{ln(1+\mu)} \quad 0 \le \frac{|x|}{x_{max}} \le 1$$

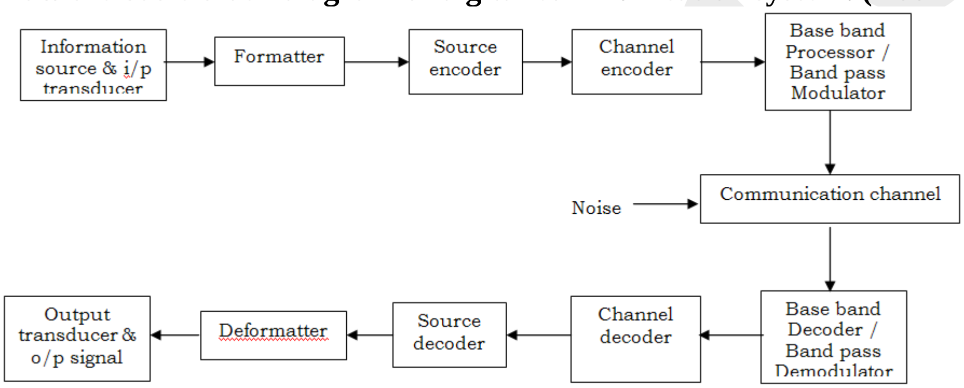
Typical Value of μ= 255

Value for A giving Uniform Quantization μ =0

20

Draw a typical digital communication system. (Nov 2012) BTL4

Draw the basic block diagram of digital communication system. (Nov-Dec 2011)



21

How can BER of a system can be improved? (Nov 2012) BTL 4

1. Increasing transmitted signal power.
2. Improving frequency filtering techniques.
3. Modulation and demodulation techniques.
4. Coding and decoding techniques.

22

An analog waveform with maximum frequency content of 3 KHz is to be transmitted over an M-ary PCM System, where M=16. What is the minimum number of bits/sample that should be used in digitizing the analog waveform? (Quantization error is specified not to exceed ±1% of the peak to peak analog signal) (Nov 2012) BTL 3

Quantities Given: p=±1%=0.01; $M=2^k$=16: k=4; Fm=3KHz.

Solution:

No of bits in PCM $l \ge \log_2 1/2p$

$l \ge 5.6$ bits

$l = 6$ bits

Sampling Rate Fs=2* Fm = 6KHz = 6K Samples/Sec

Bit tx rate : Rb= no of bits*Fs = 36 Kbps.

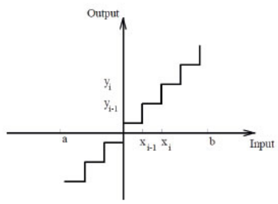
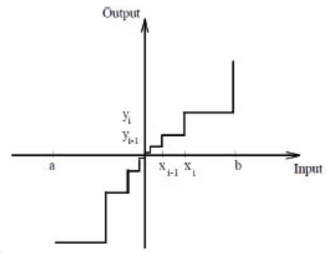
Baud Rate : B = Rb/k =36K/4 = 9K baud.

23

What is meant by Quantization? (May 2012) BTL1

While converting the signal value from analog to digital, quantization is performed. The analog value is assigned to nearest digital value. This is called quantization. The quantized value is then converted into equivalent binary value. The quantization levels are fixed depending upon the number of bits. Quantization is performed in every Analog to Digital Conversion.

24 **Compare Uniform and non-uniform quantization (Nov 2011)** BTL 4

Uniform quantization	**non-uniform quantization**
In uniform quantization, the step size or the difference between two quantization levels remain constant over the complete amplitude range.	In non-uniform quantization step size varies.
SNR ratio varies with input signal amplitude	SNR ratio can be maintained constant
 (a)	

25 **What is quantization error? (May 2011)** BTL1

Quantization error or noise is produced by the quantizer by rounding off the sample values of an analog baseband signal to the nearest permissible representation levels of the quantizer. It is signal independent and uniformly distributed over the range -Δ/2 to +Δ/2. And it is denoted by 'q'. The distribution function is

$$f_Q(q) = \begin{cases} 1/\Delta, & -\Delta/2 \le q \le \Delta/2 \\ 0, & otherwise \end{cases}$$

Quantization noise power $\sigma_Q^2=\Delta^2/12$. Where σ_Q^2-Variance of Quantizer noise. Δ- Step size of uniform quantizer.

26 **Define time limited and time unlimited signals. (Apr 2011)** BTL1

Time limited signal is one that is non-zero only for a finite length time interval and time unlimited signal is one which is non-zero for infinite length time interval. A signal that is band limited is not time-limited and vice-versa.

27 **Why is prefiguring done before sampling? (Nov 2010)** BTL 4

To exclude frequencies greater than ±W Hz, prefiguring such as low pass filtering is required to do proper sampling.

28 **Define quantization noise power. (Nov 2010)** BTL1

Quantization noise power of the uniform quantizer is nothing but the variance of the quantizer noise. It can be defined as $\sigma_Q^2=\Delta^2/12$. Where σ_Q^2-Variance of Quantizer noise. Δ- Step size of uniform quantizer.

29 **What is meant by distortion less transmission? (Nov 2010)** BTL1

If the overall system response has constant magnitude and if its phase shift is linear with frequency then that is said to be distortion less transmission.

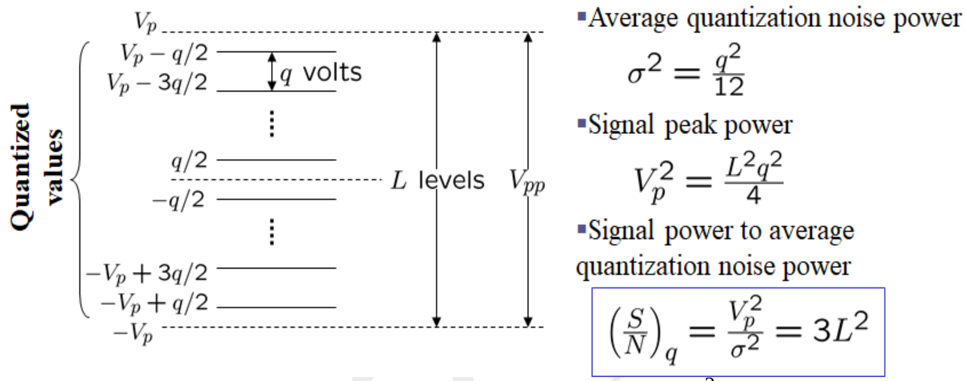
30 **Which parameter is called figure of merit of a digital communication system? Why? (Nov 2010)** BTL 4

The ratio of bit energy to noise power spectral density E_b/N_0 is called as the figure of merit of a digital communication system. This is because in digital communication system a symbol is transmitted and received by using a transmission window within a symbol tree. Since power goes to zero, symbol energy is a more useful parameter. So, an energy related parameter in terms of bit level is required to compare different systems.

PART * B

1 **Derive the expression for Signal to Noise ratio of Uniform quantizer (7) (April 2018)** BTL 1
Answer: Page 190 - S. Haykin

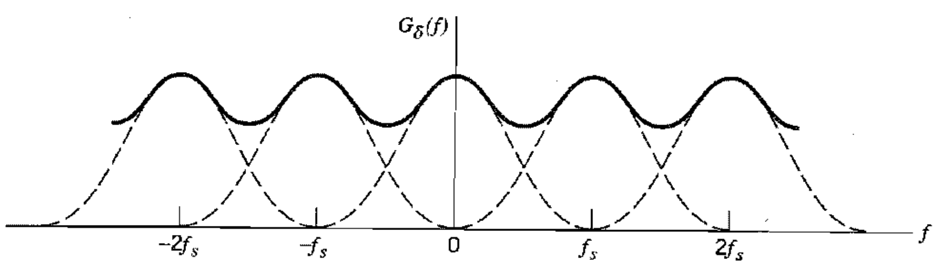
Uniform Quantizer: Quantizer - uniform step size – L – Quantization levels – step size- Δ (2M)
Variance of quantization noise: quantization noise – quantization – unavoidable- noise power- [$\sigma_Q^2 = \Delta^2/12$]
(3M)



Signal to Noise Ratio: Ratio – Signal Power- Noise Power - SNR $=3L^2$ – directly proportional – number of quantization levels.
(2M)

2 **Write a detailed note on aliasing and signal reconstruction (6) (April 2018) (Nov 2017)** BTL 1
Answer: Page 146 - S. Haykin

Aliasing: Overlapping of sampled signal spectrum, low frequency –high frequency mixing, Data loss (1M)
Condition for Aliasing: Fs < Fm (1M)
Aliasing Effects:

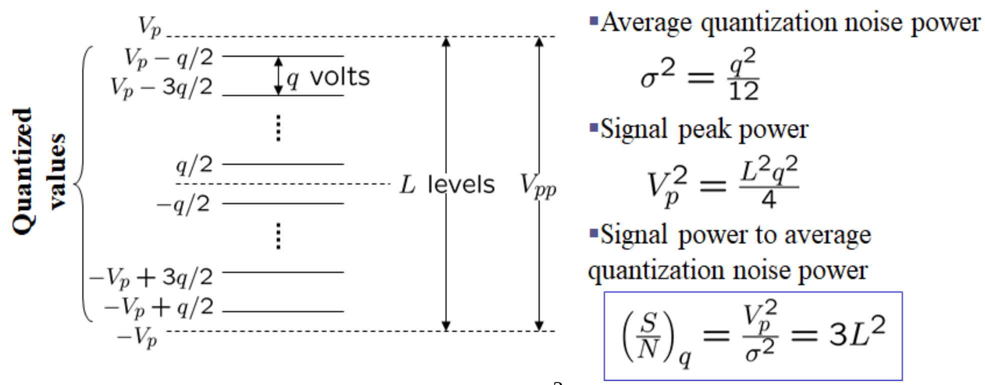


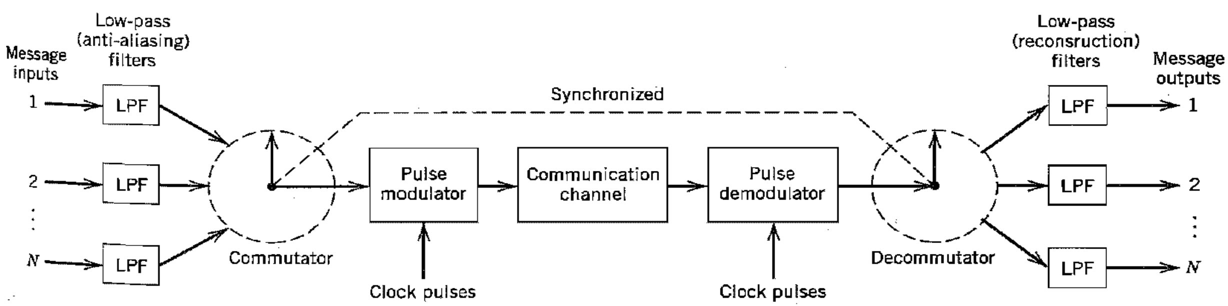
Signal reconstruction: Getting back original signal, low frequency, analog signal (2M)

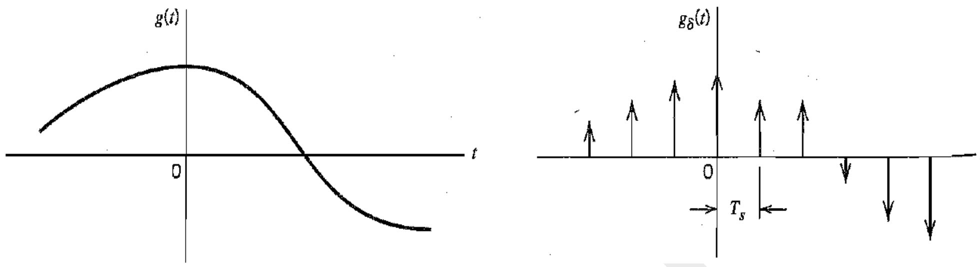
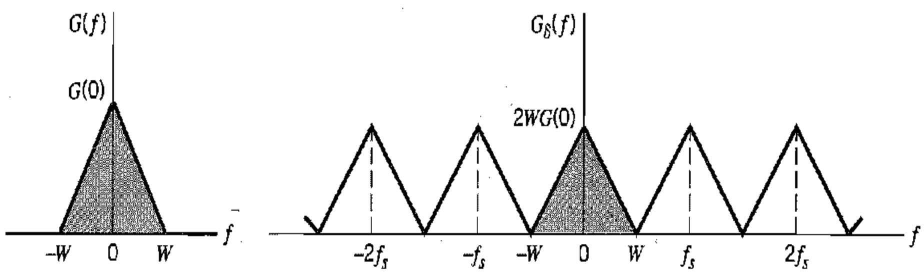
Reconstructed signal : $g(t) = \sum_{n=-\infty}^{\infty} g\left(\frac{n}{2W}\right) sinc(2Wt - n)$ (2M)

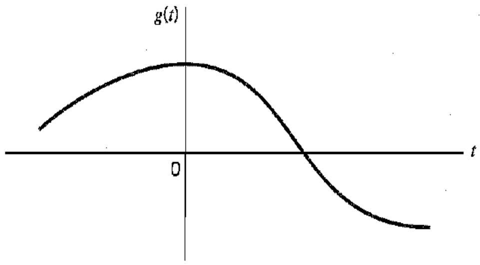
3 **A PCM system has a uniform quantizer followed by a v bit encoder. Show that the rms signal to noise ratio is approximately given by (1.8 +6 v) dB, assuming a sinusoidal input (7) (April 2018)** BTL 4
Answer: Page 190 - S. Haykin

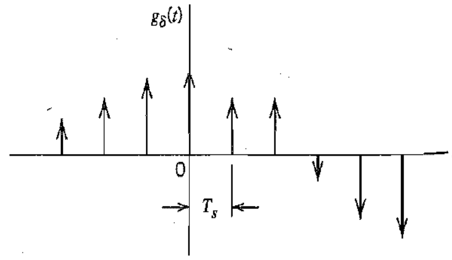
	Step size: $\Delta=2A/2^R$ (1M) **Signal Power:** $A^2/2$ (1M) **Noise Power:** $\Delta^2/12$ $(SNR)_{o,q} = A^2/2*2^{2R}*12/4A^2$ (2M) $=3/2*2^{2R}$ (2M) **SNR in dB** =1.8 +6 v (1M)
4	**Show that the signal to noise power ratio of a uniform quantizer in PCM system increases significantly with increase in number of bits per sample. Also determine the signal to quantization noise ratio of an audio signal S(t)= 4sin(2π500t) which is quantized using a 10 bit PCM (6) (April 2018)** BTL 6 **Answer: Page 190 - S. Haykin** **Signal:** S(t) =4sin(2π500t) **bit PCM**: $L=2^n$ n=10, hence 1024 levels. (1M) **Amplitude**: A=4V Peak to peak value 2*A= 8V. **Average signal power**: $P_{avg} = A^2/2$ = 8Watts. **Interval:** ΔV=2*A/L=8/1024=7.81 mV (2M) **Quantization noise**: $N_q = \Delta V^2/12$ **Signal to noise ratio:** SNR=Pavg/Nq = 1573770 (2M) SNR dB = $10\log_{10}$(SNR) = 61.96dB (1M)
5	**In detail explain logarithmic Companding of speech signals (4) (Nov 2017)** BTL 1 **Answer: Page 193 - S. Haykin** **Companding**: Compression at transmitter side- -expansion at receiver side (1M) **Companding Types** – A law and μ – law Companding. (1M) **A-law Companding with Characteristics** **A-law compression**: (1M) $$\frac{c(\lvert x\rvert)}{x_{max}} = \begin{cases} \frac{A\lvert x\rvert/x_{max}}{1+\ln A}, & 0 \le \frac{\lvert x\rvert}{x_{max}} \le 1/A \\ \frac{1+\ln(A\lvert x\rvert/x_{max})}{1+\ln A}, & 1/A \le \frac{\lvert x\rvert}{x_{max}} \le 1 \end{cases}$$ Typical Value - A= 87.56 Value for A giving Uniform Quantization A =1 **μ-law Companding with Characteristics**

	(1M) **µ– law compression:** $$\frac{c(\|x\|)}{x_{max}} = \frac{ln(1+\frac{\mu\|x\|}{x_{max}})}{ln(1+\mu)} \quad 0 \le \frac{\|x\|}{x_{max}} \le 1$$ Typical Value of µ= 255 Value for A giving Uniform Quantization µ =0
6	**Show that the signal to noise power ratio of a uniform quantizer is PCM system increases significantly with increase in number of bits per sample. Also determine the signal to quantization noise ratio of an audio signal S(t)= 3cos(2π500t) which is quantized using a 10-bit PCM (9) (Nov 2017)** BTL 6 **Answer: Page 190 - S. Haykin** **Signal:** S(t) =3sin(2π500t) **10Bit PCM:** $L=2^n$ n=10, hence 1024 levels. (3M) **Amplitude**: A=3V, Peak to peak value 2*A= 6V. **Average signal power**: Pavg $=A^2/2$ = 4.5Watts (2M) **Interval**: ΔV=2*A/L=8/1024=5.859 mV (2M) **Quantization noise**: Nq = $\Delta V^2/12 = 2.86*10^{-6}$ **Signal to Noise Ratio:** SNR=Pavg/Nq = 1573426.57 (3M) SNR dB = $10\log_{10}$(SNR) = 61.968dB (3M)
7	**What is meant by quantization? Derive the expression for signal-to-quantization noise ratio in PCM system. (10) (April 2017)** BTL 1 **Answer: Page 190 - S. Haykin** **Quantization**: discretization in amplitude domain. (1M) **Types:** Uniform- Uniform step size, Non-uniform - unequal step size. (2M) **Diagram**: (2M)  **SNR of PCM**: With Uniform Quantizer: SNR $=3L^2$ (2M)
8	**The information in an analog signal with maximum frequency of 3 KHz is required to be transmitted using 16 quantization levels in PCM system. Determine** **(1) maximum number of bits/sample** **(2) minimum sampling rate required**

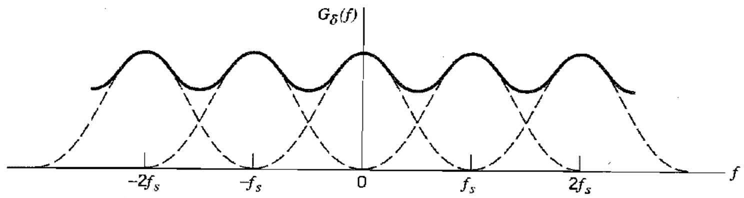
	(3) the resulting transmission date rate. (6) (April 2017) BTL 4 **Answer: Page 174 - S. Haykin** **Message length**: L=2^k (1M) **No of bits in PCM:** $l \geq \log_2 1/2p$ (1M) **Sampling Rate:** Fs=2*Fm (1M) **Bit Tx rate:** Rb= l*Fs (1M) **Baud Rate:** B = Rb/k (2M)
9	**Explain time division multiplexing system for N-number of channels (8) (April 2017)** BTL 4 **Answer: Page 162 - S. Haykin** **Time Division Multiplexing:** Transmission of number of signals - single channel - time slots (2M) **Low Pass Filter:** Removes noise components (3M) **Commutator:** Sampling – Interleaving **Pulse Modulator**: Pulse amplitude Modulation **Channel:** Wired – Wireless channel **Pulse Demodulator**: Pulse Amplitude Demodulation **DE commutator**: Disinter leaving – Reconstruction-LPF **Block diagram**: (3M)  **Applications**: RF Communication - Military Applications
10	**What is TDM? Explain the difference between analog TDM and digital TDM. (13) (May 2016)** BTL 4 **Answer: Page 162 - S. Haykin** **Time Division Multiplexing:** Transmission of number of signals - single channel - time slots (2M) **Block diagram**: (3M) **Low Pass Filter:** Removes noise components (6M) **Commutator:** Sampling – Interleaving **Pulse Modulator**: Pulse amplitude Modulation **Channel:** Wired – Wireless channel **Pulse Demodulator**: Pulse Amplitude Demodulation **DE commutator**: Disinter leaving – Reconstruction **Applications**: RF Communication - Military Applications **Difference between analog / digital TDM**: (2M) Analog TDM -sampling and quantizer block - included. Digital TDM - sampling and quantizer block - included.

11	**State the low pass sampling theorem and explain reconstruction of the signal from its samples (13) (May 2016)** BTL 1 **Answer: Page 134 - S. Haykin** **Sampling:** Discretization in time domain of analog signal (2M) **Theorem:** Finite energy signal g(t) - no frequency components greater than W Hz, -completely determined - sequence of points spaced 1/(2W) seconds apart. Finite energy signal g(t)- no frequency components greater than W Hz, - completely recovered - sequence of points spaced 1/(2W) seconds apart. (3M) **Derivation of Sampling:** $g\delta(t) = g(t) * \delta(nTs)$ (3M) **Waveform:** (2M)  **Sampled signal spectrum:**  (1M) **Reconstruction**: Getting Back analog signal (2M) **Reconstructed signal** $g(t) = \sum_{n=-\infty}^{\infty} g\left(\frac{n}{2W}\right) sinc(2Wt - n)$ (1M)
12	**Describe the process of sampling and how the message signal is reconstructed from its samples. Also illustrate the effect of aliasing with neat sketch. (13M) (Nov 2015)** BTL 1 **Answer: Page 134 - S. Haykin** **Definition:** Discretization in time domain of analog signal (2M) **Theorem:** Finite energy signal g(t) - no frequency components greater than W Hz, -completely determined - sequence of points spaced 1/(2W) seconds apart. Finite energy signal g(t)- no frequency components greater than W Hz, - completely recovered - sequence of points spaced 1/(2W) seconds apart. (2M) **Derivation of Sampling:** $g\delta(t) = g(t) * \delta(nTs)$ (3M) **Waveform**: (2M)





Aliasing effect with diagram: Overlapping - sampled signal spectrum (2M)
Condition for Aliasing: Fs < Fm (2M)



13

Explain the practical limitations in sampling and reconstruction (6) (Nov 2014) BTL 4
Answer: Page 134 - S. Haykin

Sampling: Discretization in time domain of analog signal - sampling. (2M)
Practical Limitation: Aliasing (1M)
Aliasing effect with diagram: Overlapping - sampled signal spectrum. (3M)

14

Explain non-uniform quantization techniques (8) (June 2014) BTL 1
Answer: Page 193 – S. Haykin

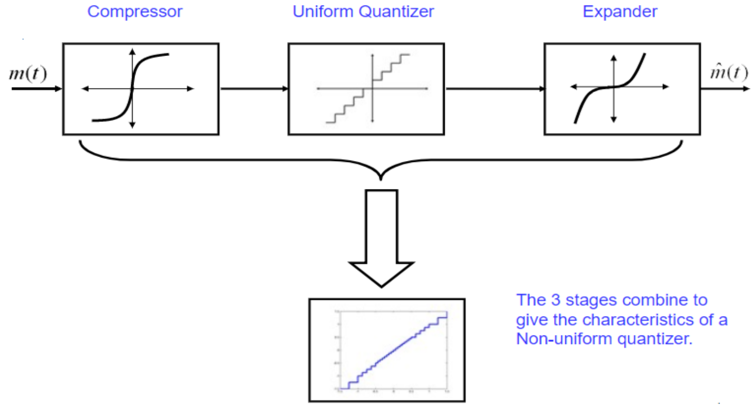
Non-uniform Quantization: step size varies (2M)
Companding: Compression at transmitter side - Expansion at the receiver side (2M)
Companding Types – A law and μ – law Companding. (1M)
A-law Companding with Characteristics
A-law compression: (1M)

$$\frac{c(|x|)}{x_{max}} = \begin{cases} \dfrac{A|x|/x_{max}}{1+lnA}, & 0 \le \dfrac{|x|}{x_{max}} \le 1/A \\ \dfrac{1+ln(A|x|/x_{max})}{1+lnA}, & 1/A \le \dfrac{|x|}{x_{max}} \le 1 \end{cases}$$

Typical Value - A= 87.56
Value for A giving Uniform Quantization A =1
μ-law Companding with Characteristics (1M)
μ– law compression:

$$\frac{c(|x|)}{x_{max}} = \frac{ln(1+\frac{\mu|x|}{x_{max}})}{ln(1+\mu)} \quad 0 \le \frac{|x|}{x_{max}} \le 1$$

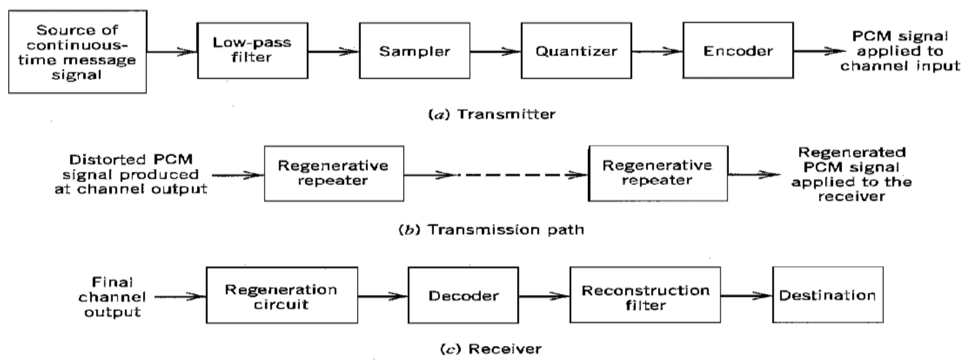
Typical Value of μ= 255
Value for A giving Uniform Quantization μ =0
Diagram: **(1M)**



15

With neat block diagram, explain pulse code modulation and demodulation system (8) (May-2012) BTL 1
Answer: Page 172 - S. Haykin

Pulse code Modulation: Conversion- analog signal - digital - particular waveform format (2M)
Explanation: Sampler-Discretization in time (3M)
Quantizer- Discretization in amplitude
Noises in PCM system: Quantisation noise, Channel Noise (3M)



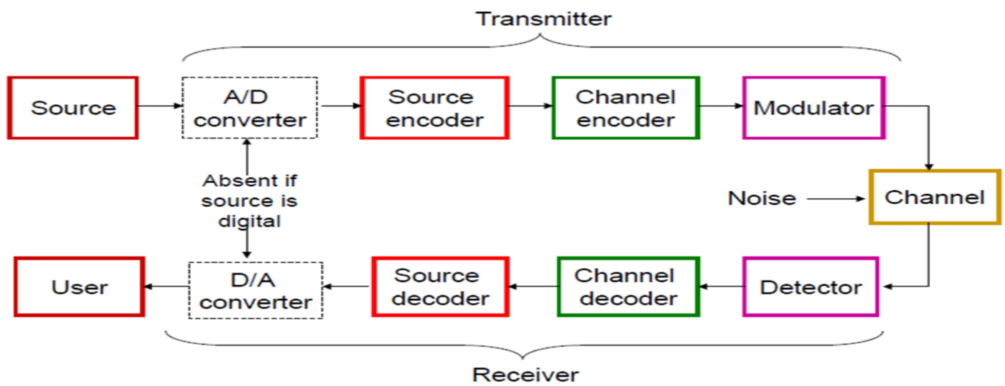
PART * C

1

Explain in detail about digital hierarchy with examples. (15) (April 2018) BTL 1
Answer: Page 4 - S. Haykin

Digital Communication: Transmitting digital message (2M)

Block Diagram of Digital Hierarchy: (4M)



	Explanation of each block: (7M) **Sampling and Quantization**: Analog signal - digital signal. **Source encoder and decoder**: Digital - particular format - transmission. **Channel encoder/Decoder**: Further coding - error free communication **Modulator/Demodulator**: Long distance transmission - reception of signals. **Channel:** Communication medium between Tx and RX- wired or wireless.
2	**Explain the advantages of digital modulation technique. (5) (Nov 2017)** BTL 2 **Answer: Page 1 - S. Haykin** **Definition:** Transmitting digital message (3M) **Advantages:** Robustness – Security – Integration- Low cost – Simple - Adaptable, etc. (2M)
3	**The bandwidth of TV, Video + audio signal is 4.5 MHz If the signal is converted to PCM bit stream with 1024 quantization levels. Determine the number of bits per second generated by the PCM system. Assume that signal is sampled at the rate of 20% above Nyquist rate. (15)** BTL 1 **Answer: Page 134 - S. Haykin** **Length:** $L=2^k$ (3M) **Bits in PCM:** $l \geq \log_2 1/2p$ (3M) **Sampling rate:** Fs=2*Fm (3M) **Bit Tx rate:** Rb= l*Fs (3M) **Baud Rate**: B = Rb/k (3M)
4	**The information in an analog signal with maximum frequency of 8 KHz is required to be transmitted using 32 quantization levels in PCM systems. Interpret** **(a) The maximum number of bits per sample** **(b) The minimum sampling rate** **(c) The resulting transmission data rate (15)** BTL 4 **Answer: Page 134 - S. Haykin** **Length:** $L=2^k$ (3M) **Bits in PCM:** $l \geq \log_2 1/2p$ (3M) **Sampling rate:** Fs=2*Fm (3M) **Bit Tx rate:** Rb= l*Fs (3M) **Baud Rate**: B = Rb/k (3M)
5	i) **Find the sampling rate for the following signal m(t)=2[cos(500*pi*t) *cos(1000*pi*t)] (7)** ii) **Can you find the Nyquist Rate for m(t)=5*cos(5000*pi*t) *cos²(8000*pi*t)? (8)** BTL 3 **Answer: Page 134 - S. Haykin** **Sampling rate**: Fs≥ 2*Fm (7M) **Nyquist Rate**: Minimum Sampling Rate: Fs=2* Fm (8M)

EC8451 ELECTROMAGNETIC FIELDS L T P C
4 0 0 4

OBJECTIVES:

- To gain conceptual and basic mathematical understanding of electric and magnetic fields in free space and in materials
- To understand the coupling between electric and magnetic fields through Faraday's law, displacement current and Maxwell's equations
- To understand wave propagation in lossless and in lossy media
- To be able to solve problems based on the above concepts

UNIT I INTRODUCTION 12

Electromagnetic model, Units and constants, Review of vector algebra, Rectangular, cylindrical and spherical coordinate systems, Line, surface and volume integrals, Gradient of a scalar field, Divergence of a vector field, Divergence theorem, Curl of a vector field, Stoke's theorem, Null Identities, Helmholtz's theorem

UNIT II ELECTROSTATICS 12

Electric field, Coulomb's law, Gauss's law and applications, Electric potential, Conductors in static electric field, Dielectrics in static electric field, Electric flux density and dielectric constant, Boundary conditions, Capacitance, Parallel, cylindrical and spherical capacitors, Electrostatic energy, Poisson's and Laplace's equations, Uniqueness of electrostatic solutions, Current density and Ohm's law, Electromotive force and Kirchhoff's voltage law, Equation of continuity and Kirchhoff's current law

UNIT III MAGNETOSTATICS 12

Lorentz force equation, Law of no magnetic monopoles, Ampere's law, Vector magnetic potential, Biot-Savart law and applications, Magnetic field intensity and idea of relative permeability, Magnetic circuits, Behavior of magnetic materials, Boundary conditions, Inductance and Inductors, Magnetic energy, Magnetic forces and torques

UNIT IV TIME-VARYING FIELDS AND MAXWELL's EQUATIONS 12

Faraday's law, Displacement current and Maxwell-Ampere law, Maxwell's equations, Potential Functions, Electromagnetic boundary conditions, Wave equations and solutions, Time-harmonic fields

UNIT V PLANE ELECTROMAGNETIC WAVES 12

Electromagnetic wave generation and equations – Wave parameters; velocity, intrinsic impedance, propagation constant – Waves in free space, lossy and lossless dielectrics, conductors- skin depth - Poynting vector – Plane wave reflection and refraction.

OUTCOMES:

- Display an understanding of fundamental electromagnetic laws and concepts
- Write Maxwell's equations in integral, differential and Phasor forms and explain their physical Meaning
- Explain electromagnetic wave propagation in lossy and in lossless media
- Solve simple problems requiring estimation of electric and magnetic field quantities based on these concepts and laws

TEXT BOOKS:

1. Mathew N. O. Sadiku, 'Principles of Electromagnetics', 6th Edition, Oxford University Press Inc. Asian edition, 2015.
2. William H. Hayt and John A. Buck, 'Engineering Electromagnetics', McGraw Hill Special Indian edition, 2014.
3. Kraus and Fleish, 'Electromagnetics with Applications', McGraw Hill International Editions, Fifth Edition, 2010.

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1. V.V.Sarwate, 'Electromagnetic fields and waves', First Edition, Newage Publishers, 1993.
2. J.P.Tewari, 'Engineering Electromagnetics - Theory, Problems and Applications', Second Edition, Khanna Publishers.
3. Joseph. A.Edminister, 'Schaum's Outline of Electromagnetics, Third Edition (Schaum's Outline Series), McGraw Hill, 2010.
4. S.P.Ghosh, Lipika Datta, 'Electromagnetic Field Theory', First Edition, McGraw Hill Education(India) Private Limited, 2012.
5. K A Gangadhar, 'Electromagnetic Field Theory', Khanna Publishers; Eighth Reprint : 2015

Subject Code: EE8451 **Year/Semester: II/04**
Subject Name: Electromagnetic Fields **Subject Handler: Dr. Prajith Prabhakar**

UNIT I INTRODUCTION

Electromagnetic model, Units and constants, Review of vector algebra, Rectangular, cylindrical and spherical coordinate systems, Line, surface and volume integrals, Gradient of a scalar field, Divergence of a vector field, Divergence theorem, Curl of a vector field, Stoke's theorem, Null Identities, Helmholtz's theorem

Q. No	Questions
1	**Define scalar and vector.** BTL 1 **Scalar:** A quantity that is characterized only by magnitude is called a scalar. **Vector:** A quantity that is characterized both by magnitude and direction is called a vector.
2	**Define Gradient.** BTL 1 The gradient of any scalar function is the maximum space rate of change of that function. If the scalar V represents electric potential, ∇ V represents potential gradient. $\nabla V = \frac{\partial V}{\partial x}\bar{a}_x + \frac{\partial V}{\partial y}\bar{a}_y + \frac{\partial V}{\partial z}\bar{a}_z$. This operation is called the gradient.
3	**Define divergence and curl.** BTL 1 **Divergence:** The divergence of a vector 'A' at any point is defined as the limit of its surface integrated per unit volume as the volume enclosed by the surface shrinks to zero. $\nabla .A = Lt_{v \to 0} \frac{1}{v} \iint_s \bar{A} . \bar{n}\, ds$. $\nabla .A = \frac{\partial A_x}{\partial x} + \frac{\partial A_y}{\partial y} + \frac{\partial A_z}{\partial z}$. This operation is called divergence. Divergence of a vector is a scalar quantity

	Curl: The curl of a vector ‘A’ at a any point is defined as the limit of its cross product with normal over a closed surface per unit volume as the volume shrinks to zero. $\nabla \times A = Lt_{v \to 0} \frac{1}{v} \oint_s \bar{n} \times A ds.$
4	**Show that the vector $\bar{H} = 3y^4z\, a_x + 4x^3z^2\, a_y + 2x^3y^2\, a_z$ is solenoidal.** BTL 1 $\nabla . H = \left(\frac{\partial}{\partial x}\bar{a}_x + \frac{\partial}{\partial y}\bar{a}_y + \frac{\partial}{\partial z}\bar{a}_z \right) . (3y^4z\bar{a}_x + 4x^3z^2\bar{a}_y + 2x^3y^2\bar{a}_z)$ $= \frac{\partial}{\partial x}(3y^4z) + \frac{\partial}{\partial y}(4x^3z^2) + \frac{\partial}{\partial z}(2x^3y^2) = 0 + 0 + 0 = 0$;Hence $\bar{H}$ is solenoidal.
5	**Determine the angle between $A = 2\, a_x + 4\, a_y$ and $B = 6\, a_y - 4\, a_z$. (Nov 2016)** BTL 5 $\theta = Cos[A . B/(A\ . B)]$ $A = 2^2 + 4^2 = 4.47$ $B = 6^2 + 4^2 = 7.21$ $A . B = 2 * 6 + 4 * 4 = 28$ θ=0.5182º
6	**Define Stoke’s and divergence Theorem. (Nov 2013, May 2014, Nov 2016)** BTL 1 **Stoke’s Theorem** The line integral of a vector around a closed path is equal to the surface integral of the normal component of its equal to the integral of the normal component of its curl over any closed surface. $\oint H .dl = \iint_s \nabla \times H dS$ **Divergence theorem** The volume integral of the divergence of a vector field over a volume is equal to the surface integral of the normal component of this vector over the surface bounding the volume. $\iiint_v \nabla . A dV = \iint_s A .dS$
7	**Write down the expression for conversion of Cylindrical to Cartesian system.** BTL 1 The Cylindrical co-ordinates (r , Φ , z) can be converted into Cartesian co-ordinates(x, y, z). **Given** **Transform** r x = r cosθ Φ y = r sinθ z z= z
8	**What is the physical significance of curl in a vector field? (Nov 2011)** BTL 1 The curl of a vector is an axial vector whose magnitude is the maximum circulation of A per unit area as the area tends to zero and whose direction is the direction normal direction of the area when the area is oriented to make the circulation maximum.
9	**Write down the expression for conversion of Cartesian to Spherical system.** BTL 1 The Cartesian co-ordinates (x, y, z) can be converted into Spherical co-ordinates (r, θ, Φ). **Given** **Transform**

	x $r = \sqrt{x^2+y^2+z^2}$ y $\theta = \cos^{-1}\left(\frac{z}{\sqrt{x^2+y^2+z^2}}\right)$ z $\Phi = \tan^{-1}(y/x)$
10	**Write down the expression for conversion of Spherical to Cartesian system.** BTL 1 The Spherical co-ordinates (r, θ, Φ) can be converted into Cartesian co-ordinates (x, y, z). **Given** **Transform** r x = rsinθ.cosΦ θ y = r sinθ.sin Φ Φ z = rcosθ
11	**Transform the Cartesian co-ordinates x = 2, y = 1, z = 3 into spherical co-ordinates.** BTL 5 **Given** **Transform** x = 2 $r = \sqrt{x^2+y^2+z^2} = \sqrt{4+1+9} = 3.74$ y = 1 $\theta = \cos^{-1}\left(\frac{z}{\sqrt{x^2+y^2+z^2}}\right) = \cos\text{-}1\left(\frac{3}{\sqrt{14}}\right) = 36.7^{o}$ z = 3 $\Phi = \tan^{-1}(y/x) = \tan^{-1}(1/2) = 26.56^{o}$ The spherical co-ordinates are (3.74, 36.7 ^{o}, and 26.56 ^{o}).
12	**Define electric flux, electric flux density and electric field intensity. (May 2016)** BTL 1 **Electric flux:** The lines of electric force are known as electric flux. It is denoted by Ψ. Ψ = Q (charge) Coulomb. **Electric flux density:** Electric flux density or displacement density is defined as the electric flux per unit area. D = Q/A **Electric field intensity:** Electric field intensity is defined as the electric force per unit positive charge. It is denoted by E. $E = \frac{F}{Q} = \frac{Q}{4\pi\varepsilon r^2}$ V/m.
13	**Two vectors are given P=3i+5j+2k and Q=2i-4j+3k.Determine the angular separation between them. (November 2011)** BTL 5 P. Q= IPIIQI cosθ, P.Q=-8, IPI=6.1644 IQI=5.38516, Cosθ=-0.2409, θ=103.94.
14	**Two vector quantities A=4i+3j+5k and B=i-2j-2k.are oriented in two different directions. Determine the angular separation between them. (Nov 2012) (May 2012)** BTL 5 $A.B = IAI\ IBI \cos\theta$ $\theta = \cos^{-1}\frac{A.B}{IAI\ IBI} = 67.84^{o}$

15	**What are the different sources of Electromagnetic fields? (May 2012) (May 2019)** BTL 1 Electromagnetic fields are present everywhere in our environment but are invisible to the human eye. Electric fields are produced by the local build-up of electric charges in the atmosphere associated with thunderstorms. The earth's magnetic field causes a compass needle to orient in a North-South direction and is used by birds and fish for navigation.
16	**Define the unit vector in cylindrical co-ordinate systems. (Nov 2013)** BTL 6 A vector A in cylindrical coordinates can be written as (A_ρ, A_φ, A_z) Where a_ρ, a_ϕ and a_z are unit vectors in the ρ, ϕ and z directions.
17	**State the condition for the vector to be solenoidal and irrotational. (Nov 2012)** BTL 1 A.B=0 and A X B=0
18	**State Gauss's law and Coulomb's law. (May 2016)** BTL 1 **Gauss's law:** The electric flux passing through any closed surface is equal to the total charge enclosed by that surface. $\Psi = Q$ **Coulomb's law.** Coulomb's law states that the force between two very small charged objects separated by a large distance compared to their size is proportional to the charge on each object and inversely proportional to the square of the distance between them. $F \alpha\ Q_1Q_2$ $F \alpha\ \frac{1}{r^2}$ $F \alpha\ \frac{Q_1Q_2}{r^2} = \frac{Q_1Q_2}{4\pi\varepsilon r^2}\overline{a_{12}}$ Newton
19	**Name a few applications of Gauss's law in electrostatics. (Nov 2013)** BTL 1 Gauss's law is applied to determine the electric field intensity from a closed surface. (e.g) Electric field can be determined for shell, two concentric shell or cylinders, etc.
20	**What is the electric field intensity at a distance of 20cm from a charge of 20μc/m^2 lying on the z=0 plane. in vacuum?(Nov/Dec 2014)** BTL 5 $E = \frac{\rho_s}{2\varepsilon_0} a_z = \frac{20\ x10^{-6}}{2x8.854\ x10^{-12}} a_z = 1.12 \times 10^6 a_z V/m.$
21	**Points P and Q are located at (0,2,4) and (-3,1,5). Calculate the distance vector from P to Q. (Nov/Dec 2014)** BTL 5 $R_{pq} = r_q - r_p$ = (-3,1,5) (0,2,4) = (-3,-1,1)
22	**Given $\bar{A}$ =4$\overline{a_x}$ +6$\overline{a_y}$ - 2$\overline{a_z}$ and $\bar{B}$ =-2$\overline{a_x}$ +4$\overline{a_y}$ +8$\overline{a_z}$. Show that the vectors are orthogonal. (April /May 2015)** BTL 5 $A.B$=(4*-2)+(6*4)+(-2*8)= -8+24-16 = 0. Therefore, A , B are orthogonal.
23	**Express in matrix form the unit vector transformation from the rectangular to cylindrical co-ordinate system. (April /May 2015)** BTL 1 $\begin{matrix} a_\rho \\ a_\phi \\ a_z \end{matrix} = \begin{matrix} \cos\varphi & \sin\varphi & 0 \\ -\sin\varphi & \cos\varphi & 0 \\ 0 & 0 & 1 \end{matrix} \begin{matrix} a_x \\ a_y \\ a_z \end{matrix}$

24	**What are the practical applications of electromagnetic fields? (Nov/Dec 2015)** BTL 1 Electric fans, electric motors, magnetic tape, mobiles and telephones.

PART * B

1

Given that D = (10 ρ^3/4) cylindrical coordinates, evaluate both sides of divergence tl **= 5. (13 M)** BTL 5

L.H.S.

$$\iint D \cdot dS = \int_{z=0}^{5} \int_{\phi=0}^{2\pi} \left(\frac{10\rho^3}{4}\right)_{\rho=4} a_\rho \cdot \rho \, d\phi \, dz \, a_\rho$$

$$= \int_{z=0}^{5} \int_{\phi=0}^{2\pi} \frac{10 \times 4^4}{4} d\phi \, dz$$

$$= 640 \times 5 \times 2\pi = 6400\pi.$$

R.H.S

(6 M)

$$\iiint \nabla \cdot D dV = \int_{z=0}^{5} \int_{\phi=0}^{2\pi} \int_{\rho=0}^{4} \nabla . D \rho d\rho \, d\phi \, dz$$

$$\nabla \cdot D = \frac{1}{\rho} \frac{\partial}{\partial \rho}(\rho D_\rho)$$

$$= \frac{1}{\rho} \frac{\partial}{\partial \rho}\left(\frac{10\rho^4}{4}\right) = \frac{1}{\rho}(10\rho^3) = 10\rho^2$$

$$\therefore \iiint \nabla \cdot D dV = \int_{z=0}^{5} \int_{\phi=0}^{2\pi} \int_{\rho=0}^{4} 10\rho^3 d\rho \, d\phi \, dz$$

$$= 10\left[\frac{\rho^4}{4}\right]_{\rho=0}^{4} \int_{z=0}^{5} \int_{\phi=0}^{2\pi} d\phi \, dz$$

$$= 640 \times 2\pi \times 5$$

$$= 6400\pi.$$

L.H.S. = R.H.S.

Hence, divergence theorem is verified.

(7 M)

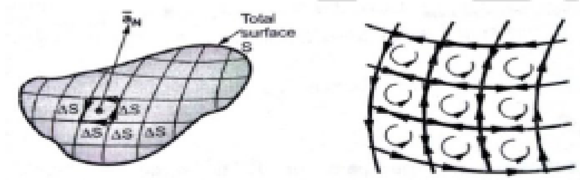
2	**State and prove Divergence theorem and Stokes's Theorem. (Nov 2011, Nov 2012, May 2012, Nov 2014, Nov 2016) (13M)** BTL 1 **Answer: Page No. 1.16 - Dr. P. Dananjayan** Statement:**(**2 M) The volume integral of the divergence of a vector field over a volume is equal to the surface integral of the normal component of this vector over the surface bounding the volume. $\iiint_v \nabla . A dV = \oiint_S A.dS$ Proof: ➢ Divergence of any vector A is given by $\nabla . A = \frac{\partial A_x}{\partial x} + \frac{\partial A_y}{\partial y} + \frac{\partial A_z}{\partial z}$ ➢ Taking volume integral on both sides $\iiint_v \nabla . A \; dv = \iiint \left[\frac{\partial A_x}{\partial x} + \frac{\partial A_y}{\partial y} + \frac{\partial A_z}{\partial z} \right] . dv$ ➢ Consider an element volume in x direction $\iiint_v \frac{\partial A_x}{\partial x} dx \; dy \; dz = \iint \left[\int \frac{\partial A_x}{\partial x} . dx \right] dy \; dz$ $\iiint_v \frac{\partial A_z}{\partial z} dx \; dy \; dz = \iint_S A_z ds_z$ ➢ Then, $\iiint_v \nabla . A \; dv = \oiint A.ds$

(4 M)

Stoke's Theorem(2 M)

The line integral of a vector around a closed path is equal to the surface integral of the normal component of its equal to the integral of the normal component of its curl over any closed surface.

$$\oint_L \vec{F} \cdot d\vec{L} = \int_S (\nabla \times \vec{F}) \cdot \overline{ds}$$



Proof of stokes theorem

- Consider a surface S which is splitted in to number of incremental surfaces.
- Each incremental surface is having area Δs .
- Applying definition of curl to any of these incremental surfaces we can write
  - $(\nabla \times \overline{F})_N = \dfrac{\oint \overline{F} . \overline{dL}_{\Delta s}}{\Delta S}$
  - Where N → Normal to Δs according to right hand rule

  $\overline{dL}_{\Delta s}$ → Perimeter of the incremental surface Δs
- Curl of $\vec{F}$ in normal direction is dot product of curl of $\vec{F}$ with $\bar{a}_N$.
- $\bar{a}_N$ - Unit vector, normal to the surface ΔS .
  - $(\nabla \times \overline{F})_N = (\nabla \times \overline{F}) . \bar{a}_N$
  - $\oint \overline{F} . \overline{dL}_{\Delta s} = (\nabla \times \overline{F}) . \bar{a}_N \Delta S$
  - $\oint \overline{F} . \overline{dL}_{\Delta s} = (\nabla \times \overline{F}) . \Delta S$

- Obtain total curl for every incremental surface, add closed line integrals for each Δs .
- Hence summation of all closed line integrals for each and every Δs ends up.
- Single closed line integral to be obtained for outer boundary of total surface S

$$\oint_L \overline{F} . \overline{dL} = \int_S (\nabla \times \overline{F}) . ds$$ (5 M)

3	**Transform $4\bar{a}_x$-$2\bar{a}_y$-$4\bar{a}_z$ at (2, 3, 5) to spherical coordinates. (Nov 2016) (13 M)** BTL 5 **Answer: Page - 1.58 -Dr. P. Dananjayan** Formula: (3 M) $\begin{bmatrix} A_r \\ A_\theta \\ A_\phi \end{bmatrix} = \begin{bmatrix} \sin\theta\cos\phi & \sin\theta\sin\phi & \cos\theta \\ \cos\theta\cos\phi & \cos\theta\sin\phi & -\sin\theta \\ -\sin\phi & \cos\phi & 0 \end{bmatrix} \begin{bmatrix} A_x \\ A_y \\ A_z \end{bmatrix}$ $A_x = 4 \quad A_y = -2 \quad A_z = -4$ $A_\rho = A_x \cos\phi + A_y \sin\phi = 4\cos\phi - 2\sin\phi$ $\phi = \tan^{-1}\left(\frac{y}{x}\right) = \tan^{-1}\left(\frac{3}{2}\right) = 56.31°$ $A_\rho = 4\cos 56.31° - 2\sin 56.31° = 2.219 - 1.664 = 0.555$ $A_\phi = -A_x \sin\phi + A_y \cos\phi$ $= -4\sin 56.31° - 2\cos 56.31° = -3.328 - 1.109 = -4.44$ The vector in cylindrical system can be written as $0.555\, a_\rho - 4.44\, a_\phi - 4\, a_z$.
4	**Write short notes on the following (i) Gradient (ii) Divergence (iii) Curl and (iv) Strokes theorem. (Nov 2013, Nov 2011) (13 M)** BTL 1 **Answer: Page -1.05- Dr. P. Dananjayan** **(i) Gradient.** (3M) The gradient of any scalar function is the maximum space rate of change of that function. If the scalar V represents electric potential, ∇ V represents potential gradient. $\nabla V = \frac{\partial V}{\partial x} a_x + \frac{\partial V}{\partial y} a_y + \frac{\partial V}{\partial z} a_z$. This operation is called the gradient. **(ii) Divergence:**(3M) The divergence of a vector 'A' at any point is defined as the limit of its surface integrated per unit volume as the volume enclosed by the surface shrinks to zero. $\nabla . A = Lt_{v \to 0} \frac{1}{v} \iint_s A . n\, ds.$

$\nabla . A = \frac{\partial A_x}{\partial x} + \frac{\partial A_Y}{\partial y} + \frac{\partial A_z}{\partial z}$. This operation is called divergence. Divergence of a vector is a scalar quantity.

(iii) Curl:(3 M)

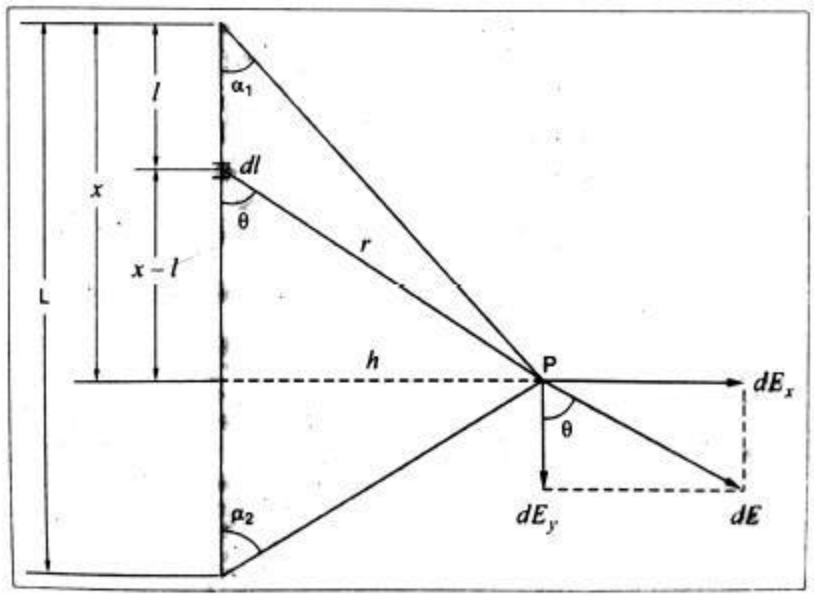
The curl of a vector 'A' at a any point is defined as the limit of its cross product with normal over a closed surface per unit volume as the volume shrinks to zero.

$\nabla \times A = Lt_{v \to 0} \frac{1}{v} \iint_s n \times A ds.$

(iv) Stoke's Theorem (4M)

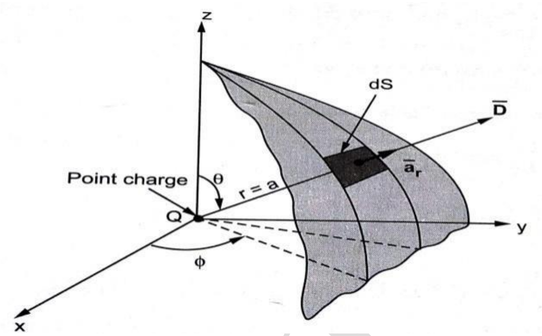
The line integral of a vector around a closed path is equal to the surface integral of the normal component of its equal to the integral of the normal component of its curl over any closed surface.

$\int H . dl = \iint_S \nabla \times H dS$

5	**Derive an expression for Electric field intensity due to a line charge which has a uniform linear charge density of ρLC/m. Also extend it to a conductor of infinite length. (Nov 2014, Nov 2015, April 2015) (13 M)** BTL 1 **Answer: Page - 1.23-Dr. P. Dananjayan** Diagram: (3M)  ➢ Consider a uniformly charged line of length L. ➢ Linear charge density is ρl c/m ➢ Consider a small element dl ➢ P be any point at a distance r from dl. (2M) ▪ dEx =dEsinθ ▪ dEy =dEcosθ ➢ Ex = ρl/(4πεh) *[cos α1 + cos α2] (2 M) ➢ Ey = ρl/(4πεh) *[sin α1 +sin α2] (2 M) ➢ Case (i) If the point is at bisector of a line, then α1=α2 = α • Ey = 0, E becomes Ex • E = ρl/(2πεh) (2 M) ➢ Case (ii) If the line is infinitely long the α = 0 • Ey = 0, E becomes Ex ➢ E = ρl/(2πεh) (2 M) ➢

6

State and prove the Gauss law. (April 2015) (13 M) BTL 1
Answer: Page -1.28 -Dr. P. Dananjayan
Statement: (2 M)
Diagram: (4 M)
Expression: (7M)
Gauss's law: The electric flux passing through any closed surface is equal to the total charge enclosed by that surface. $\Psi = Q$
Proof:



- Spherical surface = Gaussian surface
- Ds is normal to $\overline{a}_r$ direction

- $\psi = \int D.ds$
- $D = \frac{Q}{4\pi r^2}.\overline{a}_r$
- $ds = r^2 \sin\theta \; d\theta \; d\phi \; \overline{a}_r$
- $\psi = \int_0^{2\pi}\int_0^{\pi} \frac{Q}{4\pi r^2} \times r^2.\overline{a}_r \sin\theta \; d\theta \; d\phi \; \overline{a}_r$
- $\psi = \frac{4\pi Q}{4\pi} = Q$

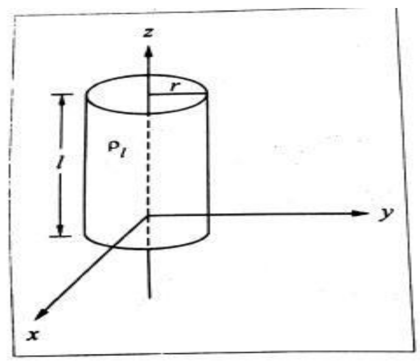
7	**Explain the applications of Gauss Law. (13 M)** BTL 1 **Answer: Page - 1.32 - Dr. P. Dananjayan** Application: (2 M)

Explain any two types:

- The surface is closed.
- Electric flux density is either normal or tangential to surface.
- Electric flux density is constant over surface where D is normal.
    - Infinite line charge.
    - Single shell of charge.

Infinite line charge.(6 M)

- Consider an infinite line charge of ρl c/m.
- Consider a circular cylinder of radius 'r'
- length 'l' as Gaussian surface
- Flux density Ds is normal to the surface.



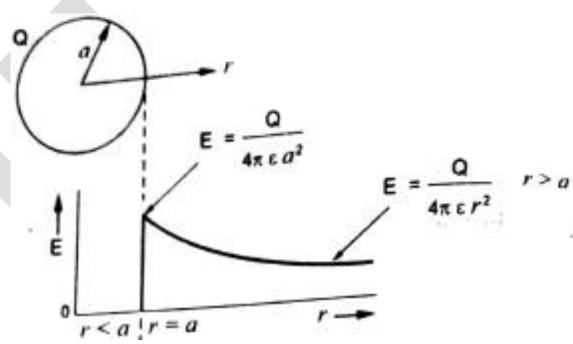
- By applying Gauss's Law to closed surface.

$$Q = \oint D_s \cdot ds$$

$$= D_s \int_{\text{sides}} ds + D_s \int_{\text{top}} ds + D_s \int_{\text{bottom}} ds$$

- Ds = Q / 2πr l
- Ds = ρl / 2πr
- E = ρl / 2πε0r

Single shell of charge(5 M)



- Charge Q is uniformly distributed over surface.
- Apply Gauss's law inside shell.
- Flux density is zero.

- $\int D.\,ds = 0$
- $\varepsilon \int E.\,ds = 0$
- $E = 0$

➢ By applying Gauss's law just outside shell.

➢ Integral of flux density D over a spherical surface.

- $\int D.\,ds = Q$
- $\varepsilon \int E.\,ds.\ Q$
- $E = Q / 4\,\pi\,\varepsilon\, r^2$

8

A vector field D = [5r^2 / 4] Ir given in spherical coordinates. Evaluate both sides of

3 M) BTL 5

Divergence theorem is

$$\iint D\cdot ds = \iiint \nabla\cdot D\,dv\,.$$

L.H.S.: $$\iint D\cdot ds = \int_{\phi=0}^{2\pi}\int_{\theta=0}^{\pi}\left(\frac{5r^2}{4}\right)_{r=1} I_r\cdot(r^2\sin\theta\, d\theta d\phi)\,(-I_r) + \int_{\phi=0}^{2\pi}\int_{\theta=0}^{\pi}\left(\frac{5r^2}{4}\right)_{r=2} I_r\,[r^2\sin\theta\; d\theta d\phi]\,(I_r)$$

$$= \int_0^{2\pi}\int_0^{\pi} -\frac{5}{4}\sin\theta\, d\theta d\phi + \int_0^{2\pi}\int_0^{\pi} 5\times 4\sin\theta\, d\theta d\phi$$

$$= +\frac{5}{2}\int^{2\pi}(+\cos\theta)^{\pi}\, d\phi + 20\int^{2\pi}(-\cos\theta)^{\pi}\, d\phi$$

$$= \frac{5}{2}(-2)[\phi]_0^{2\pi} + 20(2)[\phi]_0^{2\pi}$$

(3 M)

$$= -\frac{5}{2}\times 2\pi + 40\times 2\pi$$

$$= 80\,\pi\ -\ 5\,\pi$$

$$\iint D\cdot dS = 75\,\pi$$

R.H.S.: $$\iiint \nabla\cdot D\,dv$$

$$\nabla\cdot D = \frac{1}{r^2}\frac{\partial}{\partial r}(r^2 D_r) = \frac{1}{r^2}\frac{\partial}{\partial r}\left[r^2.\frac{5}{4}.r^2\right]$$

$$= \frac{1}{r^2}5r^3$$

$$= 5r$$

$$dV = r^2\sin\theta\, dr\, d\theta\, d\phi$$

$$= \int_{\phi=0}^{2\pi}\int_{\theta=0}^{\pi}\int_{r=1}^{2} 5r\times r^2\sin\theta\, dr\, d\theta\, d\phi$$

$$= \int_0^{2\pi}\int_0^{\pi}\int_1^{2} 5r^3\sin\theta\, dr\, d\theta\, d\phi$$

(5 M)

$$= 5\int_0^{2\pi}\int_0^{\pi}\left(\frac{r^4}{4}\right)_1^2 \sin\theta\, d\theta\, d\phi$$

$$= 5\times\left(\frac{16}{4}-\frac{1}{4}\right)\int_0^{2\pi}\int_0^{\pi}\sin\theta\, d\theta\, d\phi$$

$$= 5\times\frac{15}{4}\int_0^{2\pi}(-\cos\theta)_0^{\pi}\, d\phi$$

$$= 5\times\frac{15}{4}(+2)\cdot[2\pi]$$

$$\iiint \nabla\cdot D\,dv = 75\,\pi\,.$$

L.H.S = R.H.S.

Hence Divergence Theorem is verified.

(5 M)

9

Show that the vector E= $(6xy+z^2)a_x + (3x^2 - z)a_y + (3xz^2 - y)a_z$ is irrotational and find

$$\nabla\times E = \begin{vmatrix} \bar{a}_x & \bar{a}_y & \bar{a}_z \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ 6xy+z^3 & 3x^2-z & 3xz^2-y \end{vmatrix}$$

$$= \bar{a}_x\left[\frac{\partial}{\partial y}(3xz^2-y)-\frac{\partial}{\partial z}(3x^2-z)\right]-\bar{a}_y\left[\frac{\partial}{\partial x}(3xz^2-y)-\frac{\partial}{\partial z}(6xy+z^3)\right]$$
$$+\ \bar{a}_z\left[\frac{\partial}{\partial x}(3x^2-z)-\frac{\partial}{\partial y}(6xy+z^2)\right]$$

$$= \bar{a}_x\cdot[-1+1]-\bar{a}_y\cdot[3z^2-3z^2]+\bar{a}_z\cdot[6x-6x]$$

$$= 0$$

Hence E is irrotational.

(6 M)

$$-\nabla\cdot V = E = (6xy+z^3)\,\bar{a}_x + (3x^2-z)\,\bar{a}_y + (3xz^2-y)\,\bar{a}_z$$

$$-\left[\bar{a}_x\frac{\partial v}{\partial x}+\bar{a}_y\frac{\partial v}{\partial y}+\bar{a}_z\frac{\partial v}{\partial z}\right] = (6xy+z^3)\,\bar{a}_x+(3x^2-z)\,\bar{a}_y+(3xz^2-y)\,\bar{a}_z$$

Equating on both sides,

$$-\frac{\partial v}{\partial x} = 6xy+z^3$$

$$-\frac{\partial v}{\partial y} = 3x^2-z$$

$$-\frac{\partial v}{\partial z} = 3xz^2-y$$

Then,

$$-\partial v = (6xy+z^3)\,\partial x$$

$$-v = \int(6xy+z^3)\,\partial x$$

$$= 3x^2y+xz^3+c_1 \quad \text{where } c_1 \text{ is constant.}$$

	$$-\partial v = (3x^2 - z)\,\partial y$$ $$-v = 3x^2 y - yz + c_2$$ $$-\partial v = (3xz^2 - y)\,\partial z$$ $$-v = xz^3 - yz + c_3$$ Then, adding these values of v $$v = -2(3x^2 y + xz^3 - yz) + c$$ where $c = c_1 + c_2 + c_3$ (7 M)
10	**Check validity of the divergence theorem considering the field D=2xy ax + x²ay c/m² and the rectangular parallelepiped formed by the planes x=0,x=1,y=0,y=2 &z=0,z=3 (13 M)** BTL 2 **Answer: Page -1.60 - Dr. P. Dananjayan** Formula: The volume integral of the divergence of a vector field over a volume is equal to the surface integral of the normal component of this vector over the surface bounding the volume. (3 M) Verification: (10 M) $\iiint_v \nabla . A dV = \iint_S A . dS$ **☺Solution:** By divergence theorem, $$\iint \bar{D}\cdot n\,ds = \iiint_V \nabla\cdot\bar{D}\,dv$$ $$\nabla\cdot\bar{D} = \left(\bar{a}_x\frac{\partial}{\partial x} + \bar{a}_y\frac{\partial}{\partial y} + \bar{a}_z\frac{\partial}{\partial z}\right)\cdot(2xy\,\bar{a}_x + x^2\bar{a}_y)$$ $$= \frac{\partial}{\partial x}(2xy) + \frac{\partial}{\partial y}(x^2) + 0$$ $$= 2y + 0 = 2y$$ $$\iiint \nabla\cdot\bar{D}\,dv = \int_{x=0}^{1}\int_{y=0}^{2}\int_{z=0}^{3} 2y\,dx\,dy\,dz$$

$$= \int_0^1 \int_0^2 [\,2yz\,]_0^3 \, dx\, dy = \int_0^1 \int_0^2 6\, y\, dx\, dy$$

$$= \int_0^1 \left[6\, \frac{y^2}{2} \right]_0^2 dx = \int_0^1 12\, dx = [\,12\,x\,]_0^1 = 12$$

Evaluation of $\iint \mathrm{D} \cdot \boldsymbol{n}\, \boldsymbol{ds}$

$$\iint \mathrm{D} \cdot n\, ds = \iint \mathrm{D} \cdot \bar{a}_x\, dy\, dz + \iint \mathrm{D} \cdot (-\bar{a}_x)\, dy\, dz + \iint \mathrm{D} \cdot \bar{a}_y\, dx\, dz$$

$$+ \iint \mathrm{D} \cdot (-\bar{a}_y)\, dx\, dz + \iint \mathrm{D} \cdot \bar{a}_z\, dx\, dy + \iint \mathrm{D} \cdot (-\bar{a}_z)\, dx\, dy$$

$$\iint \mathrm{D} \cdot \bar{a}_x\, dy\, dz = \iint (2\,xy\,\bar{a}_x + x^2\,\bar{a}_y)\, (\bar{a}_x)\, dy\, dz$$

$$= \int_0^2 \int_0^3 2\,xy\, dy\, dz$$

$$= \int_0^2 [\,2\,xyz\,]_0^3\, dy = \int_0^2 6\,xy\, dy$$

$$= \left[6\,x\, \frac{y^2}{2} \right]_0^2 = 12\,x = 12 \qquad [\because x = 1]$$

$$\iint \mathrm{D} \cdot (-\bar{a}_x)\, dy\, dz = \iint (2\,xy\,\bar{a}_x + x^2\,\bar{a}_y)\, (-\bar{a}_x)\, dy\, dz$$

$$= 0 \qquad [\because x = 0]$$

$$\iint \mathrm{D} \cdot \bar{a}_y\, dx\, dz = \iint (2\,xy\,\bar{a}_x + x^2\,\bar{a}_y)\, (\bar{a}_y)\, dx\, dz$$

$$= \int_0^1 \int_0^3 x^2\, dx\, dz = \int_0^1 [\,x^2\, z\,]_0^3\, dx$$

$$= \int_0^1 3\,x^2\, dx = 3\, \frac{x^3}{3} \Big|_0^1 = 1$$

$$\iint D \cdot (-\bar{a}_y)\, dx\, dz = \iint (2\,xy\,\bar{a}_x + x^2\,\bar{a}_y)(-\bar{a}_y)\, dx\, dz$$

$$= -\int_0^1 \int_0^3 x^2\, dx\, dz = -\int_0^1 [\,x^2 z\,]_0^3\, dx$$

$$= -3\int_0^1 x^2\, dx = -3\,\frac{x^3}{3}\Big|_0^1 = 1$$

$$\iint D \cdot \bar{a}_z\, dx\, dy = \iint D \cdot (-\bar{a}_z)\, dx\, dy$$

$$= 0 \qquad [\because\ \bar{a}_z =$$

$$\therefore \iint D \cdot n\, ds = 12 + 0 + 1 - 1 = 12$$

$$\text{Hence,} \iint D \cdot n\, ds = \iiint_v \nabla \cdot D\, dv$$

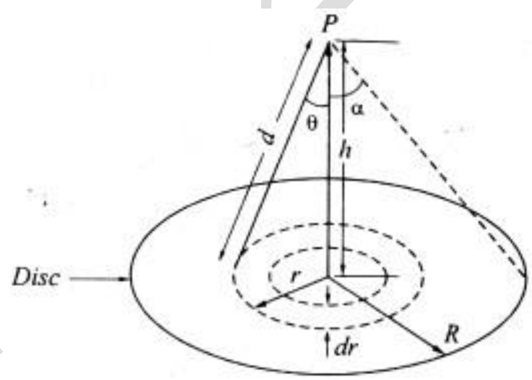
PART * C

1

Derive expression for electric field intensity due to uniformly charged circular disc of σ C/m². (Nov 2016) (15 M) BTL 2

Answer: Page - 1.25 - Dr. P. Dananjayan

Diagram: (3 M)



- Consider a circular disc radius R.
- Charge density ρs c/m^2
- Annular ring of radius r.
- Radial thickness dr.
- Area of annular ring ds = 2 π r dr
- dE = ρs ds / 4πε d^2
- dEy = ρs ds cos θ/ 4πε d^2
- E = [ρs / 2ε] * [1 – h/(√(h^2 + R^2))] (12 M)

2	**State and verify Divergence theorem for the vector $A = 4x\, i - 2y^2\, j + z^2\, k$, taken over the cube bounded by x = 0, x = 1, y = 0, y = 1. (15 M)** BTL 3 **Answer: Page - 1.67 - Dr. P. Dananjayan** Statement: (3 M) Verification: LHS = RHS = 3 (12 M)

The volume integral of the divergence of a vector field over a volume is equal to the surface integral of the normal component of this vector over the surface bounding the volume.

$$\iiint_v \nabla \cdot A\,dV = \oint\!\!\oint_S A \cdot dS$$

Given: $A = 4x\vec{i} - 2y^2\vec{j} + z^2\vec{k}$

$$\nabla \cdot A = \left(\vec{i}\frac{\partial}{\partial x} + \vec{j}\frac{\partial}{\partial y} + \vec{k}\frac{\partial}{\partial z}\right) \cdot (4x\vec{i} - 2y^2\vec{j} + z^2\vec{k})$$

$$= 4 - 4y + 2z$$

$$\iiint \nabla \cdot A = \int_0^1\int_0^1\int_0^1 (4 - 4y + 2z)\,dx\,dy\,dz$$

$$= \int_0^1\int_0^1 4z - 4yz + \frac{2}{2}z^2 \Big|_0^1 dx\,dy$$

$$= \int_0^1\int_0^1 (5 - 4y)\,dx\,dy$$

$$= \int_0^1 (5y - \frac{4}{2}y^2) \Big|_0^1 dx$$

$$= \int_0^1 3\,dx$$

$$= 3x \Big|_0^1 = 3$$

$$\oint\!\!\oint A \cdot ds = \iint A \cdot \vec{i}\,dy\,dz + \iint A(-\vec{i})\,dy\,dz + \iint A\,\vec{j}\,dx\,dz + \iint A(-\vec{j})\,dx\,dz + \iint A\,\vec{k}\,dx\,dy + \iint A(-\vec{k})\,dx\,dy$$

$$\iint A \cdot \vec{i}\;x\,dy\,dz = \int_0^1\int_0^1 (4x\vec{i} - 2y^2\vec{j} + z^2\vec{k})\,\vec{i}\,dy\,dz$$

$$= \int_0^1\int_0^1 4x\,dy\,dz$$

$$= \int_0^1 4xy \Big|_0^1 dz$$

$$= 4xz \Big|_0^1 = 4x$$

$$= 4 \qquad [\because x = 1]$$

$$\iint A(-\vec{i})\,dy\,dz = 0 \qquad [\because x = 0]$$

	$$\iint A(\vec{j})\, dx\, dz = \int_0^1\int_0^1 (4x\vec{i} - 2y^2\vec{j} + z^2\vec{k})\,\vec{j}\, dy\, dz$$ $$= \int_0^1\int_0^1 -2y^2\, dx\, dz$$ $$= \int_0^1 -2xy^2 \Big\vert_0^1 dz$$ $$= -2y^2 z \Big\vert_0^1$$ $$= -2y^2$$ $$= -2 \qquad [\because y = 1]$$ $$\iint A(-\vec{j})\, dx\, dz = 0 \qquad [\because y = 0]$$
3	**Determine the divergence of these vector fields. (15 M)** BTL 3 **(i)** **P =$x^2yz\, a_x + xz a_z$ (3 M)** **(ii)** **Q = $\rho \sin\varphi\, a_\rho + \rho^2 z\, a_\varphi + z\cos\varphi\, a_z$ (6 M)** **(iii)** **T = $(1/r^2)\cos\theta\, a_r + r\sin\theta\cos\varphi\, a_\theta + \cos\theta\, a_\varphi$ (6 M)** **Answer: Page - 1.42 - Dr. P. Dananjayan**

	(i) $\nabla.P = \frac{\partial P_x}{\partial x} + \frac{\partial P_y}{\partial y} + \frac{\partial P_z}{\partial z}$ $= \frac{\partial}{\partial x}(x^2 y z) + 0 + \frac{\partial}{\partial z}(xz)$ $= \mathbf{2xyz + x}$ ***(ii)*** $\nabla.Q = \frac{1}{\rho}\frac{\partial}{\partial \rho}(\rho Q_\rho) + \frac{1}{\rho}\frac{\partial Q_\phi}{\partial \phi} + \frac{\partial Q_z}{\partial z}$ $= \frac{1}{\rho}\frac{\partial}{\partial \rho}(\rho^2 \sin\phi) + \frac{1}{\rho}\frac{\partial}{\partial \phi}(\rho^2 z) + \frac{\partial}{\partial z}(z \cos\phi)$ $= \frac{1}{\rho}\cdot 2\rho\sin\phi + 0 + \cos\phi$ $= \mathbf{2\sin\phi + \cos\phi}$ $\nabla.T = \frac{1}{r^2}\frac{\partial}{\partial r}(r^2 T_r) + \frac{1}{r\sin\theta}\frac{\partial}{\partial \theta}(\sin\theta\, T_\theta) + \frac{1}{r\sin\theta}\frac{\partial T_\phi}{\partial \phi}$ (Spherical) $= \frac{1}{r^2}\frac{\partial}{\partial r}(r^2 \cdot \frac{1}{r^2}\cos\theta) + \frac{1}{r\sin\theta}\frac{\partial}{\partial \theta}(\sin\theta \cdot r\sin\theta\cos\phi) + \frac{1}{r\sin\theta}\frac{\partial}{\partial \phi}(\cos\theta)$ $= 0 + \frac{1}{r\sin\theta}\frac{\partial}{\partial \theta}(r\cos\phi\sin^2\theta) + 0$ $= \cos\phi\frac{\partial}{\partial \theta}(\sin^2\theta) = \cos\phi \cdot 2 \cdot \sin\theta \cdot \cos\theta$ $= \mathbf{2\cos\phi\sin\theta \cdot \cos\theta}$ ☺☺
4	**A charge Q_2=121 nCis located in vacuum at P_2 (-0.03, 0.01, -0.04) m. Find the force on Q_2 due to Q_1 =100μC at P_1(0.03, 0.08, 0.02) m. (May 2016) (7 M)** BTL 3 **Answer: Page -1.71 - Dr. P. Dananjayan**

	☺***Solution:*** $Q_1 = 100\ \mu C$ $P_1\ (0.03, 0.08, 0.02)$ $Q_2 = 121\ nC$ $P_2\ (-0.03, 0.01, -0.04)$ The distance between any two points say (x_1, y_1, z_1) and (x_2, y_2, z_2) is given by $d = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2}$ $= \sqrt{(0.03 + 0.03)^2 + (0.08 - 0.01)^2 + (0.02 + 0.04)^2}$ $= \sqrt{0.0121}$ $d = 0.11\ m$ (3 M) $F = \frac{Q_1 Q_2}{4\pi \varepsilon_0 d^2}$ $= \frac{100 \times 10^{-6} \times 121 \times 10^{-9}}{4 \times 3.14 \times 8.854 \times 10^{-12} \times (0.11)^2}$ Newtons $F = 8.989$ Newtons $\therefore$ **The force on Q_2 due to Q_1 is 8.989 Newtons.** (4 M)

Calculate electric field intensity at P(3, -4, 2) in free space called by

(a) Q1 = 2 µc at (0, 0, 0)(4 M)

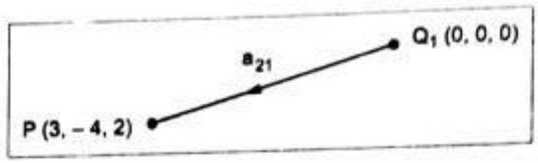
(b) Q2 = 3 µC at (-1, 2, 3) (4 M)

(c) Q1 = 2 µC at (0, 0, 0) and Q2 = 3 µC at (-1, 2, 3) (7M) (May 2019) BTL 5

Answer: Page -1.80 - Dr. P. Dananjayan

Solution:

(*a*)



$$\text{Unit vector } \bar{a}_{21} = \frac{r_1 - r_2}{|r_1 - r_2|}$$

$$= \frac{3\bar{a}_x - 4\bar{a}_y + 2\bar{a}_z}{\sqrt{9+16+4}}$$

$$= \frac{3\bar{a}_x + 4\bar{a}_y + 2\bar{a}_z}{\sqrt{29}}$$

Electric field intensity at P due to Q_1

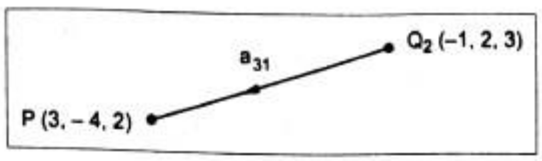
$$E = \frac{Q_1}{4\pi\varepsilon_0 r^2}\,\bar{a}_{21}$$

$$= \frac{2\times 10^{-6}}{4\pi \times \frac{1}{36\pi\times 10^9} \times (\sqrt{29})^2} \cdot \frac{3\,\bar{a}_x + 4\,\bar{a}_y + 2\,\bar{a}_z}{\sqrt{29}}$$

$$= \frac{2\times 9\times 10^3}{29\sqrt{29}}\,(3\,\bar{a}_x + 4\,\bar{a}_y + 2\,\bar{a}_z)$$

$$\mathbf{E = 345\,\bar{a}_x - 460\,\bar{a}_y + 230\,\bar{a}_z \quad V/m}$$

(*b*)



$$\bar{a}_{31} = \frac{\bar{a}_x(3-(-1)) + \bar{a}_y(-4-(2)) + \bar{a}_z(2-3)}{(3+1)^2 + (-4-2)^2 + (2-3)^2}$$

$$= \frac{4\,\bar{a}_x - 6\,\bar{a}_y - \bar{a}_z}{\sqrt{16+36+1}} \cdot \frac{4\,\bar{a}_x - 6\,\bar{a}_y - \bar{a}_z}{\sqrt{53}}$$

Electric intensity at P due to Q_2

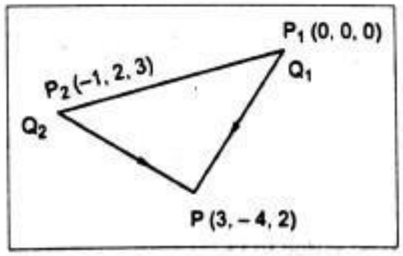
$$E = \frac{Q}{4\pi\varepsilon_0 r^2}\,\bar{a}_{31}$$

$$= \frac{3\times 10^{-6}}{4\pi \times \frac{1}{36\pi\times 10^9} \times (\sqrt{53})^2} \cdot \frac{4\,\bar{a}_x - 6\,\bar{a}_y - \bar{a}_z}{\sqrt{53}}$$

$$= \frac{3\times 9\times 10^3}{53\sqrt{53}}\,(4\,\bar{a}_x - 6\,\bar{a}_y - \bar{a}_z)$$

$$\mathbf{E = 280\,\bar{a}_x - 420\,\bar{a}_y - 70\,\bar{a}_z \quad V/m}$$

(c)



$$\bar{a}_{31} = \frac{3\,\bar{a}_x - 4\,\bar{a}_y + 2\,\bar{a}_z}{\sqrt{9+16+4}} = \frac{3\,\bar{a}_x - 4\,\bar{a}_y + 2\,\bar{a}_z}{\sqrt{29}}$$

Electric field intensity at P due to Q_1

$$E_1 = 345\,\bar{a}_x - 460\,\bar{a}_y + 230\,\bar{a}_z \text{ V/m}$$

Electric field intensity at P due to Q_2

$$E_2 = 280\,\bar{a}_x - 420\,\bar{a}_y + 70\,\bar{a}_z \text{ V/m}$$

Total electric field intensity at P due to Q_1 and Q_2

$$E = E_1 + E_2$$

$$= 345\,\bar{a}_x - 460\,\bar{a}_y + 230\,\bar{a}_z + 280\,\bar{a}_x - 420\,\bar{a}_y + 70\,\bar{a}_z$$

$$\mathbf{E = 65\,\bar{a}_x - 880\,\bar{a}_y + 160\,\bar{a}_z \text{ V/m}}$$

<table>
<tr><td colspan="2">UNIT II ELECTROSTATICS</td></tr>
<tr><td colspan="2">Electric field, Coulomb's law, Gauss's law and applications, Electric potential, Conductors in static electric field, Dielectrics in static electric field, Electric flux density and dielectric constant, Boundary conditions, Capacitance, Parallel, cylindrical and spherical capacitors, Electrostatic energy, Poisson's and Laplace's equations, Uniqueness of electrostatic solutions, Current density and Ohm's law, Electromotive force and Kirchhoff's voltage law, Equation of continuity and Kirchhoff's current law</td></tr>
<tr><td>Q. No</td><td>Part * A</td></tr>
<tr><td></td><td>Questions</td></tr>
<tr><td>1</td><td>What do you understand by linear, surface and volume charge densities?BTL 1
Linear Charge density: It is the charge per unit length (Col / m) at a point on the line of charge.
$\rho_l = Lt_{\Delta l \to 0} \left(\frac{\Delta Q}{\Delta l}\right)$
Surface charge density: It is the charge per surface area (C/m^2) at a point on the surface of the charge.
$\rho_s = Lt_{\Delta s \to 0} \left(\frac{\Delta Q}{\Delta s}\right)$
Volume charge density: It is the charge per volume (C/m^3) at a point on the volume of the charge.
$\rho_V = Lt_{\Delta v \to 0} \left(\frac{\Delta Q}{\Delta v}\right)$</td></tr>
<tr><td>2</td><td>Define potential and potential difference. (Nov2012)(May2012)(Nov2013)(Nov 2018) BTL 1
Potential: Potential at any point as the work done in moving a unit positive charge from infinity to that point in an electric field = $\frac{Q}{4\pi\varepsilon r}$ Volts.
Potential Difference: Potential difference is defined as the work done in moving a unit positive charge from one point in an electric field. V= $\frac{Q}{4\pi\varepsilon}\left(\frac{1}{r_A} - \frac{1}{r_B}\right)$ Volts.</td></tr>
<tr><td>3</td><td>Find the electric potential at a point (4 , 3) m due to a charge of 10^{-9} C located at the origin in free space.BTL 5
V= $\frac{Q}{4\pi\varepsilon_o r}$; r = $\sqrt{4^2 + 3^2}$ = 5m. V= $\frac{10^{-9}}{4\pi x 8.854 x 10^{-12} x (5)}$ = 1.8V</td></tr>
<tr><td>4</td><td>Define Capacitance.BTL 1
The capacitance of two conducting planes is defined as the ratio of magnitude of charge on either of the conductor to the potential difference between conductors. It is given by,
$C = \frac{Q}{V}$ Farad.</td></tr>
</table>

5	**What is meant by conduction current?** BTL 1 Conduction current is nothing but the current flows through the conductor. Conduction current density is given by $J_c = \sigma E$ Amp / m^2.
6	**Write the Poisson's equation and Laplace equation.(May 2014, May 2016, May 2019)** BTL 1 **Poisson equation;** $\nabla^2 V = -\rho/\varepsilon$ where ρ – Volume charge density ,ε - Permittivity of the medium, ∇ - Laplacian operator. $\frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial Y^2} + \frac{\partial^2 V}{\partial z^2} = -\rho/\varepsilon$ **Laplace equation:** $\nabla^2 V = 0$; $\frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial Y^2} + \frac{\partial^2 V}{\partial z^2} = 0$
7	**Give the relationship between potential gradient and electric field.** BTL 1 $E = -\nabla V$; $E = -\left(\frac{\partial}{\partial x}\bar{a}_x + \frac{\partial}{\partial y}\bar{a}_y + \frac{\partial}{\partial z}\bar{a}_z\right) V$.
8	**Define dipole and dipole moment.** BTL 1 Dipole or electric dipole is nothing but two equal and opposite point charges are separated by a very small distance. The product of electric charge and distance (spacing) is known as dipole moment. It is denoted by m where Q is the charge and l is the length (m) =Q. l C/m
9	**What is meant by conservative property of Electric field? (Nov 2011)** BTL 1 The line integral of electric field along a closed path is zero. Physically this implies that no net work is done in moving a charge along a closed path in an electrostatic field. Thus an electrostatic field is said to have conservative property.
10	**What is meant by Displacement current density?** BTL 1 Displacement current is nothing but the current flows through the Capacitor. Displacement current density is given by $J_d = \frac{\partial D}{\partial t}$ Amp / m^2
11	**State the boundary conditions at the interface between two perfect dielectrics.** BTL 1 The tangential component of electric field E is continuous at the surface. That is E is the same just outside the surface as it is just inside the surface. $E_{t1} = E_{t2}$ The normal component of electric flux density is continuous if there is no surface charge density. Otherwise D is discontinuous by an amount equal to the surface charge density. $D_{n1} = D_{n2}$
12	**Find the energy stored in a parallel plate capacitor of 0.5m by 1m has a separation of 2cm and a voltage difference of 10V.** BTL 5 $C = \varepsilon_o \frac{A}{d} = \frac{8.854 \times 10^{-12} \times 0.5 \times 1}{2 \times 10^{-2}} = 2.2135 \times 10^{-10}$F Energy stored in a capacitor $E = 1/2\ CV^2 = 1/2 \times 2.2135 \times 10^{-10} \times 10^2 = 1.10675 \times 10^{-8}$ Joules.

13	**Express the value of capacitance for a co-axial cable.** BTL 5 C= $\frac{2\pi\varepsilon_o\varepsilon_r}{\ln\frac{b}{a}}$; Where b – outer radius: a – inner radius.
14	**Determine the capacitance of a parallel plate capacitor with two metal plates of size 30cm x 30cm separated by 5mm in air medium.** BTL 5 Given data: A = 0.3 X0.3 = 0.09m^2; d=5 x 10^{-3}m. ε_o =8.854 x 10^{-2};C= $\frac{A}{2}$ ε_o= $\frac{0.09\times 8.854\times 10^{-12}}{5\times 10^{-3}}$ = 15.9nF
15	**What is the physical significance of divD?** BTL 1 $\nabla . D = \rho_v$. The divergence of a vector flux density is electric flux per unit volume leaving a small volume. This is equal to the volume charge density.
16	**A parallel plate capacitor has a charge of 10-3 C on each plate while the potential difference between the plates is 1000V.Calaculate the value of capacitance. (Nov 2012)(May2012)** BTL 5 Given data, Q = 10-3C, V = 1000V, C = $\frac{Q}{V}$ = $\frac{10^{-3}}{10^{3}}$ = 1µF.
17	**Give the significant physical difference between Poisson's and Laplace equation. (Nov 2011, Nov/Dec14, Nov 2018)** BTL 2 **Poisson equation:** $\nabla^2 V = -\rho/\varepsilon$ Where ρ – Volume charge density, ε – Permittivity of the medium, ∇^2 - Laplacian operator. $\frac{\partial^2 V}{\partial x^2}+\frac{\partial^2 V}{\partial Y^2}+\frac{\partial^2 V}{\partial z^2}$ = - ρ/ε **Laplace equation:** $\nabla^2 V = 0$; $\frac{\partial^2 V}{\partial x^2}+\frac{\partial^2 V}{\partial Y^2}+\frac{\partial^2 V}{\partial z^2}$ =0 The Laplace equation is defined only for the region which is free of charges.
18	**State the properties of electric flux lines.(Nov/Dec 2014)** BTL 1 a. It must be independent of the medium. b. Its magnitude solely depends upon the charge from which it originates, c. If a point charge is enclosed in an imaginary sphere of radius R, the electric flux must pass perpendicularly and uniformly through the surface of the sphere and d. The electric flux density, the flux per unit area is then inversely proportional to R^2.
19	**What is the electric field intensity at a distance of 20 cm from a charge of 2 µC in vacuum? (Nov/Dec 2015)** BTL 5 E=$\frac{Q}{4\pi\epsilon r^2}$ V/m ; E=$\frac{2*10^{-6}}{4\pi*8.854*10^{-12}*0.02^2}$ V/m ; E = 4.49 * 10^7 V/m

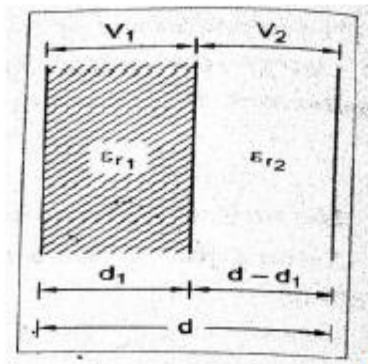
20	**Calculate the capacitance per Km between a pair of parallel wires each of diameter 1cm at a spacing of 50cms. (Nov/Dec 2015)**BTL 5 $c = \frac{\epsilon A}{d} F/km$; A = 2π rh = 2π * $1*10^{-5}*1$= $6.28 *10^{-5}$ km^2; d = 50 $*10^{-3}$ km; c = $\frac{8.854\times10^{-12}\times6.28\times10^{-5}}{50\times10^{-3}}$ F/km = $1.112 *10^{-4}$ F/km.
21	**Find the electric field intensity in free space if D=30az C/m². (April /May 2015)**BTL 5 D= ; E = $\frac{D}{\epsilon}$; E = $\frac{30}{8.854*10^{-12}}$ = $3.388*10^{12}$ V/m
22	**What is the practical significance of Lorentz's Force?(April /May 2015)(Nov/Dec 2015)**BTL 1 When an electric charge element is moving in a uniform magnetic field (B) with velocity V, the charge experience a force (dF). This force is called as Lorentz's force. $dF = dQVBsin\theta$, θ is angle between V and B. The direction of lorentz's force is maximum if the direction of movement of charge is perpendicular to the orientation of field lines.
23	**Find the capacitance of an isolated spherical shell of radius α. (Nov 2016)**BTL 5 C= 4πεr
24	**Find the magnitude of D for a dielectric material in which E=0.15MV/m and ε_r=5.25. (Nov 2016)**BTL 5 ; $D = 8.854\times10^{-12}\times5.25\times0.15\times10^{6} = 6.97\mu V/m$
25	**Define capacitor and capacitance. (May 2016)**BTL 1 Capacitor is a passive element that stores electrical energy in an electric field. Capacitance is the ability of a body to store an electric charge.
	PART * B
1.	**Derive the expression for energy and energy density in the static electric field.(Nov 2013, Nov 2015, Nov 2018) (13 M)** BTL 2 **Answer: Page - 2.24 – Dr. P. Dananjayan** Energy: (7 M) ➢ Capacitor stores the electrostatic energy. ➢ Voltage connected across the capacitor, capacitor charges. ➢ Potential is defined as work done per unit charge. ➢ V = dW/dQ ➢ dW = V. dQ ➢ but V = Q/C ➢ W = $\int_0^Q \frac{Q}{C} dQ$ ➢ W = $Q^2/2C$ ➢ But Q = CV ➢ Energy = ½ C V^2 Energy Density: (6 M) ➢ Consider a elementary cube of side Δd. ➢ ΔC = εA/Δd = εΔd

- $\Delta W = ½ \Delta C (\Delta V)^2$
- But $\Delta V = E. \Delta d$
- $\Delta W = ½ \varepsilon E^2 \Delta V$
- Energy Density = ½ DE

2

Deduce an expression for the capacitance of a parallel plate capacitor with two dielectrics of relative permittivity ε_1 and ε_2 respectively interposed between the plates.(Nov 2013, May 2015, May 2016) (13 M)BTL 2

Answer: Page - 2.16–Dr. P. Dananjayan



(2M)

- Consider a parallel plate capacitor consist of two dielectrics.
- εr1 and εr2 relative permittivity of medium 1 and 2.
- V = V1 + V2
- V1 = E1 d1
- V2 = E2 (d – d1)
- V = E1 d1 + E2 (d – d1)(5 M)

$$E_1 = \frac{D}{\varepsilon_0 \varepsilon_{r_1}} = \frac{Q}{A \varepsilon_{r_1} \varepsilon_0}$$

$$E_2 = \frac{D}{\varepsilon_0 \varepsilon_{r_2}} = \frac{Q}{A \varepsilon_{r_2} \varepsilon_0}$$

-

$$V = \frac{Q}{A \varepsilon_0}\left[\frac{d_1}{\varepsilon_{r_1}} + \frac{d-d_1}{\varepsilon_{r_2}}\right]$$

$$\frac{Q}{V} = \frac{A \varepsilon_0}{\dfrac{d_1}{\varepsilon_{r_1}} + \dfrac{d-d_1}{\varepsilon_{r_2}}}$$

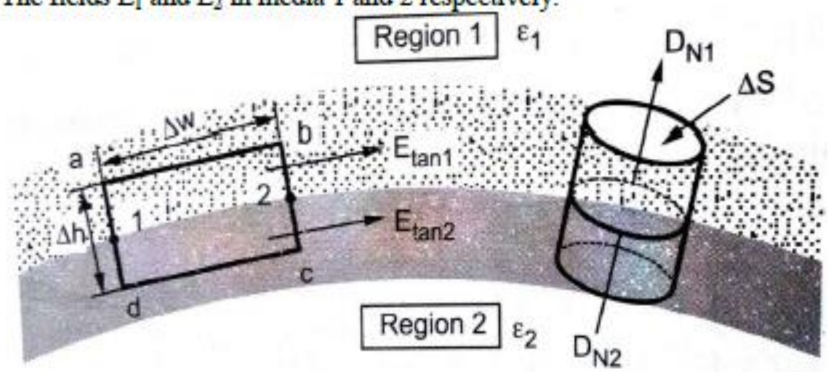
$$C = \frac{A \varepsilon_0}{\dfrac{d_1}{\varepsilon_{r_1}} + \dfrac{d-d_1}{\varepsilon_{r_2}}}$$

-

Capacitance = A ε0 εr / (d_1 εr + (d – d_1)(6 M)

3.	**Derive the electrostatic boundary conditions at the interface between two dielectrics and a conductor to dielectric medium.(Nov2013, Nov 2014, Nov 2015, Nov 2018) (13 M)** BTL 1 **Answer: Page- 2.25 - Dr. P. Dananjayan**

- The boundary conditions at an interface separating
- Dielectric (ε_{r1}) and dielectric (ε_{r2})
- Conductor and dielectric
- Conductor and free space
- To determine the boundary conditions, we need to use Maxwell's equations:
- $\oint E.dl = 0$-----(1)
- $\oint_s D.ds = Q_{enc}$ ------(2)
- Where Q_{enc} is the free charge enclosed by the surface S.
- Electric field intensity is decomposed into two orthogonal components.
- $E = E_t + E_n$ -------(3)
- Where E_t and E_n are tangential and normal components of E to the interface of interest.
- **Dielectric to Dielectric Boundary Conditions:**
- Consider E field existing in a region that consists of two different dielectrics.
- The fields E_1 and E_2 in media 1 and 2 respectively.



Boundary between two perfect dielectrics

- $E_1 = E_{1t} + E_{1n}$ ------(4a)
- $E_2 = E_{2t} + E_{2n}$ ------(4b)
- Apply equation (1) to the closed path abcda, assuming that the path is very small with respect to the spatial variation of E. we obtain,
- $0 = E_{1t}\Delta w - E_{1n}\frac{\Delta h}{2} - E_{2n}\frac{\Delta h}{2} - E_{2t}\Delta w + E_{2n}\frac{\Delta h}{2} + E_{1n}\frac{\Delta h}{2} - - - - - - (5)$

  Where $E_t = |E_t|$ and $E_n = |E_n|$

  The $\frac{\Delta h}{2}$ terms cancel and equ (5)becomes,

  $0 = (E_{1t} - E_{2t})\Delta w$

  $\boxed{\boldsymbol{E_{1t} = E_{2t}}}$-----(6) (6 M)

  Tangential components of E are the same on the two sides of the boundary. Since $D = \varepsilon E = D_t + D_n$, equation (6) can be written as,
- $\frac{D_{1t}}{\varepsilon_1} = E_{1t} = E_{2t} = \frac{D_{2t}}{\varepsilon_2}$
- $\frac{D_{1t}}{\varepsilon_1} = \frac{D_{2t}}{\varepsilon_2} - - - - - - (7)$
- D_t undergoes some change across the interface. Hence D_t is said to be discontinuous across the interface.
- Similarly, we apply equation (2) to the pillbox (Cylindrical Gaussian Surface), the contribution due to the sides vanishes. Allowing $\Delta h \rightarrow 0$ gives,
- $\Delta Q = \rho_S \Delta S = D_{1n}\Delta S - D_{2n}\Delta S$

Boundary between two perfect dielectrics

- $E_1 = E_{1t} + E_{1n}$ ------(4a)
- $E_2 = E_{2t} + E_{2n}$ ------(4b)
- Apply equation (1) to the closed path abcda, assuming that the path is very small with respect to the spatial variation of E. we obtain,

  $0 = E_{1t}\Delta w - E_{1n}\frac{\Delta h}{2} - E_{2n}\frac{\Delta h}{2} - E_{2t}\Delta w + E_{2n}\frac{\Delta h}{2} + E_{1n}\frac{\Delta h}{2} - - - - - - (5)$

  Where $E_t = |E_t|$ and $E_n = |E_n|$
- The $\frac{\Delta h}{2}$ terms cancel and equ (5)becomes,
- $0 = (E_{1t} - E_{2t})\Delta w$
- $\boxed{\boldsymbol{E_{1t} = E_{2t}}}$-----(6) (6 M)

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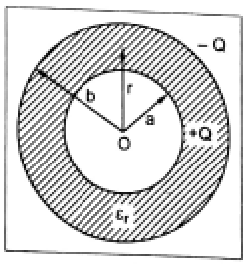
- $\Delta Q = \rho_S \Delta S = D_{1n}\Delta S - D_{2n}\Delta S$

Explanation --3 M

- $\boxed{\frac{\tan\theta_1}{\tan\theta_2} = \frac{\varepsilon_{r1}}{\varepsilon_{r2}}}$ (7 M)

4.	**Find the potential at a point (3,5,2) due to two-point charges one located at (2,0,0) and the other at (-2,0,0). The charges are 4 μc AND -5 μc respectively. (6 M)** BTL 5 **Answer: Page - 2.30 - Dr. P. Dananjayan** ➢ r 1 = 7.35 m ➢ r 2 = 5.48 m ➢ VA = Q/4πε0r1 = -6122 V (2 M) ➢ VB = Q/4πε0r2 = 6569 V (2 M) ➢ V = VA + VB ➢ Answer – 447 V (2 M)
5.	**Derive the Poisson'sand Laplace's Equations. (May/June 2014, Nov/Dec 16, April/May 2018) (13 M)**BTL 1 ➢ $\nabla . D = \rho_v$; $D = \varepsilon E$ ➢ $\nabla . (\varepsilon E) = \rho_v$ ➢ $\varepsilon . \nabla . E = \rho_v$ ➢ $\nabla . E = \frac{\rho_v}{\varepsilon}$ ➢ $E = -\nabla V$ ➢ $\nabla . (-\nabla V) = \frac{\rho_v}{\varepsilon}$ ➢ $\nabla . \nabla V = \frac{\rho_v}{\varepsilon}$ ➢ $\nabla^2 V = -\frac{\rho_v}{\varepsilon}$ This is Poisson's equation.(6 M) ➢ In a certain region, volume charge density is zero, $\rho_v = 0$ which is true for dielectric medium. ➢ Then the Poisson's equation takes the form, ➢ $\nabla^2 V = 0$ ∇^2V is laplacian of 'V' ➢ This is special case of Poisson's equation and is called Laplace equation. ➢ ∇^2Operation / Laplace equation in different co-ordinate system: ➢ The potential 'V' can be expressed in any of the 3-co-ordinate system as $V(x, y, z), (r, \phi, z)$ & (r, θ, ϕ). ➢ <u>Cartesian co-ordinate system or Rectangular co-ordinate system</u> ➢ $\nabla^2 V = \frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial y^2} + \frac{\partial^2 V}{\partial z^2} = 0$ ➢ <u>Cylindrical co-ordinate system</u> ➢ $\nabla^2 V = \frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial V}{\partial r}\right) + \frac{1}{r^2}\left(\frac{\partial^2 V}{\partial \phi^2}\right) + \frac{\partial^2 V}{\partial z^2} = 0$ ➢ <u>Spherical co-ordinate system</u> ➢ $\nabla^2 V = \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial V}{\partial r}\right) + \frac{1}{r^2 \sin\theta}\frac{\partial}{\partial \theta}\left(\sin\theta\frac{\partial V}{\partial \theta}\right) + \frac{1}{r^2 \sin^2\theta}\frac{\partial^2 V}{\partial \phi^2} = 0$ (7M)

6	**A capacitor consists of two parallel metal plates 30cm x 30cm surface area, separated by 5mm in air. Determine its capacitance. Find the total energy stored by the capacitor and the energy density if the capacitor is charged to a potential difference of 500V?(Nov 2014) (6M)** BTL 5 **Answer: Page - 2.73 - Dr. P. Dananjayan** ➢ Energy = ½ C V^2 = 19.92 µ Joules (2 M) ➢ Energy Density = ½ DE = 0.0442 (2 M) ➢ Potential = V/d = 500/(5*10^{-3}) (2 M)
7	**Derive an expression for capacitance of concentric spheres. (Nov 2015) (7M)** BTL 2 **Answer:Page - 2.19 - Dr. P. Dananjayan**  ➢ Consider two concentric spheres. ➢ Inner radius 'a' and outer radius 'b'. ➢ εr be permittivity of dielectric medium. ➢ Charge Q distributed uniformly over the outer surface of inner sphere. (3 M) $$E = \frac{Q}{4\pi \varepsilon r^2} \quad (a \le r \le b)$$ The potential difference between the sphere is $$V = -\int_b^a \frac{Q}{4\pi\varepsilon r^2} \cdot dr = -\frac{Q}{4\pi\varepsilon}\int_b^a \frac{dr}{r^2}$$ $$= \frac{Q}{4\pi\varepsilon}\left[\frac{1}{r}\right]_b^a$$ $$= \frac{Q}{4\pi\varepsilon}\left[\frac{1}{a} - \frac{1}{b}\right]$$ $$= \frac{Q}{4\pi\varepsilon}\left[\frac{b-a}{ab}\right]$$ ***The capacitance of two concentric sphere is*** $$C = \frac{Q}{V} = 4\pi\varepsilon\left[\frac{ab}{b-a}\right]$$ $$C = 4\pi\varepsilon\left[\frac{ab}{b-a}\right]$$ **(4 M)**

PART * C

1. **If** $V = 2x^2y + 20z - \frac{4}{x^2+y^2}$ **V, find electric field & flux density at P(6,–2,3). (7 M)**

BTL 5

Answer: Page - 2.35 - Dr. P. Dananjayan

☺***Solution:*** $E = -\nabla V$

$$= -\left[\bar{a}_x \frac{\partial}{\partial x} + \bar{a}_y \frac{\partial}{\partial y} + \bar{a}_z \frac{\partial}{\partial z}\right]\left(2x^2 y + 20z - \frac{4}{x^2+y^2}\right)$$

$$= -\left[\bar{a}_x\left(4xy + \frac{8x}{(x^2+y^2)^2}\right) + \bar{a}_y\left(2x^2 + \frac{8y}{(x^2+y^2)^2}\right) + \bar{a}_z 20\right]$$

$$E(6,-2.5,3) = -[(-60+0.0268)\bar{a}_x + (72-0.012)\bar{a}_y + 20\bar{a}_z$$

$$D = \varepsilon_0 E$$ (4M)

$$D(6,-2.5,3) = 8.854 \times 10^{-12} \times [59.97\,\bar{a}_x - 71.99\,\bar{a}_y - 20\,\bar{o}.]$$

$$= \mathbf{0.53\,\bar{a}_x - 0.637\,\bar{a}_y - 0.177\,\bar{a}_z \quad nc/m^2}$$ (3 M)

3.	**Given an electric field** $E = -\frac{6y}{x^2}\hat{a}_x + \frac{6}{x}\hat{a}_y + 5\,\hat{a}_z$ **V/m, find the potential difference** Potential difference $V_{AB} = -\int_B^A E \cdot dl$ $= -\int_4^{-7} -\frac{6y}{x^2}\,dx - \int_1^2 \frac{6}{x}\,dy - \int_2^1 5\,dx$ $= 6y\left[\frac{-1}{x}\right]_4^{-7} - \frac{6}{x}\left[y\right]_1^2 - 5\left[x\right]_2^1$ $= \frac{66}{28}y - \frac{6}{x} + 5$ $x = 4, \quad y = 1$ $V_{AB} = 2.357 - 1.5 + 5 = \mathbf{5.857\ volts}$ (8 M)
4.	**Given that the potential** $V = \frac{120\sin\theta}{r^2}$ **find the E and V at r = 3, θ = 60 , φ = 25** For spherical co-ordinates, $\nabla V = \frac{\partial V}{\partial r}\bar{a}_r + \frac{1}{r}\frac{\partial V}{\partial \theta}\bar{a}_\theta + \frac{1}{r\sin\theta}\frac{\partial V}{\partial \phi}\bar{a}_\phi$ $\frac{\partial V}{\partial r} = \frac{-240\sin\theta}{r^3}$ $\frac{\partial V}{\partial \theta} = \frac{120\cos\theta}{r^2}$ $\frac{\partial V}{\partial \phi} = 0$ $\nabla V = \frac{-240\sin\theta}{r^3}\bar{a}_r + \frac{120\cos\theta}{r^3}\bar{a}_\theta$ $E = -\nabla V = \frac{240\sin 60^\circ}{3^3}\bar{a}_r - \frac{120\cos 60^\circ}{3^3}\bar{a}_\theta$ $= 7.7\,\bar{a}_r - 2.22\,\bar{a}_\theta$ $\lvert E \rvert = \sqrt{(7.7)^2 + (2.22)^2} = \mathbf{8.014\ V/m}$ (8 M)
5.	**Given V = $x^2y + 10z + 2\log(x^2+y^2)$ find V, E, D at (1, 2, 3). (15 M)** BTL 5 (*i*) $V = x^2y + 10z + 2\log(x^2+y^2)$ $V(1,2,3) = 1\times 2 + 10\times 3 + 2\log(1+4) = 2 + 30 + 2\log(5)$ $= 32 + 2\log 5 = \mathbf{33.4\ V}$ (3M)

	(ii) $E = -\nabla V$ $= -\left[\bar{a}_x \frac{\partial}{\partial x}(x^2 y + 2\log(x^2+y^2)) + \bar{a}_y \frac{\partial}{\partial y}(x^2 y + 2\log(x^2+y^2)) + \bar{a}_z \frac{\partial}{\partial z}(10z)\right]$ $= -(4.8\,\bar{a}_x + 2.6\,\bar{a}_y + 10\,\bar{a}_z)$ V/m (4 M) (iii) $D = \varepsilon \cdot E$ $D = \varepsilon_0\left[\left(2xy + \frac{4x}{x^2+y^2}\right)\bar{a}_x + \left(x^2 + \frac{4y}{x^2+y^2}\right)\bar{a}_y + 10\,\bar{a}_z\right]$ $D(1,2,3) = -8.854 \times 10^{-12}\,(4.8\,\bar{a}_x + 2.6\,\bar{a}_y + 10\,\bar{a}_z)$ c/m² (4 M) $\nabla \cdot D = -\varepsilon_0\left[\bar{a}_x \frac{\partial}{\partial x} + \bar{a}_y \frac{\partial}{\partial y} + \bar{a}_z \frac{\partial}{\partial z}\right] \times \left[\bar{a}_x\left(2xy + \frac{4x}{x^2+y^2}\right) + \bar{a}_y\left(x^2 + \frac{4y}{x^2+y^2}\right) + \bar{a}_z(10)\right]$ $= -\varepsilon_0\left[\frac{\partial}{\partial x}\left(2xy + \frac{4x}{x^2+y^2}\right) + \frac{\partial}{\partial y}\left(x^2 + \frac{4y}{x^2+y^2}\right) + \frac{\partial}{\partial z}(10)\right]$ $\rho_v(1,2,3) = -8.854 \times 10^{-12} \times 2 \times 2$ $= 35.416 \times 10^{-12}$ c/m³ (4 M)
6.	**Calculate the capacitance of a parallel plate capacitor with the following details:** **Plate area A = 100 cm²** **Dielectric 1, $\varepsilon_{r1} = 4$, $d_1 = 2$ mm** **Dielectric 2, $\varepsilon_{r2} = 3$, $d_2 = 3$ mm** **If 200 V is applied across the plates, what will be the voltage gradient across each dielectric? (8 M)**BTL 5 **Answer: Page - 2.44 - Dr. P. Dananjayan** ➢ D = Q/A ➢ E = D / εo εr ➢ C = Q / V ➢ C = 59 pf (2 M) ➢ V1 = 66.66 V(2 M) ➢ V2 = 133.33 V(2 M) ➢ E1 = 33.33 kV/m(2M) ➢ E2 = 44.44 kV/m
7.	**A parallel plate capacitor with d = 1 m and plate area 0.8 m² and a dielectric relative permittivity of 2.8. A dc voltage of 500 V is applied between the plates, find the capacitance and energy stored. (8 M)**BTL 5 **Answer: Page - 2.61 – Dr. P. Dananjayan** ➢ d = 1m A = 0.8 m²

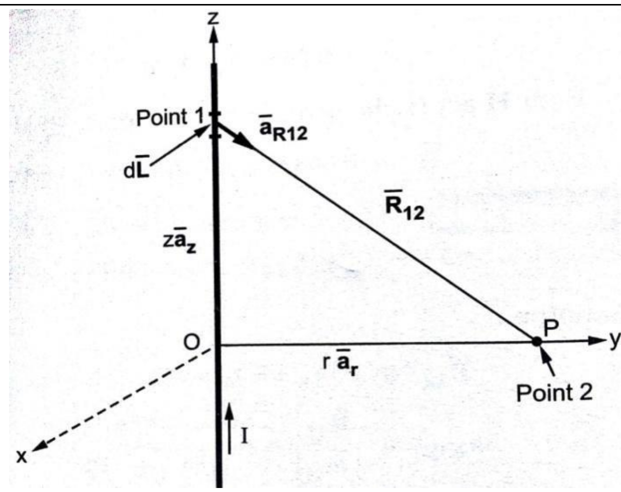
	➢ $\varepsilon r = 2.8$ ➢ $C = \varepsilon A / d$ ➢ Energy Stored = ½ C V^2 = 0.99 J (8 M)
UNIT III MAGNETOSTATICS	
Lorentz force, magnetic field intensity (H) – Biot–Savart's Law - Ampere's Circuit Law – H due to straight conductors, circular loop, infinite sheet of current, Magnetic flux density (B) – B in free space, conductor, magnetic materials – Magnetization, Magnetic field in multiple media Boundary conditions, scalar and vector potential, Poisson's Equation, Magnetic force, Torque, Inductance, Energy density, Applications.	
Q. No	**Part * A**
	Questions
1	**Define magnetic flux and magnetic flux density.** BTL 1 **Magnetic flux:** Magnetic flux is defined as the flux passing through any area. Its unit is Weber. $\Phi = \int_a B \cdot da$ Weber. **Magnetic flux density.** Magnetic flux density is defined as the magnetic flux density passing per unit area. Its unit is Weber / meter or Tesla. $B = \frac{\Phi}{A}$; $B = \mu H$
2	**Define magnetic Gauss's Law. (May 2019)** BTL 1 The total magnetic flux passing thorough any closed surface is equal to zero. $\int_a B \cdot da = 0$
3	**State Biot- Savart law.** BTL 1 It states that the magnetic flux density at any point due to current element is proportional to the current element and sine of the angle between the elemental length and the line joining and inversely proportional to the square of the distance between them. $dB = \frac{\mu_o Idl \sin \theta}{4 \pi r^2}$
4	**State the Lorentz force equation. (Nov 2013)** BTL 1 The force on a moving particle due to combined electric and magnetic field is given by F = Q $\left[E + V \times B\right]$.This force is called Lorentz force.
5	**State Ampere's circuital law. (May 2014, May 2016, Nov 2016)** BTL 1 Ampere's circuital law states that the line integral of magnetic field intensity H about any closed path is exactly equal to the direct current enclosed by the path. $\int H \cdot dl = I$

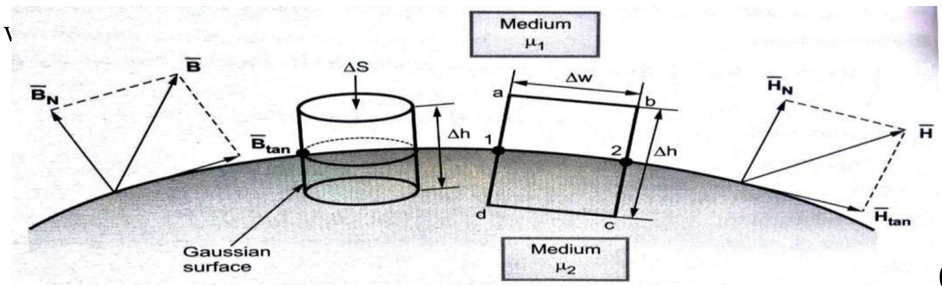
6	**Distinguish between diamagnetic, paramagnetic and ferromagnetic materials.** BTL 1 **Diamagnetic:** In diamagnetic materials magnetization is opposed to the applied field. It has magnetic field. **Paramagnetic:** In paramagnetic materials magnetization is in the same direction as the field. It has weak magnetic field. **Ferro magnetic:** In Ferromagnetic materials is in the same direction as the field. It has strong magnetic field.
7	**Compare scalar magnetic potential with vector magnetic potential.(Nov/Dec 2014)** BTL 1 **Scalar magnetic potential** / **Magnetic vector potential** **Scalar magnetic potential:** It is defined as dead quantity whose negative gradient gives the magnitude intensity if there is no current source present. $H = -\nabla V_m$ where,Vm is the magnetic scalar potential. $V_m = -\int H.dl$ **Magnetic vector potential:** It is defined as that quantity whose curl gives the magnetic flux density. $B = \nabla$ x A; where A is the magnetic vector potential. $A = \frac{\mu}{4\pi}\iiint_V \frac{J}{r}dr$ Web / m
8	**A solenoid with a radius of 2cm is wound with 20 turns per cm length and carries 10mA. Find H at the centre if the total length is10cm.** BTL 5 Given data,N=nl = 20 x 10 = 200 turns; l =10 X 10^{-2} m; I = 10 x 10^{-3}A; $H = \frac{NI}{l}$ = 20AT/m.
9	**Determine the force per unit length between two long parallel wires separated by 5 cm in air and carrying currents 40A in the same direction.** BTL 5 Force / length = $\frac{\mu_o I_1 I_2}{2\pi D} = \frac{40 \times 40}{2\pi \times 5 \times 10^{-2}} x\, 4\pi x 10^{-7}$ =6.4 x 10^{-3} N/m.
10	**Define magnetic susceptibility and their relation with relative permeability.** BTL 1 Magnetic susceptibility is defined as the ratio of magnetization to the magnetic field intensity. It is dimensionless quantity. $\chi_m = \frac{M}{H}$ $\mu_r = 1 + \chi_m$ Where μ_r is relative permeability; χ_m is susceptibility
11	**Give four similarities between Electrostatic field and Magnetic field. (Nov/Dec 2014)** BTL 1

Electrostatic field	Magnetic field
1. Electric field intensity E (volts/m) **2.** Electric flux density D=εE c/m **3.** Energy stored is $1/2CV^2$ **4.** Charges are rest	1. Magnetic field intensity H (Amp/m) 2. Magnetic flux density B=μH (web / m2) 3. Energy stored is $1/2LI^2$ 4. Charges are in motion

12	**What will be effective inductance, if two inductors are connected in (a) series and (b) parallel?** BTL 2 *(a)* For series $L = L_1 + L_2 \pm 2M$ (b)For Parallel $L = \frac{L_1 L_2 - M^2}{L_1 + L_2 \pm 2M}$ Where, (+) sign for aiding , (-) sign for opposition
13	**Distinguish between solenoid and toroid.** BTL 1 <table><tr><th>Solenoid</th><th>Toroid</th></tr><tr><td>Solenoid is a cylindrically shaped coil consisting of a large number of closely spaced turns of insulated wire wound usually on a non – magnetic frame.</td><td>If a long, slender solenoid is bent into the form of a ring and thereby closed on itself, it becomes toroid</td></tr><tr><td>Inductance of solenoid is given by $L = \frac{\mu_o N^2 A}{l}$</td><td>Inductance of solenoid is given by $L = \frac{\mu_o N^2 A}{2\pi R} = \frac{\mu_o N^2 r^2}{2R}$;</td></tr></table>
14	**Define magneto-static energy density. (Nov 2011)** BTL 1 It is defined as the ratio of magnetic energy per unit volume.
15	**Write the expression for the inductance per unit length of a long solenoid of N turns and having a length 'L' meter carrying a current of I amperes. (May/June 2014, Nov 2018)** BTL 1 $H = \frac{NI}{2l}[\cos\theta_2 - \cos\theta_1]$
16	**State the boundary condition at the interface between two magnetic materials of different permeability. (May 2012)** BTL 1 $H_{t1}=H_{t2}$, $B_{n1}=B_{n2}$, H_{t1}, H_{t2} are the tangential magnetic field in region 1 and 2 respectively. B_{n1}, B_{n2} are the normal magnetic flux density in region 1 and 2 respectively.
17	**Write down the magnetic boundary conditions. (Nov 2013, May 2016)** BTL 1 1. The tangential component of magnetic field intensity is continuous across the boundary.$H_{t1} = H_{t2}$. 2. The normal component of magnetic flux density is continuous across the boundary.$B_{n1} = B_{n2}$
18	**State Ohm's law for magnetic circuits. (Nov 2012, Nov/Dec14)** BTL 1 Sum of Magnetic motive force (mmf) in a closed path is zero.
19	**State Lorentz Law of force. (May 2012)** BTL 1 When a current carrying conductor is placed in a magnetic field, it experiences a force given by,dF = I x B dl = BI dl sinθ Newton.

20	**State the law of conservation of magnetic flux. (Nov 2011)** BTL 1 An isolated magnetic charge does not exist. Thus, the total flux through a closed surface is zero. $\iint B\,.ds = 0$ .This is called as law of conservation of magnetic flux.
21	**Determine the value of magnetic field intensity at the centre of a circular loop carrying a current of 10A. The radius of the loop is 2m. (Nov/Dec 2014)** BTL 5 $H = \frac{I}{2a} = \frac{10}{2x2} = 2.5A/m$
22	**What is the mutual inductance of two inductively tightly coupled coils with self - inductance of 25mH and 100mH?(Nov/Dec2015)** BTL 5 L_1 = 25mH, L_2 = 100mH, M=K $\sqrt{L_1 L_2}$ = $\sqrt{25 X 100}$ = 50mH
23	**Find the force of interaction between two charges 4*10^{-3} and 6*10^{-3} spaced 10cm apart n kerosene ($\varepsilon_r = 2$).(April /May 2015)** BTL 5
	Force of repulsion = $\frac{Q_1 Q_2}{4\pi\varepsilon_o R^2} a_r$ = 1.07908 N
24	**Find the maximum torque on an 100 turns rectangular coil of 0.2 m by 0.3m, carrying current of 2A in the field of flux density 5 Wb/m^2 .(April /May 2015)** BTL 5 T_{max} = NBIA = 60 Nm
25	**A conductor 4m long lies along the y-axis with the current of 10A in $a_y$direction, if the field is B=0.05a_x Tesla. Calculate the force on the conductor. (Nov 2016)** BTL 5 $F = IlB\sin\theta = 10 \times 4 \times 0.05 \times \sin 90 = 2N$
	Part * B
1	**Derive an expression for the magnetic field intensity and magnetic flux density at a point P in a medium of permeability 'μ' due to (i) an infinitely long current carrying conductor at a distance 'r' meters from the point.(ii) a finite length conductor. (April 2015, Nov 2011, Nov 2012, May 2012, Nov 2018) (13 M)** BTL 2 **Answer: Page –3.3- Dr. P. Dananjayan** ➢ Consider an infinite long straight conductor along z-axis. ➢ Current passing through a conductor is a direct current of I. ➢ The field intensity H at the point 'p' is to be calculated, which is at the distance 'r' from the z-axis. ➢ Consider small differential element at point 1, along the z-axis at a distance z from origin. $I\,d\overline{L} = Idz\,\overline{a}_z$ (4 M)

	 (2M) ➢ The distance vector joining point 1 to point 2 is $\bar{R}_{12}$ can be written as • $\bar{R}_{12} = -z\bar{a}_z + r\bar{a}_r$ • $\bar{a}_{R12} = \frac{\bar{R}_{12}}{\lvert\bar{R}_{12}\rvert} = \frac{r\bar{a}_r - z\bar{a}_z}{\sqrt{r^2+z^2}}$ • $\bar{dL} \times \bar{a}_{R12} = \begin{pmatrix} \bar{a}_r & \bar{a}_\phi & \bar{a}_z \\ 0 & 0 & dz \\ r & 0 & -z \end{pmatrix} = rdz\bar{a}_\phi$
2.	**Derive the expression for force between two parallel conductors. (7M)(Nov 2018)** BTL 1 **Answer: Page - 3.17 - Dr. P. Dananjayan** ➢ According to amperes force law, the force F between two parallel wires carrying currents I_1 and I_2 is directly proportional to the individual currents and inversely proportional to the square of the distance between them. ➢ $F \propto \frac{I_1 I_2}{R^2}$ (3M) ➢ $F = K\frac{I_1 I_2}{R^2}$ ➢ Where K is proportionality constant depending upon the medium $K = \frac{\mu}{4\pi}$
	➢ $F = \frac{\mu I_1 I_2}{4\pi R^2}$ ➢ The force F is attractive if the two currents I_1 and I_2 are the same directions. Repulsive if in opposite direction.(4 M)

3.	**Derive the magneto-static boundary conditions. (May 2014, April 2015) (13 M)** BTL 1 **Answer: Page -3.23 - Dr. P. Dananjayan** ➢ The condition at the magnetic field exiting at the boundary of the two media when the magnetic field passes from one medium to other are called boundary condition for magnetic fields. ➢ The condition of B and H are studied at the boundary. ➢ The vectors are resolved in to two components: ➢ Tangential to the boundary ➢ Normal (perpendicular) to boundary ➢ Consider a boundary between two isotropic, homogeneous linear materials  (2 M) ➢ **<u>Boundary conditions for Normal Component</u>** ➢ According to the Gauss law for the magnetic field, $\int_S \bar{B}.\bar{ds} = 0$ -- (1) ➢ Let the area of the top and bottom is same, equal to Δs $\oint_{top} B.ds + \oint_{bottom} B.ds + \oint_{bottom} B.ds = 0$ --------------------------------(2) ➢ For top surfaces $\oint_{top} B.ds = BN_1 \oint_{top} ds = BN_1 \Delta s$ -------------------------------------- (3) ➢ For bottom surfaces $\oint_{bottom} \bar{B}.\bar{ds} = BN_2 \oint_{bottom} \bar{ds} = BN_2 \Delta s$ --------------------------------(4) ➢ For lateral surface $\oint_{lateral} \bar{B}.\bar{ds} = 0$ ------------------------------------- (5) ➢ Putting values of surface integral in equation (2) we get $BN_1 \Delta s - BN_2 \Delta s = 0$---------------------------(6) ($\therefore$ B N_1 and B N_2 are in opposite direction)

$$BN_1 = BN_2 \text{------------} (7)$$

- Thus the normal component of b is continuous at the boundary. (4 M)

Boundary conditions for tangential Component

- According to ampere's circuital law

$$\oint \overline{H}.dl = I$$

- Consider a closed rectangular path a b c d, length Δl and height Δh.

$$\oint \overline{H}.\overline{dL} = \int_a^b \overline{H}.\overline{dL} + \int_b^c \overline{H}.\overline{dL} + \int_c^d \overline{H}.\overline{dL} + \int_d^a \overline{H}.\overline{dL} = I$$

- Allowing ΔH to zero

$$\int_b^c \overline{H}.\overline{dL} + \int_d^a \overline{H}.\overline{dL} = 0$$

$$\overline{H}_{tan1}\Delta l - \overline{H}_{tan2}\Delta l = I$$

$$\overline{H}_{tan1} - \overline{H}_{tan2} = \frac{I}{\Delta l}$$

$$\overline{a}_N \times \left(\overline{H}_{tan1} - \overline{H}_{tan2}\right) = J_s \quad J_s = \text{ surface current density}$$

- In vector form

$$\overline{H}_{tan1} - \overline{H}_{tan2} = a_N \times \overline{J}_s$$

$$\overline{H}_{tan1} - \overline{H}_{tan2} = J_s$$

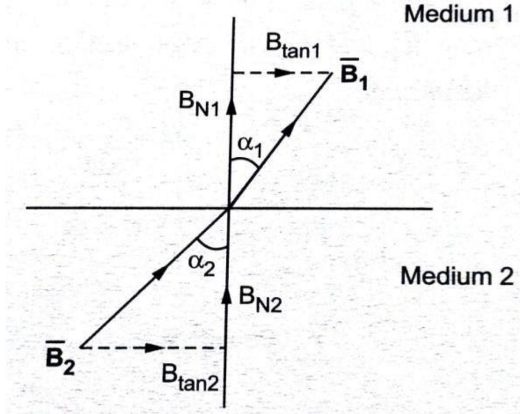
- Where $\overline{a}_N$ – unit vector in the direction normal at the boundary form medium1 to medium2.
- For B, the tangential components can be related with permeabilities of two media

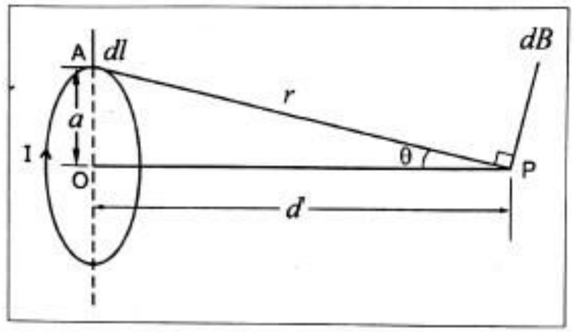
$$\frac{B_{tan1}}{\mu_1} - \frac{B_{tan2}}{\mu_2} = J_s$$

- Consider a special case that the boundary is free of current in other words, media are not conductors. So $J_s = 0$

$$\overline{H}_{tan1} - \overline{H}_{tan2} = 0$$

$$\overline{H}_{tan1} = \overline{H}_{tan2} \quad (4\text{ M})$$

	 ➢ **In medium 1,** $$\tan\alpha_1 = \frac{B_{\tan 1}}{B_{N_1}}$$ ➢ **In medium 2,** $$\tan\alpha_2 = \frac{B_{\tan 2}}{B_{N_2}}$$ $$\frac{\tan\alpha_1}{\tan\alpha_2} = \frac{B_{\tan 1}}{B_{N_1}} \cdot \frac{B_{N_2}}{B_{\tan 2}}$$ ➢ We know that $B_{N_1} = B_{N_2}$ $$\frac{\tan\alpha_1}{\tan\alpha_2} = \frac{B_{\tan 1}}{B_{\tan 2}} = \frac{\mu_{r_1}}{\mu_{r_2}}$$ (3 M)

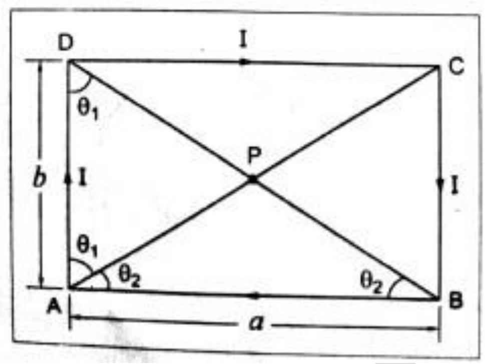
4.	**Develop an expression for the magnetic field intensity at any point on the line through the centre at a distance 'h' m from the centre and perpendicular to the plane of a circular loop (in XY plane) of radius 'a' m and carrying a current I Ampere in the an[illegible] 9) (13 M)** BTL 2 **Answer: Page – 3**  (4 M) ➢ Let a = circular coil radius ➢ I = current ➢ Idl = current element ➢ d = distance between point P to centre of the coil ➢ $dB = \mu 0\ I\ dl \sin\theta / (4\pi r^2)$ ➢ $\sin\theta = a / (\sqrt{(a^2 + d^2})$

- if d = 0, the field at the center B = μ0I/2a
- H = I/2a (9 M)

5.

Derive an expression for magnetic field intensity in a rectangular loop which is carrying a current of 'I' amperes and is situated in a uniform magnetic field 'B' Wb/m^2. (Nov 2014) (8 M) BTL 2

Answer: Page -3.06 - Dr. P. Dananjayan



(2 M)

The magnetic field intensity at the centre P due to segment AB or CD.

$$H = \frac{I}{4\pi d}\left[\cos\theta_1 + \cos\theta_2\right]$$

$$\text{But} \quad d = \frac{b}{2}, \quad \theta_1 = \theta_2 = \theta$$

$$\therefore \quad H = \frac{2I}{4\pi b}\cdot 2\cos\theta$$

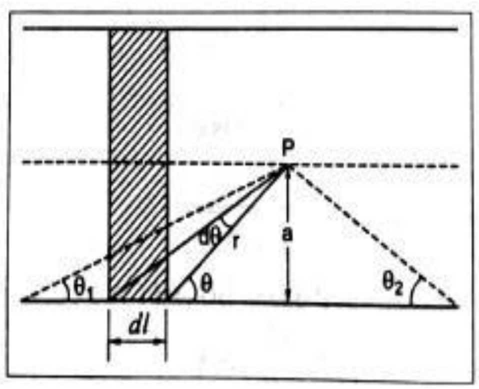
$$= \frac{I}{\pi b}\cos\theta$$

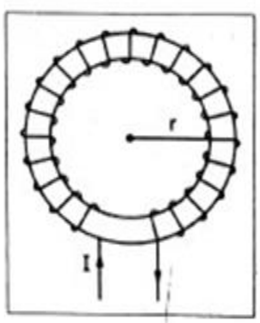
$$\text{where} \quad \cos\theta = \frac{b}{\sqrt{a^2+b^2}}$$

The magnetic field intensity at P due to AB and CD

$$H_1 = \frac{2I}{\pi b}\cos\theta$$

$$H_1 = \frac{2I}{\pi\sqrt{a^2+b^2}}$$

	Similarly, the magnetic field intensity at P due to segment BC or DA $$H = \frac{I}{4\pi d}\left[\cos\phi_1 + \cos\phi_2\right]$$ But $d = \frac{a}{2}$, $\quad \phi_1 = \phi_2 = \phi$ $$\therefore\ H = \frac{2I}{4\pi a}\, 2\cos\phi$$ $$= \frac{I}{\pi a}\cos\phi$$ where $\cos\phi = \frac{a}{\sqrt{a^2+b^2}}$ For square loop of side a, $$a = b$$ $$H = \frac{4I}{\pi a\sqrt{2}} = \frac{2\sqrt{2}\,I}{\pi a}\ \text{A/m}$$ (6 M)
6.	**Derive the expression for magnetic field intensity due to long solenoidal. (13 M) BTL 2** **Answer: Page – 3.08 - Dr. P. Dananjayan** ➢ Let N = no. of turns ➢ L = length ➢ a = mean radius ➢ I = current ➢ Idl = Current element ➢ Solenoid  (4 M

	$$dB = \frac{\mu_0 \sin^3\theta}{2r\sin\theta}\frac{NI}{l}\cdot\frac{r\,d\theta}{\sin\theta}$$ $$= \frac{\mu_0 N I \sin\theta\, d\theta}{2l}$$ The total magnetic flux density at point P due to whole solenoid is given by $$B = \frac{\mu_0 N I}{2l}\int_{\theta_1}^{\pi-\theta_2}\sin\theta\, d\theta$$ $$B = \frac{\mu_0 N I}{2l}[\cos\theta_1 + \cos\theta_2]$$ The magnetic field intensity due to solenoid at P is given by $$H = \frac{NI}{2l}[\cos\theta_1 + \cos\theta_2]$$
7.	**Derive the expression for magnetic field intensity due to the centre of the Toroidal coil. (7M)** BTL 2 **Answer: Page – 3.11 - Dr. P. Dananjayan**  (2 M ➢ **Consider a toroidal coil of mean radius 'r'**

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- **Current = 1**
- **No. of turns = N**

$$\oint H \cdot dl = N I$$

$$H \int_0^{2\pi r} dl = N I$$

$$H \, 2\pi r = N I$$

$$\text{The magnetic field } H = \frac{N I}{2\pi r}$$

$$\text{The magnetic flux density is } B = \mu_0 H = \frac{\mu_0 N I}{2\pi r}$$

$$B = \frac{\mu_0 N I}{2\pi r}$$

(5 M)

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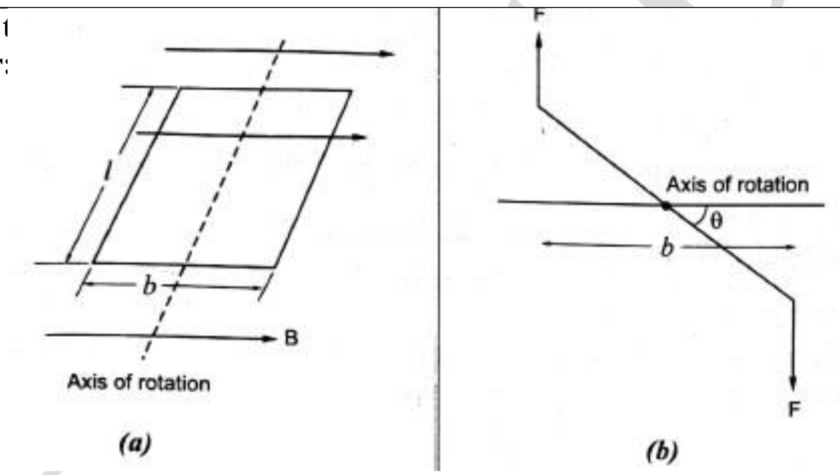
Obtain t BTL 2

Answer:



(3 M)

- Consider the rectangular loop.
- Length = l
- Breath = b
- Current = I
- F = BIl sin θ
- T = 2 * Torque on each side
- T = 2 * Force * Distance
- T = BIA sin θ
- Magnetic moment of loop is IA
- m = IA
- T = m B sin θ
- m = T/B(4 M)

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9.	**Derive an expression for Scalar magnetic potential and vector magnetic potential. (13 M) (Nov 2018)**BTL 2 **Answer: Page - 3.20 - Dr. P. Dananjayan**

	Scalar Magnetic Potential: Ampere's circuital law states that the line integral of magnetic field intensity H about any closed path is exactly equal to the direct current enclosed by the path. $\oint H.dl = I$ (2 M) If there is no current is enclosed. J = 0 $\oint H.dl = 0$ Magnetic field H can be expressed as negative gradient of a scalar function. $H = -\nabla V_m$ where, V_m is called scalar magnetic potential. $V_m = -\int H \cdot dl$ Magnetic field H can be expressed as negative gradient of a scalar function. $H = -\nabla V_m$ where, V_m is called scalar magnetic potential. $V_m = -\int H \cdot dl$ This scalar potential also satisfies Laplace's equation. In free space, $\nabla \cdot B = 0$ $\mu_0 \nabla \cdot H = 0$ But, $H = -\nabla V_m$ $\mu_0 \nabla \cdot (-\nabla V_m) = 0$ $-\mu_0 \nabla^2 V_m = 0$ $\nabla^2 V_m = 0$ (5 M) **Vector Magnetic Potential** **Divergence of vector is scalar, vector potential is expressed in terms of curl.**(2 M) *i.e.,* $\nabla \cdot B = 0$ $B = \nabla \times A$ where, A is magnetic vector potential. Take curl on both sides, $\nabla \times B = \nabla \times \nabla \times A$ By the identity, $\nabla \times \nabla \times A = \nabla (\nabla \cdot A) - \nabla^2 A$

	But $\nabla \times B = \mu J$ $\nabla(\nabla \cdot A) - \nabla^2 A = \mu J$ For the steady dc, $(\nabla \cdot A) = 0$ then, $-\nabla^2 A = \mu J$ $\bar{a}_x \nabla^2 A_x + \bar{a}_y \nabla^2 A_y + \bar{a}_z \nabla^2 A_z = -\mu(\bar{a}_x J_x + \bar{a}_y J_y + \bar{a}_z J_z)$ Equating $\nabla^2 A_x = -\mu J_x$ $\nabla^2 A_y = -\mu J_y$ $\nabla^2 A_z = -\mu J_z$ The general, magnetic vector potential can be expressed as $\mathbf{A} = \frac{\mu}{4\pi} \iiint \frac{J}{r}\, dv$ (4 M)

The internal flux linkage of the conductor A is given by

$$\phi_1 = \frac{\mu_0 \mu_r I}{8\pi}$$

The external flux linkage with the conductor A is given by

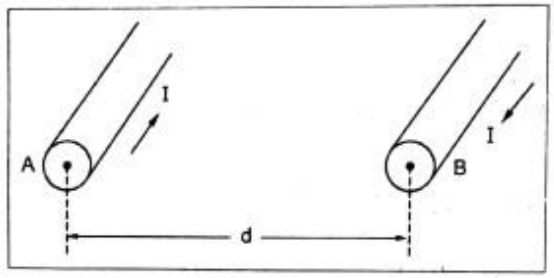
$$\phi_2 = \frac{\mu_0 I}{2\pi} ln\left(\frac{d}{a}\right)$$

The total flux linkage of A is $\phi = \phi_1 + \phi_2$

$$= \frac{\mu_0 \mu_r I}{8\pi} + \frac{\mu_0 I}{2\pi} ln\left(\frac{d}{a}\right)$$

$$L_A = \frac{\phi}{I}$$

$$L_A = \frac{\mu_0}{4\pi}\left[\frac{\mu_r}{2} + 2\, ln\left(\frac{d}{a}\right)\right] \text{ H/m}$$

10.	**Determine the inductance per unit length of a two-wire transmission line with separation distance d. Each wire has a radius a. (8 M)** BTL 1 **Answer: Page - 3**  (2 M)

	Similarly for conductor B, the total flux linkage is $$\phi = \frac{\mu_0 \mu_r I}{8\pi} + \frac{\mu_0 I}{2\pi} ln\left(\frac{d}{a}\right)$$ The total inductance of conductor B is $$L_B = \frac{\mu_0}{4\pi}\left[\frac{\mu_r}{2} + 2\,ln\left(\frac{d}{a}\right)\right]$$ $L = L_A + L_B$ **L =** $\mu_0 / 4\pi$ * [μr + 4 ln (d/a)] (6 M)
	PART * C
1.	**Evaluate the inductance of a solenoid of 2500 turns wound uniformly over a length of 0.5 m on a cylindrical paper tube 4 cm in diameter. The medium is air. (Nov 2016) (8 M)** BTL 3 **Answer: Page - 3.70 - Dr. P. Dananjayan** N = 2500 l = 0.5 m d = 4 cm $A = \pi d^2/4 = 12.566 * 10^{-4}$ (4 M) Inductance $L = \mu 0\, N^2 A / l$ = 19.7386 mh (4 M)
2.	**At a point P(x,y,z) the components of vector magnetic potential A are given as A_x = (4x + 3y + 2z) ; A_y = (5x + 6y + 3z) and A_z = (2x + 3y + 5z). Determine magnetic flux density B at any point P. (7 M)** BTL 3 $$B = \nabla \times A = \begin{bmatrix} \bar{a}_x & \bar{a}_y & \bar{a}_z \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ 4x+3y+2z & 5x+6y+3z & 2x+3y+5z \end{bmatrix}$$ (2 M) B = 2 a_z(5 M)
3.	**In cylindrical co-ordinates, $A = 50\rho^2 \hat{a}_z$ Wb/m is a vector magnetic potential in a certain region of free space. Find the magnetic field intensity H, magnetic flux density B and current density J. (15 M)** BTL 5 $$B = \nabla \times A = \frac{1}{\rho}\begin{vmatrix} \vec{a}_\rho & \rho\,\vec{a}_\phi & \vec{a}_z \\ \frac{\partial}{\partial \rho} & \frac{\partial}{\partial \phi} & \frac{\partial}{\partial z} \\ 0 & 0 & 50\rho^2 \end{vmatrix}$$ $$= \frac{1}{\rho}\vec{a}_\rho\left[\frac{\partial}{\partial \phi}(50\rho^2)\right] - \vec{a}_\phi\left[\frac{\partial}{\partial \rho}(50\rho^2)\right]$$ $$= 0 - 100\rho\,\vec{a}_\phi$$ $$\mathbf{B} = -100\rho\,\vec{a}_\phi \text{ Wb/m}^2$$ (7 M)

	$H = \frac{B}{\mu_0} = \frac{-100}{\mu_0} \rho \vec{a}_\phi = \frac{-100}{4\pi \times 10^{-7}} \rho \vec{a}_\phi$ A/m $J = \nabla \times H$ $= \frac{1}{\rho} \begin{vmatrix} \vec{a}_\rho & \rho \vec{a}_\phi & \vec{a}_z \\ \frac{\partial}{\partial \rho} & \frac{\partial}{\partial \phi} & \frac{\partial}{\partial z} \\ 0 & \frac{\rho(-100\rho)}{\mu_0} & 0 \end{vmatrix}$ $J = \frac{-200}{\mu_0} \vec{a}_z$ A/m^2 (8 M)
4.	**If the vector magnetic potential is given by** $A = \frac{10}{x^2+y^2+z^2} \hat{a}_x$**, obtain the magnetic flux density in vector form. (8 M)** BTL 5 Magnetic flux density, $\vec{B} = \nabla \times \vec{A}$ $\Rightarrow \vec{B} = \begin{vmatrix} \vec{a}_x & \vec{a}_y & \vec{a}_z \\ \partial/\partial x & \partial/\partial y & \partial/\partial z \\ 10(x^2+y^2+z^2)^{-1} & 0 & 0 \end{vmatrix}$ (4 M) $\boxed{\vec{B} = -\frac{20z}{(x^2+y^2+z^2)^2} \vec{a}_y + \frac{20y}{(x^2+y^2+z^2)^2} \vec{a}_z}$ (4 M)
5.	**A wire carrying a current of 100 A is bend into the form of a circle of diameter 10 cm. Calculate (a) flux density at the center of the coil, (b) flux density at a point on the axis of the coil and 12 cm from it. (8 M) BTL 5** **Answer: Page - 3.46 - Dr. P. Dananjayan** B = μ_0 N I / 2 a = 1.256 m Wb/m^2(4 M) **B= 0.0714** m Wb/m^2(4 M)
6.	**Derive the expression for energy and energy density stored in magnetic field. (15 M)** BTL 1 **Answer: Page - 3.41 - Dr. P. Dananjayan** **Energy** ➢ current through an inductor is increased from 0 to I ➢ potential across the inductor is v. ➢ energy supplied by the source in time is dv. ➢ dW = vi dt ➢ W = $\int_0^I vi\,dt$

	➢ $W = \frac{1}{2} LI^2$ (7 M) Energy Density: Substituting the value of L in the above equation $W = \frac{1}{2} \frac{\mu_0 N^2 A}{l} I^2$ $= \frac{1}{2} \mu_0 \left(\frac{N I}{l}\right)^2 l A$ $W = \frac{1}{2} \mu_0 H^2 l A$ Energy stored per unit volume $W = \frac{1}{2} \mu_0 H^2 \quad J/m^3$ $= \frac{1}{2} (\mu_0 H) H$ Magnetic energy density $W = \frac{1}{2} B H \quad joules/m^3$ The energy stored in a magneto static field is $W = \int_v w \, dv$ $W = \frac{1}{2} \int_v B \cdot H \cdot dv = \frac{1}{2} \int \mu H^2 dv$ (8 M)

UNIT IV TIME VARYING FIELDS AND MAXWELLS EQUATIONS	
Magnetic Circuits - Faraday's law – Transformer and motional EMF – Displacement current - Maxwell's equations (differential and integral form) – Relation between field theory and circuit theory – Applications.	
Q. No	**Part * A**
1	**State Faraday's law of electromagnetic induction. (May 2016, Nov 2016)** BTL 1 Faraday's law states that electromagnetic force induced in a circuit is equal to the rate of change of magnetic flux linking the circuit. Emf= $\frac{d\Phi}{dt}$
2	**Define mmf and reluctance.** BTL 1 Magnetic motive force (mmf) is given by mmf = flux x reluctance mmf = $\Phi\Re$ Amp.turns. Reluctance is the ratio of mmf of magnetic circuit to the flux through it. $\Re = \frac{mmf}{flux\ (\Phi)}$. It is also written as $\Re = \frac{l}{\mu A}$;Where l is the length, A is the area of cross-section, μ is permeability
3	**What is the expression for energy stored and energy density in magnetic field?**BTL1 Energy W = $\frac{1}{2}LI^2$;WhereL is the inductance, I is the current. Energy density (w) = $\frac{1}{2}BH = \frac{1}{2}\mu H^2$
4	**State Lenz's law.**BTL 1 Lenz's law states that the induced emf in a circuit produces a current which oppose the change in magnetic flux producing it.emf = $-\frac{d\Phi}{dt}$
5	**What is meant by Displacement current? (Nov 2013, May 2016, Nov 2018)**BTL 1 Displacement current is nothing but the current flows through the Capacitor. I_c=C dV/dt.
6	**State Ampere's circuital law. Should the path of integration be circular?**BTL 1 The integral of the tangential component of the magnetic field strength around a closed path is equal to the current enclosed by the path. $\oint H.dl = I$ .The path of integration must be enclosed one. It must be any shape and it need not be circular alone.

7	**Write the fundamental postulate for electromagnetic induction.** BTL 1 A changing magnetic flux (Φ) through a closed loop, produces an emf or voltage at the terminals as given by $v = -\frac{d\Phi}{dt}$ where the voltage is the integral of the electric field E around the loop.For uniform magnetic field Φ = B.A where B is the magnetic flux density and A is the area of the loop. $v = \int E.dl = -\iint \frac{\partial B}{\partial t} ds$ .This is Faraday's law. It states that the line integral of the electric field around a stationary loop equals the surface integral of the time rate of change of the magnetic flux density B integrated over the loop area.

8

Write down the Maxwell's equation in point form. BTL 1

From Ampere's Law

$$\nabla \times H = J + \frac{\partial D}{\partial t}$$

From Faraday's Law

$$\nabla \times E = -\frac{\partial B}{\partial t}$$

From Electric Gauss's Law, $\nabla . D = \rho$,

From Magnetic Gauss's Law, $\nabla . B = 0$

9

Write down the Maxwell's equation in integral form. BTL 3

From Ampere's Law

$$\oint H.dl = \iint_s \left(J + \frac{\partial D}{\partial t} \right) ds$$

From Faraday's Law

$$\oint E.dl = -\iint_s \frac{\partial B}{\partial t} ds$$

From Electric Gauss's Law

$$\oint\!\!\oint_s D.ds = \iiint_v \rho dv$$

From Magnetic Gauss's Law

$$\oint\!\!\oint_s B.ds = 0$$

10

Mention four similarities between electric circuit and magnetic circuit.(Nov/Dec 2014) BTL 1

Electric circuit	Magnetic circuit
1.emf (volts)	1. mmf(Amp-turns)
2.current = $\frac{\text{emf}}{\text{resistance}}$	2.magnetic flux = $\frac{\text{mmf}}{\text{reluctance}}$
3.resistance R = $\frac{\rho l}{A}$	3. Reluctance $\Re = \frac{l}{\mu A}$
4.Conductance G = $\frac{1}{R}$	4. Permeance P = $\frac{1}{\Re}$

11

Write down the Maxwell's equations in point phasor forms. BTL 1

$$\nabla \times H = J + j\omega D = (\sigma + j\omega\varepsilon) E$$

$$\nabla \times E = -j\omega B = -j\omega\mu H$$

$$\nabla . D = \rho$$

$$\nabla . B = 0$$

12

Write the expression for total current density. (May 2012) BTL 1

$J = J_C + J_D$

J_C is conduction current density, J_D is displacement current density.

13	**Why** $\nabla .B = 0$ **and** $\nabla \times E = 0$. ? BTL 1

$\nabla . B = 0$ States that there is no magnetic charge. The net magnetic flux emerging through any closed surface is zero.
In a region in which there is no time changing magnetic flux, the voltage around the loop would be zero. By Maxwell's equation, $\nabla \times E = -\frac{\partial B}{\partial t}$=0 (irrotational).

14 **Why** $\nabla . D = 0$ **?**BTL 4
In a free space there is no charge enclosed by the medium. The volume charge density is zero. By Maxwell's equation $\nabla . D = \rho_v = 0$.

15 **Find the emf induced in a circuit having an inductance of 700µH if the current through it varies at the rate of 5000A/sec. (Nov 2011)**BTL 3
E=L di/dt= 700 µH X 5000A/sec.=3.5 volts

16 **Compare the relation between Circuit theory and Field theory.(Nov/Dec 2014, Nov 2018)**BTL 1

Circuit Theory	**Field Theory**
This analysis originated by its own.	Evolved from Transmission theory.
Applicable only for portion of RF range.	Beyond RF range (Microwave)
The dependent and independent parameters I, V are directly obtained for the given circuit.	Not directly, through E and H.
Parameters of medium are not involved.	Parameter of medium (permittivity and permeability) are involved in the analysis.
Laplace Transform is employed.	Maxwell's equation is employed
Z, Y, and H parameters are used.	S parameter is used.
Low power is involved.	Relatively high power is involved.
Simple to understand.	Needs visualization ability
Two-dimensional analysis	Three – dimensional analysis
Frequency is used as reference.	Wave length is used as reference
Lumped components are involved	Distributed components are involved.

17 **Distinguish between conduction and displacement current.(Nov 2011, Nov 2018)**BTL 1

Conduction current.	**Displacement current**
Conduction current is nothing but the current flows through the conductor.	Displacement current is nothing but the current flows through the Capacitor.
$I_c = \sigma E$.	$I_d = \int_s \frac{\partial D}{\partial t} . ds$

18 **A conductor of 1m length is moved with a velocity of 100m/sec. perpendicular to a field of 1 tesla. What is the value of emf induced?(Nov 2012)**BTL 3
$E_{induced} = vlB$, where v=100m/sec, l=1m, B=1 tesla, Therefore $E_{induced}$=100x1x1 =100

19 **What is the significance of displacement current?(Nov 2012)**BTL 1

	The displacement current I_D through a specified surface is obtained by integration of the normal component of J_D over the surface. $I_d = \int_S J_D . ds = \int_S \frac{\partial D}{\partial t} . ds$ $I_d = \varepsilon \frac{\partial E}{\partial t} ds$ This is a current which directly passes through the capacitor.
20	**A loop is rotating about the Y axis in a magnetic field B= B_0sinwt i web/m^2. What is the type the voltage induced in the loop? (May 2012)**BTL 3 Motional or Generator emf is induced in the conductor as the conductor position varies with respect to time.
21	**Calculate the characteristics impedance of free space and of the medium whose relative permeability is 1 and relative permittivity is 3. (Nov 2012)(Nov/Dec2015)**BTL 3 $\eta = \frac{E}{H} = \sqrt{\frac{\mu}{\varepsilon}}$ $= \sqrt{\frac{4\pi\times10^{-7}\times1}{8.854\times10^{-12}\times3}}$ =217.4
22	**A parallel plate capacitor with plate area of 5 cm^2 and plate separation of 3 mm has a voltage 50 sin 10^3t V applied to its plates. Calculate the displacement current assuming$\epsilon = 2\,\epsilon_0$.(Nov/Dec2015)**BTL 3 $I_d = \frac{\partial D}{\partial t} = \epsilon\frac{\partial E}{\partial t}$; $E = \frac{V}{d}$ $I_d = \frac{\epsilon}{d}\frac{\partial v}{\partial t} = \frac{2\epsilon_0}{d}\frac{\partial v}{\partial t}$ $=\frac{2\times8.854\times10^{-12}}{3\times10^{-3}}\frac{\partial(50\sin10^3t)}{\partial t}$ = $2.951*10^{-4}\cos10^3t$ A/m^2
23	**Define mutual inductance and self-inductance. (Apr/May2015)** BTL 1 **Mutual inductance.** The mutual inductance between two coils is defined as the ratio of induced magnetic flux linkage in one coil to the current through in other coil(M) = $-\frac{N_2\Phi_{12}}{i_1}$;Where N_2 is number of turns in coil 2; Φ_{12} is magnetic flux links in coil 2 and i_1 is the current through coil 1. **Self -inductance.** The self -induction of a coil is defined as the ratio of total magnetic flux linkage in the circuit to the current through the coil (L) = $\frac{N\Phi}{i}$ Where Φ is magnetic flux; N is number of turns of coil; i is the current.
24	**Distinguish between transformer emf and motional emf. (Nov 2013)(Apr/May 2015)**BTL 1 The emf induced in a stationary conductor due to the change in flux linked with it, is called transformer emf or static induced emf. emf = - $\iint \frac{\partial B}{\partial t} .ds$ eg. Transformer.

	The emf induced due to the movement of conductor in a magnetic field is called motional emf or dynamic induced emf. emf =- $\oint_c v \times B \, .dl$ eg. Generator
25	**Moist soil has conductivity of 10^{-3} S/m and ε_r=2.5, determine the displacement current density if E=6.0x10^{-6} sin 9.0x10^{9} t (V/m). (Nov 2016)**BTL 4 $J_D = \varepsilon_0 \varepsilon_r \frac{\partial E}{\partial t} = 8.854 \times 10^{-12} \times 2.5 \times 6 \times 10^{-6} \times 9 \times 10^{9} \times \cos 9 \times 10^{9} t = 1.195 \times 10^{-6} \cos 9 \times 10^{9} t$
	PART * B

1	**Derive the Maxwell's equations in both point and integral forms. (Nov 2014, May 2014, Nov 2015, May 2015, Nov 2015, May 2016, Nov 2016, Nov 2018) (13 M)** BTL 1 **Answer: Page :4.13 - Dr. P. Dananjayan** **Maxwell's equation from ampere's law (Maxwell's equation-I):**(4 M) ➢ Ampere's circuital law states that the line integral of magnetic field intensity H on any closed path is equal to current enclosed by that path. $$\oint_l H.dl = I = \iint_s J.ds$$ ➢ Total current involves both conduction current and displacement current. ➢ A current through resistive element is called conduction current. ➢ Current through capacitive element is called displacement current. $\therefore J = J_C + J_D$ ➢ Conduction current density $J_C = \sigma E$ ➢ Displacement current density = $J_D = \frac{\partial D}{\partial t}$ ▪ $\therefore \oint_l H.dl = \iint_s (J_C + J_D)\, ds$ ➢ Then $\oint_l H.dl = \iint_s \left(\sigma E + \frac{\partial D}{\partial t}\right) ds$ ▪ $\oint_l H.dl = \iint_s \left(\sigma E + \varepsilon\frac{\partial E}{\partial t}\right) ds$ --------------(1) where $D = \varepsilon E$ ➢ This is Maxwell's equation in integral form from Ampere's law. ➢ By applying stoke's theorem, ▪ $\oint_l H.dl = \iint_s (\nabla \times H).ds$ ---------------------(2) ➢ Comparing equations (1) and (2) ▪ $\iint_s (\nabla \times H).ds = \iint_s \left(J + \frac{\partial D}{\partial t}\right).ds$ ▪ $\nabla \times H = J + \frac{\partial D}{\partial t}$ ▪ $\nabla \times H = \sigma E + \varepsilon\frac{\partial E}{\partial t}$ ➢ This is Maxwell's equation in differential form or point form from Ampere's law.

Maxwell's equation from Faraday's law (Maxwell's equation-II):(3 M)

- Faraday's law states that electromotive force induced in a circuit is equal to rate of decrease of magnetic flux linkage in the circuit.
  - $e = -\frac{d\phi}{dt} = -\frac{d}{dt}\iint_S B.ds$
  - But $e = \oint E.dl$
  - $\oint E.dl = -\frac{d}{dt}\iint_S B.ds$
  - $\oint E.dl = -\iint \frac{\partial B}{\partial t}.ds$ -----------------------(3) $[\because B = \mu H]$
- This is Maxwell's equation in integral form from Faraday's law.
- By applying stoke's theorem,
  - $\oint E.dl = \iint_S (\nabla \times E).ds$ ---------------------------(4)
- Comparing equations (3) and (4)
  - $\iint_S (\nabla \times E).ds = -\iint \frac{\partial B}{\partial t}.ds$
  - $\nabla \times E = -\frac{\partial B}{\partial t}$
  - $\nabla \times E = -\mu\frac{\partial H}{\partial t}$
- This is Maxwell's equation in differential form or point form from Faraday's law.

Maxwell's equation from Electric Gauss's law (Maxwell's equation-III):(3 M)

- Electric Gauss law states that electric flux passing through any closed surface is equal to the charge enclosed by that surface.
  - $\psi = Q$
- $\iint D.ds = Q$
  - $\iiint \rho_v.dv = Q$
  - Then $\iint_S D.ds = \iiint_v \rho_v.dv$-------------------------(5)
- This is Maxwell's equation in integral form from electric Gauss's law.
- By applying divergence theorem
  - $\iint_S D.ds = \iiint_v \nabla.D\,dv$ -----------------------------(6)
- Comparing equations (5) and (6)
  - $\iiint_v \nabla.D\,dv = \iiint_v \rho.dv$
  - $\nabla.D = \rho$
- This is Maxwell's equation in differential form or point form from electric Gauss's law.

Maxwell's equation from Magnetic Gauss's law (Maxwell's equation-IV):(3 M)

- Magnetic Gauss law states that the total magnetic flux through any closed surface is equal to zero.
  - $\phi = 0$
  - $\iint_S B \, . \, d s = 0$ -----------------------------(7)
- This is Maxwell's equation in integral form from Magnetic Gauss's law.
- By applying divergence theorem
  - $\iint_S B \, .d s = \iiint_v \nabla \, . \, B \, d v$ --(8)
- Comparing equations (7) and (8)
  - $\iiint_v \nabla \, . \, B = 0$
  - $\nabla \, .B = 0$
- This is Maxwell's equation in differential form or point form from Magnetic Gauss's law.

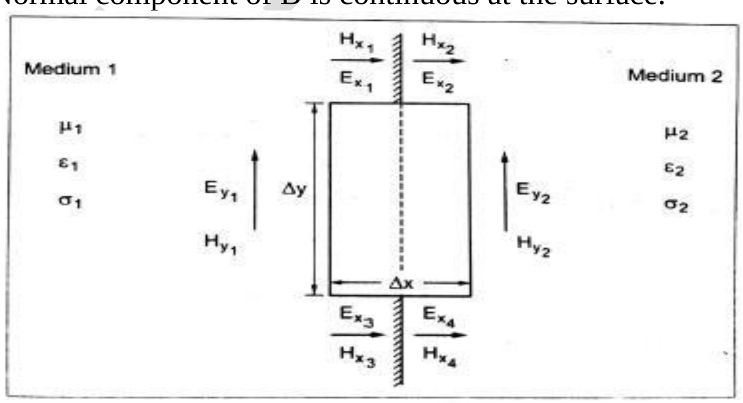
2

State the boundary conditions of time varying fields at the interface between two dielectric media, between a dielectric medium and a perfect metal. (13 M) BTL 1

Answer: Page : 4.21- Dr. P. Dananjayan

Boundary condition:(3M)

- Tangential component of E is continuous at the surface.
- Tangential component of H is continuous at the surface of perfect conductor; otherwise H is discontinuous by an amount equal to linear current density.
- Normal component of D is continuous if there is no surface charge density, otherwise D is discontinuous by an amount equal to surface current density
- Normal component of B is continuous at the surface.



The integral form of the second Maxwell's equation is

$$\oint \mathrm{E} \cdot dl = \iint_{S} \frac{\partial \mathrm{B}}{\partial t} \cdot ds$$

This is applied to a rectangle

$$\mathrm{E}_{y_1} \Delta y + \mathrm{E}_{x_1} \frac{\Delta x}{2} + \mathrm{E}_{x_2} \frac{\Delta x}{2} - \mathrm{E}_{y_2} \Delta y - \mathrm{E}_{x_4} \frac{\Delta x}{2} - \mathrm{E}_{x_3} \frac{\Delta x}{2} = \frac{\partial \mathrm{B}}{\partial t} \Delta x \, \Delta y$$

Consider the area of the rectangle is made to approach zero by reducing the width Δx to approach zero.

Then, $$\mathrm{E}_{y_1} \Delta y - \mathrm{E}_{y_2} \Delta y = 0$$

$$\mathrm{E}_{y_1} = \mathrm{E}_{y_2}$$

The tangential component of E is continuous.

The integral form of first Maxwell's equation is

$$\oint_{l} \mathrm{H} \cdot dl = \iint_{S} \left(\mathrm{J} + \frac{\partial \mathrm{D}}{\partial t} \right) ds$$

Applying to the rectangle,

$$\mathrm{H}_{y_1} \Delta y + \mathrm{H}_{x_1} \frac{\Delta x}{2} + \mathrm{H}_{x_2} \frac{\Delta x}{2} - \mathrm{H}_{y_2} \Delta y - \mathrm{H}_{x_4} \frac{\Delta x}{2} - \mathrm{H}_{x_3} \frac{\Delta x}{2} = \left(\mathrm{J} + \frac{\partial \mathrm{D}}{\partial t} \right) \Delta x \, \Delta y$$

If $\Delta x \to 0$, then $$\mathrm{H}_{y_1} \Delta y - \mathrm{H}_{y_2} \Delta y = 0$$

$$\mathrm{H}_{y_1} = \mathrm{H}_{y_2}$$

$$\underset{\Delta x \to 0}{\mathrm{Lt}} \; \mathrm{J} \cdot \Delta x = \mathrm{J}_l \quad \mathrm{A/m}$$

If the Maxwell's I equation is applied to the rectangle, then

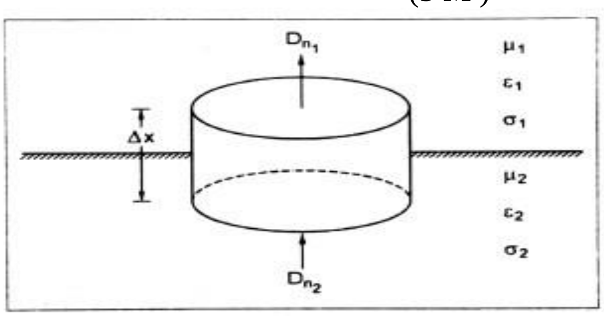
$$\mathrm{H}_{y_1} \Delta y + \mathrm{H}_{x_1} \frac{\Delta x}{2} + \mathrm{H}_{x_2} \frac{\Delta x}{2} - \mathrm{H}_{y_2} \Delta y - \mathrm{H}_{y_4} \frac{\Delta x}{2} - \mathrm{H}_{y_3} \frac{\Delta x}{2} = \left(\mathrm{J} + \frac{\partial \mathrm{D}}{\partial x} \right) \Delta x \, \Delta y$$

$$= \mathrm{J} \, \Delta x \, \Delta y + \frac{\partial \mathrm{D}}{\partial x} \Delta x \, \Delta y$$

$$\mathrm{H}_{y_1} \Delta y - \mathrm{H}_{y_2} \Delta y = \mathrm{J}_l \, \Delta y$$

$$\mathrm{H}_{y_1} - \mathrm{H}_{y_2} = \mathrm{J}_l$$

(5 M)



	The integral form of the Maxwell's 3rd equation $$\oint\!\!\oint_s D \cdot ds = \iiint_v \rho \, dv$$ Apply to the pill box at the boundary $$D_{n_1} ds - D_{n_2} ds = \rho \, ds \cdot \Delta x$$ As $\Delta x \to 0$ *i.e.*, the flat surfaces of the box are squeezed together $$D_{n_1} ds - D_{n_2} ds = 0$$ $$D_{n_1} = D_{n_2}$$ $$\underset{\Delta x \to 0}{\text{Lt}} \; \rho_v \cdot \Delta x = \rho_s$$ If the Maxwell's third equation is applied to the pill box $$D_{n_1} ds - D_{n_2} ds = \rho_v \, ds \cdot \Delta x = \rho_s \cdot ds$$ As $\Delta x \to 0$, $D_{n_1} - D_{n_2} = \rho_s$ The integral form of Maxwell's fourth equation is $$\iint B \cdot ds = 0$$ Apply to the Pill box at the boundary, $$B_{n_1} ds - B_{n_2} ds = 0$$ $$B_{n_1} = B_{n_2}$$ (5 M)
3	**State and derive the Maxwell's equations for free space in point and integral forms for time varying field. (Nov2011&2013) (13 M)** BTL 1 **Answer: Page : 4.20 - Dr. P. Dananjayan** **Maxwell's equation from ampere's law (Maxwell's equation-I):**(4 M) ➢ Ampere's circuital law states that the line integral of magnetic field intensity H on any closed path is equal to current enclosed by that path. $$\oint_l H.dl = I = \iint_S J.ds$$ ➢ Total current involves both conduction current and displacement current. ➢ A current through resistive element is called conduction current. ➢ Current through capacitive element is called displacement current. $$\therefore J = J_C + J_D$$ ➢ Conduction current density $J_C = \sigma E$ ➢ Displacement current density = $J_D = \frac{\partial D}{\partial t}$ ➢ Then $\oint_l H.dl = \iint_S \left(\sigma E + \frac{\partial D}{\partial t} \right) ds$

- $\oint_l H.dl = \iint_s \left(\sigma E + \varepsilon \frac{\partial E}{\partial t} \right) ds$ --------------(1) where $D = \varepsilon E$

➢ This is Maxwell's equation in integral form from Ampere's law.

➢ By applying stoke's theorem,

- $\oint H.dl = \iint_s (\nabla \times H).ds$ --------------------(2)

➢ Comparing equations (1) and (2)

- $\iint_s (\nabla \times H).ds = \iint_s \left(J + \frac{\partial D}{\partial t} \right).ds$
- $\nabla \times H = J + \frac{\partial D}{\partial t}$
- $\nabla \times H = \sigma E + \varepsilon \frac{\partial E}{\partial t}$

➢ This is Maxwell's equation in differential form or point form from Ampere's law.

Maxwell's equation from Faraday's law (Maxwell's equation-II):(3 M)

➢ Faraday's law states that electromotive force induced in a circuit is equal to rate of decrease of magnetic flux linkage in the circuit.

- $e = -\frac{d\phi}{dt} = -\frac{d}{dt}\iint_s B.ds$
- But $e = \oint E.dl$
- $\oint E.dl = -\frac{d}{dt}\iint_s B.ds$
- $\oint E.dl = -\iint \frac{\partial B}{\partial t}.ds$ ----------------------(3) $[\because B = \mu H]$

➢ This is Maxwell's equation in integral form from Faraday's law.

➢ By applying Stoke's theorem,

- $\oint E.dl = \iint_s (\nabla \times E).ds$ ---------------------------(4)

➢ Comparing equations (3) and (4)

- $\iint_s (\nabla \times E).ds = -\iint \frac{\partial B}{\partial t}.ds$
- $\nabla \times E = -\frac{\partial B}{\partial t}$
- $\nabla \times E = -\mu \frac{\partial H}{\partial t}$

➢ This is Maxwell's equation in differential form or point form from Faraday's law.

Maxwell's equation from Electric Gauss's law (Maxwell's equation-III): (3 M)

➢ Electric Gauss law states that electric flux passing through any closed surface is equal to the charge enclosed by that surface.

- $\psi = Q$
- $\iint D.ds = Q$
  - $\iiint \rho_v . dv = Q$
  - Then $\iint_S D.ds = \iiint_v \rho_v . dv$--------------------------(5)
- This is Maxwell's equation in integral form from electric Gauss's law.
- By applying divergence theorem
  - $\iint_S D.ds = \iiint_v \nabla . D\, dv$ ------------------------------(6)
- Comparing equations (5) and (6)
  - $\iiint_v \nabla . D\, dv = \iiint_v \rho . dv$
  - $\nabla . D = \rho$
- This is Maxwell's equation in differential form or point form from electric Gauss's law.

Maxwell's equation from Magnetic Gauss's law (Maxwell's equation-IV):(3 M)

- Magnetic Gauss law states that the total magnetic flux through any closed surface is equal to zero.
  - $\phi = 0$
  - $\iint_S B.\ ds = 0$ ----------------------------(7)
- This is Maxwell's equation in integral form from Magnetic Gauss's law.
- By applying divergence theorem
  - $\iint_S B.ds = \iiint_v \nabla . B\, dv$--(8)
- Comparing equations (7) and (8)
  - $\iiint_v \nabla . B = 0$
  - $\nabla . B = 0$

This is Maxwell's equation in differential form or point form from Magnetic Gauss's law.

$$E(x,t) = \text{Real part of } [\, E(x)\, e^{j\omega t}]$$

$$\frac{\partial E}{\partial t}(x,t) = \text{Real part of } [\, j\omega\, E(x)\, e^{j\omega t}\,]$$

Apply for Maxwell's equation,

$$\text{Real part of } [\nabla \times H] = \text{Real part of } [(\sigma\, E + j\,\omega\,\varepsilon\, E)\, e^{j\omega t}]$$

$$\nabla \times H = \sigma\, E + j\,\omega\,\varepsilon E$$

$$\nabla \times H = (\sigma + j\,\omega\,\varepsilon)\, E$$

For magnetic field, $$H(x,t) = \text{Re}\,[\, H(x)\, e^{j\omega t}\,]$$

$$\frac{\partial H}{\partial t}(x,t) = \text{Re}\,[\, j\omega H(x)\, e^{j\omega t}\,]$$

	Apply for Maxwell's equation $$\text{Re}[\nabla \times E] = -\text{Re}[j\omega\mu H e^{j\omega t}]$$ $$\nabla \times E = -j\omega\mu H$$ <table><tr><th>Differential Form</th><th>Integral Form</th></tr><tr><td>$\nabla \times H = (\sigma + j\omega\varepsilon) E$</td><td>$\oint H \cdot dl = \iint (\sigma + j\omega\varepsilon E)\, ds$</td></tr><tr><td>$\nabla \times E = -j\omega\mu H$</td><td>$\oint E \cdot dl = -\mu \iint j\omega H \cdot ds$</td></tr><tr><td>$\nabla \cdot D = \rho$</td><td>$\oint D \cdot ds = \iiint \rho\, dv$</td></tr><tr><td>$\nabla \cdot B = 0$</td><td>$\oint B \cdot ds = 0$</td></tr></table>
4	**For 1 A conductor current in copper wire, find the corresponding displacement current at 100 MHz. Assume for copper σ = 5.8 * 10^7 mho/m. (7M)** BTL 3 Conduction current $I_C = J_C A = 1$ Amp $$J_C = \frac{I}{A} = \sigma E$$ $$E = \frac{J_C}{\sigma} = \frac{1/A}{\sigma} = \frac{0.172 \times 10^{-7}}{A} \text{ V/m}$$ (4 M) Displacement current $I_D = \omega\varepsilon E \cdot A = \omega\varepsilon_0\varepsilon_r E A$ For copper $\varepsilon_r = 1$, $I_D = 2\pi \times 100 \times 10^6 \times \frac{10^{-9}}{36\pi} \times \frac{0.172 \times 10^{-7}}{A}$ $$\mathbf{I_D = 9.556 \times 10^{-11}\ A}$$ **Ans.** (3 M)
5	**A parallel plate capacitor with plate area of 0.01 m^2 and plate separation of 5 cm has a voltage 100 sin 314 t V applied to its plates. Calculate the displacement current assuming $\varepsilon = 10\,\varepsilon_0$ (May 2012, Nov 2014, Nov 2018) (8 M)** BTL 3 **Answer: Page : 4.32 - Dr. P. Dananjayan** Displacement current density $$J_D = \frac{\partial D}{\partial t} = \varepsilon \frac{\partial E}{\partial t}$$ $$E = \frac{V}{d}$$ $$J_D = \frac{\varepsilon}{d} \cdot \frac{\partial V}{\partial t} = \frac{\varepsilon}{d} \frac{\partial}{\partial t}(100 \sin 314 t)$$

	$= \frac{100\,\varepsilon}{d} \cos(314\,t) \cdot 314$ $= \frac{100}{5\times10^{-2}} \times \frac{10}{36\,\pi\times10^{9}} \times 314 \cos(314\,t)$ $= 5.55\times10^{-5} \cos(314\,t)$ A/m² (4 M) Displacement current $I_D = J_D \cdot A$ $= 5.55\times10^{-5}\times 0.01 \cos(314\,t)$ A $= \mathbf{5.55\times10^{-7} \cos(314\,t)}$ **A Ans.** (4 M)
6	**Explain in detail conduction current and displacement currents. (April 2015, Nov 2015) (13 M)** BTL 1 **Answer: Page : 4.10 - Dr. P. Dananjayan** Conduction current:(6 M) ➢ Current flowing through resistive element. ➢ Ic = V/R ➢ R = ρ l/A ➢ R = l/σA ➢ V = E l ➢ Ic = V/R = El/l = EσA ➢ Jc = Ic/A = σE ➢ J = σE Displacement Current:(7 M) ➢ Current flowing through capacitor element. ➢ I_D = dQ/dt = C dv/dt ➢ C = ε A/d ➢ I_D = ε A/d * dV/dt ➢ A * əD/ət ➢ $J_D = I_D/A$ ➢ $J_D = ə_D/ə$t
7	**Do the fields E = Em sin x sin t a_y and H = (Em/μo)*(cos x cos t) $a_z$satisfy Maxwell's** $\nabla \times E = -\frac{\partial B}{\partial t} = -\mu_0 \frac{\partial H}{\partial t}$ $\nabla \times E = \begin{bmatrix} \bar{a}_x & \bar{a}_y & \bar{a}_z \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ 0 & E_m \sin x \sin t & 0 \end{bmatrix}$ $= \bar{a}_x\left[-\frac{\partial}{\partial z}(E_m \sin x \sin t)\right] + \bar{a}_z\left[\frac{\partial}{\partial x}(E_m \sin x \sin t)\right]$ $= E_m \cos x \sin t\, \bar{a}_z$ (4 M)

	$-\mu_0 \frac{\partial H}{\partial t} = -\mu_0 \frac{\partial}{\partial t}\left[\frac{E_m}{\mu_0}\cos x \cos t\right]\bar{a}_z$ $= -E_m \cos x\,(-\sin t)\,\bar{a}_z = E_m \cos x \sin t\,\bar{a}_z$ Hence $\nabla \times E = -\mu \frac{\partial H}{\partial t}$ (4 M)
8	**In a material for which σ =5.0 S/m and Ɛr=1 with E=250 sin 10^{10} t (V/m). Find J_c and $J_D$and the frequency at which they equal magnitudes. (8 M)** BTL 3 ☺ ***Solution:*** $\sigma = 5$ s/m, $\varepsilon_r = 1$ $E = 250 \sin 10^{10} t$ (V/m) Conduction current density $J_C = \sigma E$ $= \mathbf{1250 \sin 10^{10} t}$ **(V/m) Ans.** (4 M) Displacement current density $J_D = \frac{\partial D}{\partial t} = \varepsilon_0 \frac{\partial E}{\partial t}$ $= \frac{10^{-9}}{36\pi} \times 10^{10} \times 250 \cos 10^{10} t$ (V/m) $J_D = \mathbf{22.1 \cos 10^{10} t}$ **V/m Ans.** ☺ (4 M)
	PART * C
1	$\vec{H} = 3\cos x\vec{a}_x + z\cos x\vec{a}_y$ **A/m for** $z \geq 0$ **and** $\vec{H} = 0$ **for z<0. This magnetic field is applied to a perfectly conducting surface in xy plane. Find the current density on the** ... 3 From Ampere's circuit law, Current density $J = \nabla \times H$ In cartesian form, $J = \begin{vmatrix} \bar{a}_x & \bar{a}_y & \bar{a}_z \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ H_x & H_y & H_z \end{vmatrix}$ $= \left[\frac{\partial H_z}{\partial y} - \frac{\partial H_y}{\partial z}\right]\bar{a}_x + \left[\frac{\partial H_x}{\partial z} - \frac{\partial H_z}{\partial x}\right]\bar{a}_y + \left[\frac{\partial H_y}{\partial x} - \frac{\partial H_x}{\partial y}\right]\bar{a}_z$ (3 M) From H (given), $H_x = 3\cos x$ $H_y = z\cos x$ $H_z = 0$ $J = \left[0 - \frac{\partial z\cos x}{\partial z}\right]\bar{a}_x + \left[\frac{\partial\, 3\cos x}{\partial z} - 0\right]\bar{a}_y + \left[\frac{\partial z\cos x}{\partial x} - \frac{\partial\, 3\cos x}{\partial y}\right]\bar{a}_z$ $= -\cos x\,\bar{a}_x - z\sin x\,\bar{a}_z$ A/m² $\mathbf{J = -\cos x\,\bar{a}_x - z\sin x\,\bar{a}_z}$ **A/m², for** $z \geq 0$ $= \mathbf{0}$, **for** $z < 0$ **Ans.** ☺☺ (5 M)

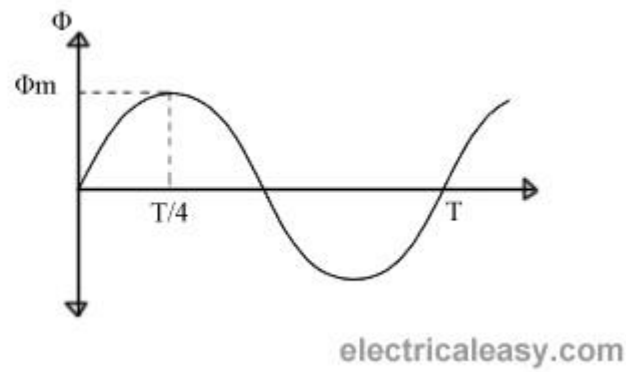
2	**If the magnetic field H = (3x cos β + 6 y sin α)$a_z$find current density J if fields are**

	invariant with time. (8 M) BTL 5 **Answer: Page: 4.35 - Dr. P. Dananjayan** $\nabla \times H = J + \frac{\partial D}{\partial t}$ If the fields are invariant with time $\frac{\partial D}{\partial t} = 0$. $\nabla \times H = J$ (3 M) $J = \begin{vmatrix} \bar{a}_x & \bar{a}_y & \bar{a}_z \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ 0 & 0 & 3x\cos\beta + 6y\sin\alpha \end{vmatrix}$ $J = \frac{\partial}{\partial y}(3x\cos\beta + 6y\sin\alpha)\,\bar{a}_x - \frac{\partial}{\partial x}(3x\cos\beta + 6y\sin\alpha)\,\bar{a}_y$ $\mathbf{J = 6\sin\alpha\,\bar{a}_x - 3\cos\beta\,\bar{a}_y\ A/m^2}$ **Ans.** ☺☺ (5 M)
3	**The conduction current flowing through a wire with conductivity σ = 3 * 10^7 s/m and relative permittivity εr = 1 is given by Ic 3 sin ωt (mA). If ω = 10^{8}ras/sec. Find the** $I_C = \sigma E A$ $E = \frac{I_C}{\sigma A} = \frac{3\times10^{-3}\sin\omega t}{3\times10^{7}\times A} = \frac{1\times10^{-10}}{A}\sin\omega t$ $\frac{\partial E}{\partial t} = \frac{1\times10^{-10}}{A}\omega\cos\omega t$ $J_D = \varepsilon\frac{\partial E}{\partial t}$ $J_D = \varepsilon\,\omega\cdot\frac{1\times10^{-10}}{A}\cos\omega t$ $= 8.85\times10^{-12}\times10^{8}\times\frac{10^{-16}}{A}\cos 10^{8}t$ (4 M) Displacement current $I_D = J_D \cdot A$ $= 8.85\times10^{-12}\times10^{8}\times\frac{10^{-16}}{A}\cos 10^{8}t\ A$ $\mathbf{I_D = 8.85\times10^{-4}\cos 10^{8}t}$ **Amperes Ans.** (4 M)
4	**Given the conduction current density in a lossy dielectric ad Jc = 0.02 sin 10^{9}t A/m^2. Find the displacement current density if σ = 10^3 mho/m and εr = 6.5 (8 M)** BTL 5 **Answer: Page: 4.35 – Dr. P. Dananjayan**

	$J_C = 0.02 \sin 10^9 t \quad A/m^2$ $\sigma = 10^3$ mho/m $\varepsilon_r = 6.5$ $J_C = \sigma E$ $E = \dfrac{J_C}{\sigma}$ $= \dfrac{0.02 \sin 10^9 t}{10^3} = 2 \times 10^{-5} \sin 10^9 t$ V/m (4 M) Displacement current density $J_D = \dfrac{\partial D}{\partial t} = \varepsilon \dfrac{\partial E}{\partial t}$ $\dfrac{\partial E}{} = 2 \times 10^{-5} \times 10^9 \cos 10^9 t$ $J_D = \varepsilon \dfrac{\partial E}{\partial t} = \varepsilon_o \varepsilon_r \dfrac{\partial E}{\partial t}$ $= 8.854 \times 10^{-12} \times 6.5 \times 2 \times 10^{-5} \times 10^9 \cos 10^9 t$ A/m $= \mathbf{115.1 \times 10^{-8} \cos 10^9 t}$ **A/m Ans.** (4 M)

5	**Derive the emf equations for transformer and motional emf. (15 M)** BTL1 **Answer: Page : 4.04 – Dr. P. Dananjayan** **EMF Equation of The Transformer**(7 M) ➢ Let, N_1 = Number of turns in primary winding N_2 = Number of turns in secondary winding Φ_m = Maximum flux in the core (in Wb) = (B_m x A) f = frequency of the AC supply (in Hz) ➢ As, shown in the fig., the flux rises sinusoidally to its maximum value Φ_m from 0. ➢ It reaches to the maximum value in one quarter of the cycle i.e in T/4 sec (where, T is time period of the sin wave of the supply = 1/f). ➢ average rate of change of flux = $\Phi_m / (T/4) = \Phi_m / (1/4f)$ ➢ average rate of change of flux = 4f Φ_m .... (Wb/s). ➢ Induced emf per turn = rate of change of flux per turn. ➢ Therefore, average emf per turn = 4f Φ_m .... (Volts). ➢ Now, we know, Form factor = RMS value / average value ➢ Therefore, RMS value of emf per turn = Form factor X average emf per turn. ➢ As, the flux Φ varies sinusoidally, form factor of a sine wave is 1.11 ➢ Therefore, RMS value of emf per turn = 1.11 x 4f Φ_m = 4.44f Φ_m. ➢ RMS value of induced emf in whole primary winding (E_1) = RMS value of emf per turn X Number of turns in primary winding $E_1 = 4.44f\, N_1\, \Phi_m$ .... eq 1

$$\frac{E_1}{N_1} = \frac{E_2}{N_2} = 4.44f\,\Phi m$$



Similarly, RMS induced emf in secondary winding (E_2) can be given as

$E_2 = 4.44f\, N_2\, \Phi_m$ .... eq 2

from the above equations 1 and 2,

- This is called the **emf equation of transformer**, which shows, emf / number of turns is same for both primary and secondary winding.

  For an ideal transformer on no load, $E_1 = V_1$ and $E_2 = V_2$.
  where, V_1 = supply voltage of primary winding
  V_2 = terminal voltage of secondary winding

- **Voltage Transformation Ratio (K)**
- As derived above,

$$\frac{E_1}{N_1} = \frac{E_2}{N_2} = K$$

- Where, K = constant
  This constant K is known as **voltage transformation ratio**.

- If $N_2 > N_1$, i.e. $K > 1$, then the transformer is called step-up transformer.
- If $N_2 < N_1$, i.e. $K < 1$, then the transformer is called step-down transformer.

Motional EMF (8 M)

- When a conductor is moved across a magnetic field, a potential difference is setup across its ends.
- This potential difference is called **'motional EMF'.**

EXPRESSION FOR MOTIONAL EMF

- Consider a wire of length "**L**" moving across the magnetic field of

	induction **B** with a velocity **v** as shown in diagram. ➢ Each free electron of the wire is moving within the wire and experience a force exerted by magnetic field. ➢ $\vec{F} = q\,(\vec{V} \times \vec{B})$ ➢ For electron we have **q = -e** ➢ $\vec{F} = -e(\vec{V} \times \vec{B})$ $\vec{F} = e(\vec{B} \times \vec{V})$ from b to a ➢ These electrons gradually accumulate at the end "a" and leaving the other end "b".In this way point "b" acquires positive charge and point "a" acquires equal negative charge. This accumulation of electrons will continue till the force of electric field balances the force due to the motion of wire. Thus, a potential difference is setup form point **b** to point **a**. **POTENTIAL DIFFERENCE** ➢ We know Potential Difference = work done per unit charge Let the total charge flows through the wire is "**q**" therefore ➢ This is called motional EMF. ➢ Therefore, motional EMF = BVlsinq ➢ If the wire is moving at right angle to the field, **q** = 90 ➢ **Motional EMF = BVL**

UNIT V PLANE ELECTROMAGNETIC WAVES	
Electromagnetic wave generation and equations – Wave parameters; velocity, intrinsic impedance, propagation constant – Waves in free space, lossy and lossless dielectrics, conductors- skin depth - Poynting vector – Plane wave reflection and refraction.	
Q. No	**Part * A**
1	**Mention the properties of uniform plane wave. (Nov 2016)** BTL 1 The properties of uniform plane wave are as follows: ➢ At every point in space, the electric field E and Magnetic field H are perpendicular to each other and to the direction of the travel. ➢ The fields vary harmonically with the time and at the same frequency, everywhere in space. ➢ Each field has the same direction, magnitude and phase at every point in any plane perpendicular to the direction of wave travel.
2	**Write down the wave equations for E and H in a non-dissipative (free space) and conducting medium. (May 2012)** BTL 1 **In Free space.** $\nabla^2 E - \mu_0 \varepsilon_0 \frac{\partial^2 E}{\partial t^2} = 0$; $\nabla^2 H - \mu_0 \varepsilon_0 \frac{\partial^2 E}{\partial t^2} = 0$ **In conducting medium.** $\nabla^2 E - \mu\varepsilon \frac{\partial^2 E}{\partial t^2} - \mu\sigma \frac{\partial E}{\partial t} = 0$; $\nabla^2 H - \mu\varepsilon \frac{\partial^2 H}{\partial t^2} - \mu\sigma \frac{\partial H}{\partial t} = 0$
3	**Define uniform plane wave.(Nov 2013)** BTL 1 If the phase of a wave is the same for all points on a plane surface it is called plane wave. If the amplitude is also constant in a plane wave, it is called uniform plane wave.
4	**Define intrinsic impedance or characteristic impedance. (Nov 2018)**BTL 1 It is the ratio of electric field to magnetic field. Or It is the ratio of square root of permeability to permittivity of the medium. $\eta = \frac{E}{H} = \sqrt{\frac{\mu}{\varepsilon}}$ Ohms
5	**Calculate intrinsic impedance or characteristic impedance of free space. (Nov 2011)** BTL 3 $\eta = \frac{E}{H} = \sqrt{\frac{\mu_o}{\varepsilon_o}} = \sqrt{\frac{4\pi \times 10^{-7}}{8.854 \times 10^{-12}}} = 120\pi = 377$ ohms
6	**Define polarization.** BTL 1 Polarization is defined as the polarization of a uniform plane wave refers to the time varying nature of the electric field vector at some fixed point in space.

7	**Define Surface impedance.** BTL 1 Surface impedance is defined as the ratio of tangential component of electric field at the surface of a conductor to the linear current density. $Zs = \frac{E_{tan}}{J_s} = \frac{\gamma}{\sigma}$; Where γ is propagation constant. σ is conductivity medium.
8	**Define Poynting vector. (May 2014, May 2016)** BTL 1 The pointing vector is defined as rate of floe of energy of a wave as it propagates. It is the vector product of electric field and magnetic field. P = E x H
9	**State Slepian vector.** BTL 1 Slepian vector is a vector which defined at every point, such that its flux coming out of any volume is zero. $(\nabla . S) = 0$. Slepian vector is given by $S = \nabla \times (\nabla H)$ Where, V is electric potential, H is magnetic field intensity.
10	**State Poynting theorem. (Nov 2013, Nov 2018)** BTL 1 The vector product of electric field intensity at any point is a measure of the rate of energy flow per unit area at that point. P = E x H
11	**Fine the skin depth at a frequency of 2MHz is Aluminum where σ = 38.2M s/m and μ_r = 1**. BTL 3 **Solution:** Given data: ζ = 38.2M s/m = 38.2 x 10^6 s/m; μ_r = 1; $\omega = 2\pi f = 2\pi x 2 x10^6$ For Good conductor, Skin depth $\delta = \frac{1}{\alpha} = \sqrt{\frac{2}{\omega\mu\zeta}} = \sqrt{\frac{2}{2\pi \times 2 \times 10^6 \times 1 \times 4\pi \times 10^{-7} \times 38.2 \times 10^6}}$ =5.758 x 10^{-5} m.
12	**State Snell's law.** BTL 1 When a wave is travelling from one medium to another medium, the angle of incidence is related to angle of reflection as follows. $\frac{\sin\theta_i}{\sin\theta_t} = \frac{\eta_1}{\eta_2} = \sqrt{\frac{\varepsilon_2}{\varepsilon_1}}$ $(\mu_1 = \mu_2 = \mu_0)$ Where θ_i is angle of incidence; θ_t is angle of refraction; ε_1 is dielectric constant of medium 1 ε_2 is dielectric constant of medium 2 .
13	**Write Helmholtz's equation.** BTL 1 $\nabla^2 E - \gamma^2 E = 0$; where $\gamma = \sqrt{j\omega\mu(\sigma + j\omega\varepsilon)}$
14	**What is Brewster angle?** BTL 1 Brewster angle is an incident angle at which there is no reflect wave for parallel polarized wave. $\theta = \tan^{-1}\sqrt{\frac{\varepsilon_2}{\varepsilon_1}}$ Where, ε_1 is dielectric constant of medium 1, ε_2 is dielectric constant of medium

15	**What do you meant by total internal reflection?** BTL 1 When a wave is incident from the denser medium to rarer medium at an angle equal to or greater than the critical angle, the wave will be totally internally reflected back. This phenomenon is called Total internal reflection.
16	**What is practical significance of skin depth? (Nov 2015, May 2016)** BTL 1 Skin depth or depth of penetration (δ) is defined as that of depth in which the wave has been attenuated to 1 / e or approximately 37% of its original value. $\delta = \frac{1}{\alpha} = \sqrt{\frac{2}{\omega\mu\sigma}}$ for good conductor. $\delta = \sqrt{\frac{1}{\pi f \mu\sigma}}$; $\delta \,\alpha\, \frac{1}{f}$ For low frequency, the skin depth δ is large. For High or microwave frequency range, the skin depth δ is small.
17	**Define normal incidence and oblique incidence.** BTL 1 **Normal incidence:** When a uniform plane wave incidences normally to the boundary between the media, then it is known as normal incidence. **Oblique incidence:** When a uniform plane wave incidences obliquely to the boundary between the two media, then it is known as oblique incidence.
18	**Define voltage reflection coefficient at the load end of the transmission line.(Nov 2011)** BTL 1 It is defined as the ratio of the magnitude of the reflected wave to that of the incident wave.
	What is 'standing wave ratio'? (Nov 2012, May 2014, Nov 2016) BTL 1 It is defined as the ratio of maximum to minimum amplitudes of voltage. $S = \frac{E_{1s\,max}}{E_{1s\,min}} = \frac{1+\lvert\Gamma\rvert}{1-\lvert\Gamma\rvert}$
21	**The capacitance and inductance of an overhead transmission line are 0.0075μF/km and 0.8mH/km respectively. Determine the characteristic impedance of the line.(Nov/Dec 2014)** BTL 3 The characteristic impedance of a transmission line is equal to the square root of the ratio of the line's inductance per unit length divided by the line's capacitance per unit length $Z_0 = \sqrt{\frac{L}{C}} = 326.5\Omega$
22	**Compare the equi-potential plots of uniform and non-uniform fields. (April /May 2015)** BTL 1 Uniform field: The equipotential surface are perpendicular to $\vec{E}$ and are equidistant for fixed increment of voltages Non-uniform field: The equipotential surface are perpendicular to $\vec{E}$ and are no equidistant for fixed increment of voltages
23	**What is the wavelength and frequency of a wave propagation in free space when β=2? (April /May 2015)** BTL 3

	β = $= \omega\sqrt{\mu_0\omega_0}$; 2 = $2\pi f\sqrt{\mu_0\omega_0}$; f = 0.955 *10^8 Hz; wavelength = 3.14m
24	**If a plane wave is incident normally from medium 1 to medium2, write the reflection and transmission co-efficients. (Nov/Dec 2014)** BTL 3 Reflection Co-efficients $Er_0 = \frac{\eta_2 - \eta_1}{\eta_2 + \eta_1} Ei_0$ Transmission Co-efficients $Et_0 = \frac{2\eta_2}{\eta_2 + \eta_1} Ei_0$
25	**A plane wave travelling in air is normally incident on a block of paraffin with $\epsilon_r = 2.3$. Find the reflection co-efficient. (Nov/Dec 2015)**BTL 3 Reflection co-efficient = $\frac{\sqrt{\epsilon_1}-\sqrt{\epsilon_2}}{\sqrt{\epsilon_1}+\sqrt{\epsilon_2}} == \frac{\sqrt{2.3}-\sqrt{1}}{\sqrt{2.3}+\sqrt{1}}$ = 0.5165/2.565 = 0.2053
	PART * B
1	**Obtain the electromagnetic wave equation for free space in terms of electric field and magnetic fields.(13 M) (Nov 2012, Nov 2015, Nov 2018)** BTL 2 **Answer: Page 5.03 - P. Dananjayan** ➢ For free space (dielectric medium) the conductivity of the medium is zero. (i.e., $\sigma = 0$) and there is no charge containing in it (i.e., $\rho = 0$). ➢ The electromagnetic wave equations for free space can be obtained from Maxwell's equations. ➢ The Maxwell's equation from Faraday's law for free space in point form is $\nabla \times E = -\frac{\partial B}{\partial t} = -\mu \frac{\partial H}{\partial t}$ ➢ Taking curl on both sides, • $\nabla \times \nabla \times E = -\mu\, \nabla \times \frac{\partial H}{\partial t}$ --------------------------------------- (1) ➢ But Maxwell's equation from ampere's law for free space in point form is $\nabla \times H = -\frac{\partial D}{\partial t} = -\varepsilon \frac{\partial E}{\partial t}$ $\nabla \times \frac{\partial H}{\partial t} = \frac{\partial \nabla \times H}{\partial t} = \frac{\partial}{\partial t}\left(\varepsilon \frac{\partial E}{\partial t}\right)$ $\nabla \times \frac{\partial H}{\partial t} = \left(\varepsilon \frac{\partial^2 E}{\partial t^2}\right)$ ----------------------------------(2) ➢ Substituting the equation (2) in (1) $\nabla \times \nabla \times E = -\mu\, \varepsilon \times \left(\frac{\partial^2 E}{\partial t^2}\right)$ - - - - - - - - - - - - - - (3) ➢ But the identity is given by, $\nabla \times \nabla \times E = \nabla(\nabla . E) - \nabla^2 E$ • $\nabla . E = \frac{1}{\varepsilon} \nabla . D = \frac{\rho}{\varepsilon} = 0$ $\nabla \times \nabla \times E = \nabla(\nabla . E) - \nabla^2 E$

$$\nabla \times \nabla \times E = -\nabla^2 E ---------------(4)$$

- Comparing equations (3) and (4)

$$\nabla^2 E = \mu\varepsilon \frac{\partial^2 E}{\partial t^2}$$

$$\nabla^2 E - \mu\varepsilon \frac{\partial^2 E}{\partial t^2} = 0 ----------------(5)$$

(6 M)

- This is the wave equation for free space in terms of electric field.
- The wave equation for free space in terms of magnetic field H is obtained in a similar manner as follows.
- The Maxwell's equation from ampere's law for free space in point form is given by

$$\nabla \times H = \varepsilon \frac{\partial E}{\partial t}$$

- Taking curl on both sides

$$\nabla \times \nabla \times H = -\varepsilon \nabla \times \frac{\partial E}{\partial t} --------------(6)$$

- But Maxwell's equation from faraday's law

$$\nabla \times E = -\mu \frac{\partial H}{\partial t}$$

- Differentiating,

$$\nabla \times \frac{\partial E}{\partial t} = -\mu \frac{\partial^2 H}{\partial t^2} -------(7)$$

- Substituting equation (7) in (6)

$$\nabla \times \nabla \times H = -\mu\varepsilon \frac{\partial^2 H}{\partial t^2} --------------(8)$$

- By the identity is given by

$$\nabla \times \nabla \times H = \nabla(\nabla . H) - \nabla^2 H ----------(9)$$

But

$$\nabla . H = \frac{1}{\mu} \nabla . B = 0$$

Then

$$\nabla \times \nabla \times H = -\nabla^2 H -------------(10)$$

- Comparing equations (8) and (10)

$$\nabla^2 H = \mu\varepsilon \frac{\partial^2 H}{\partial t^2}$$

	$$\nabla^2 H - \mu\varepsilon \frac{\partial^2 H}{\partial t^2} = 0 ------------(11)$$ ▪ ➢ This wave equation for free space in terms of H. ➢ For free space $\mu_r = 1$ and $\varepsilon_r = 1$ (air) then wave equation becomes ○ $\nabla^2 H - \mu_o\varepsilon_o \frac{\partial^2 H}{\partial t^2} = 0$ ○ $\mu_o\varepsilon_o = 4\pi\times10^{-7}\times\frac{1}{36\pi\times10^{-9}} = \frac{1}{9\times10^{16}}$ ○ $\frac{1}{\sqrt{\mu_o\varepsilon_o}} = 3\times10^8 m/s = v_o$ ➢ Where v_o is the velocity of light. ➢ Then the wave equation, ➢ $\nabla^2 H - \frac{1}{v_o^2}\frac{\partial^2 H}{\partial t^2} = 0$ (or) $\nabla^2 E - \frac{1}{v_o^2}\frac{\partial^2 E}{\partial t^2} = 0$ (7 M)

$$v = \text{Re}[V e^{j\omega t}] = |V| \cos(\omega t + \theta_v)$$

$$i = \text{Re}[I e^{j\omega t}] = |I| \cos(\omega t + \theta_i)$$

The instantaneous power is given by

$$W = |V||I| \cos(\omega t + \theta_v) \cos(\omega t + \theta_i)$$

$$W = \frac{|V||I|}{2} [\cos(\theta_v - \theta_i) + \cos(2\omega t + \theta_v + \theta_i)]$$

The instantaneous power flow per square meter *i.e.*, Poynting vector is

$$\tilde{P} = \tilde{E} \times \tilde{H}$$

The average power is given by

$$W_{av} = \frac{|V||I|}{2} \cos(\theta_v - \theta_i)$$

If $\theta_v - \theta_i = \theta$, the angle between voltage and current, then

$$W_{av} = \frac{|V||I|}{2} \cos\theta$$

2	**State Poynting theorem and thus obtain an expression for instantaneous power density vector associated with electromagnetic field. (13M) (Nov2011, May2012, Nov 2014, April 2015, Nov 2015)** BTL 1 **Answer: Page 5.42- P. Dananjayan** ➢ The vector product of electric field intensity at any point is a measure of the rate of energy flow per unit area at that point. P = E x H ➢ The instantaneous power w can be written in terms of instantaneous voltage v and current I as ➢ (6 M)

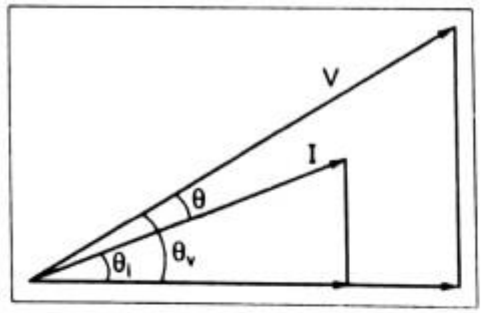


Fig. 5.11.

The reactive power is given by

➢
$$W_{rea} = \frac{|V||I|}{2} \sin\theta$$

The complex power w is defined as

$$W = \frac{1}{2} V I^*$$

Where I^* is complex conjugate of I.

$$W = \frac{|V||I|}{2} e^{j\theta}$$

➢
$$W = W_{av} + j\, W_{rea}$$

The complex Poynting vector P is

$$P = \frac{1}{2} E \times H^*$$

It consists of real and imaginary power flow per square meter.

The real Poynting vector (average Poynting vector) is

➢
$$P_{av} = \frac{1}{2} \text{Re}\,[E \times H^*]$$

The imaginary Poynting vector (reactive Poynting vector) is

$$P_{rea} = \frac{1}{2} I_m\,[E \times H^*]$$

In rectangular co-ordinates, the complex Poynting vector normal to y–z plane is

➢
$$P_x = \frac{1}{2}\,[E_y H_z^* - E_z H_y^*]$$

(7 M)

3	**Deduce the wave equations for conducting medium**. **(13M)(May 2016, Nov 2016)**BTL 1 **Answer: Page 5.01 - P. Dananjayan** ➢ Maxwell's equations in the differential form as

$$\nabla \times \vec{H} = \vec{J} + \frac{\partial \vec{D}}{\partial t}$$

$$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

$$\nabla \cdot \vec{D} = \vec{\rho}$$

$$\nabla \cdot \vec{B} = 0$$

- Let us consider a source free uniform medium having dielectric constant, ε magnetic permeability μ and conductivity ζ. The above set of equations can be written as

$$\nabla \times \vec{H} = \sigma\vec{E} + \varepsilon\frac{\partial \vec{E}}{\partial t} \qquad (5.29(a))$$

$$\nabla \times \vec{E} = -\mu\frac{\partial \vec{H}}{\partial t} \qquad (5.29(b))$$

$$\nabla \cdot \vec{E} = 0 \qquad (5.29(c))$$

$$\nabla \cdot \vec{H} = 0 \qquad (5.29(d))$$

- Using the vector identity,

$$\nabla \times \nabla \times \vec{A} = \nabla \cdot \left(\nabla \cdot \vec{A}\right) - \nabla^2 A$$

$$\nabla \times \nabla \times \vec{E} = \nabla \cdot \left(\nabla \cdot \vec{E}\right) - \nabla^2 \vec{E}$$

$$= -\nabla \times \left(\mu\frac{\partial \vec{H}}{\partial t}\right)$$

- We can write from 5.29(b)

$$\nabla \cdot \left(\nabla \cdot \vec{E}\right) - \nabla^2 \vec{E} = -\mu\frac{\partial}{\partial t}\left(\nabla \times \vec{H}\right)$$

$$\nabla \cdot \left(\nabla \cdot \vec{E}\right) - \nabla^2 \vec{E} = -\mu\frac{\partial}{\partial t}\left(\sigma\vec{E} + \varepsilon\frac{\partial \vec{E}}{\partial t}\right)$$

- $\nabla \cdot \vec{E} = 0$
- $\nabla^2 \vec{E} = \mu\sigma\frac{\partial \vec{E}}{\partial t} + \mu\varepsilon\frac{\partial^2 \vec{E}}{\partial t^2}$

- But in source free medium (eqn 5.29(c))
- In the same manner for equation eqn5.29(a) (6 M)

$$\nabla \cdot \vec{H} = 0$$

$\vec{E}$ and $\vec{H}$

$\vec{E}$ and $\vec{H}$

$\vec{E}$ and $\vec{H}$

$$\nabla\times\nabla\times\vec{H} = \nabla\cdot\left(\nabla\cdot\vec{H}\right) - \nabla^2\vec{H}$$
$$= \sigma\left(\nabla\times\vec{E}\right) + \varepsilon\frac{\partial}{\partial t}\left(\nabla\times\vec{E}\right)$$
$$= \sigma\left(-\mu\frac{\partial\vec{H}}{\partial t}\right) + \varepsilon\frac{\partial}{\partial t}\left(-\mu\frac{\partial\vec{H}}{\partial t}\right)$$

- Since fromeqn5.29(d),wecanwrite

$$\nabla^2\vec{H} = \mu\sigma\left(\frac{\partial\vec{H}}{\partial t}\right) + \mu\varepsilon\left(\frac{\partial^2\vec{H}}{\partial t^2}\right)$$

- Thesetwo equations

$$\nabla^2\vec{E} = \mu\sigma\frac{\partial\vec{E}}{\partial t} + \mu\varepsilon\frac{\partial^2\vec{E}}{\partial t^2}$$
$$\nabla^2\vec{H} = \mu\sigma\left(\frac{\partial\vec{H}}{\partial t}\right) + \mu\varepsilon\left(\frac{\partial^2\vec{H}}{\partial t^2}\right)$$

- Are known as wave equations.
- It maybe noted that the field components are functions of both space and time. For example, if we consider a Cartesian coordinate system, essentially represents $\vec{E}(x,y,z,t)$ and $\vec{H}(x,y,z,t)$.
- For simplicity, we consider
- Propagation in free space, i.e. , $\mu = \mu_0$ and $\varepsilon = \varepsilon_0$.
- The wave equation in equations 5.30and5.31reducesto

$$\nabla^2\vec{E} = \mu_0\varepsilon_0\left(\frac{\partial^2\vec{E}}{\partial t^2}\right) \qquad (5.32(a))$$
$$\nabla^2\vec{H} = \mu_0\varepsilon_0\left(\frac{\partial^2\vec{H}}{\partial t^2}\right) \qquad (5.32(b))$$

-
- Further simplifications can be made if we considering Cartesian coordinate system a special case where are considered to be independent in two dimensions, say are assumed to be independent of *y* and *z.* Such waves are called plane waves. (7 M)

4	**Discuss group velocity, phase velocity and propagation constant of electromagnetic waves.(13M) (May 2016)**BTL 2 **Answer:Page: 5.12 - P. Dananjayan** ➢ The wave equation for free space is $\nabla^2 E = \mu \varepsilon \frac{\partial^2 E}{\partial t^2}$ ➢ The phasor value of E is ➢ $E(x, t) = \text{Re}[E(x) e^{j\omega t}]$ $\nabla^2 \text{Re}[E e^{j\omega t}] = \mu \varepsilon \frac{\partial^2}{\partial t^2} \text{Re}[E e^{j\omega t}]$ $\nabla^2 \text{Re}[E e^{j\omega t}] = \mu \varepsilon \text{Re}[-\omega^2 E e^{j\omega t}]$ $\text{Re}[(\nabla^2 E + \mu \varepsilon \omega^2 E) e^{j\omega t}] = 0$ $\nabla^2 E + \mu\varepsilon \omega^2 E = 0$ $\nabla^2 E + \beta^2 E = 0$ where $\beta^2 = \mu \varepsilon \omega^2$ $\beta = \sqrt{\mu \varepsilon}\, \omega$ β is called phase shift constant. The velocity of propagation is $v = \frac{\omega}{\beta} = \frac{1}{\sqrt{\mu \varepsilon}}$ The wave propagates in x direction *i.e.,* no variation in y and z. $\frac{\partial^2 E}{\partial x^2} + \beta^2 E = 0$ The solution of the equation is $E = C_1 e^{-j\beta x} + C_2 e^{j\beta x}$ ➢ The wave equation for conducting medium is $\nabla^2 E - \mu \varepsilon \frac{\partial^2 E}{\partial t^2} - \mu \sigma \frac{\partial E}{\partial t} = 0$ (6 M)

The phasor form of wave equation is

$$\nabla^2 E - \mu\varepsilon\omega^2 E - j\omega\mu\sigma E = 0$$

$$\nabla^2 E - j(\omega\mu\sigma + j\mu\varepsilon\omega^2)\, E = 0$$

$$\nabla^2 E - j\omega\mu\,(\sigma + j\omega\varepsilon)\, E = 0$$

$$\nabla^2 E - \gamma^2 E = 0$$

$$\text{where} \quad \gamma^2 = j\omega\mu\,(\sigma + j\omega\varepsilon)$$

γ is called ***propagation constant,*** which has both real and imaginary parts.

$$\gamma = \alpha + j\beta$$

where α is attenuation constant

β is phase shift

$$\gamma = \alpha + j\beta = \sqrt{j\omega\mu\,(\sigma + j\omega\varepsilon)}$$

Attenuation factor is given by

$$\alpha = \omega\sqrt{\frac{\mu\varepsilon}{2}\left[\sqrt{1 + \frac{\sigma^2}{\omega^2\varepsilon^2}} - 1\right]}$$

By subtracting $\alpha^2 - \beta^2$ from $\alpha^2 + \beta^2$, the value of β becomes

$$\beta = \omega\sqrt{\frac{\mu\varepsilon}{2}\left[\sqrt{1 + \frac{\sigma^2}{\omega^2\varepsilon^2}} + 1\right]}$$

(7 M)

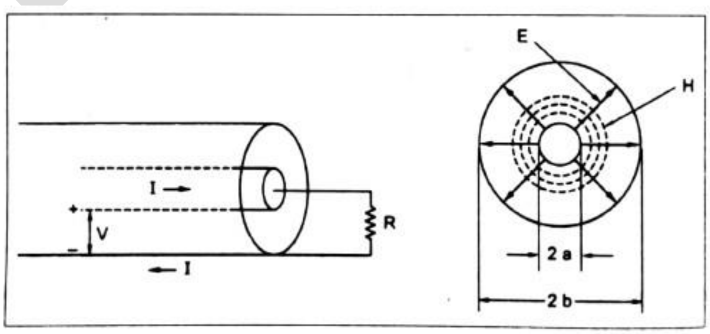
5

Derive the expression for total power flow in a coaxial cable.(8 M)BTL 3

Answer: Page 5.40 - P. Dananjayan

Let

- Co-axial cable inner radius - a
- Outer radius - b
- Current - I



	$$\oint H \cdot dl = I$$ $$\oint H \cdot dl = H \cdot (2\pi r)$$ where, r is the radius of the circle $$H \cdot (2\pi r) = I$$ ➢ $$H = \frac{I}{2\pi r}$$ (4 M) The electric field strength of coaxial cable is given by $$E = \frac{V}{r \ln (b/a)}$$ ➢ The Poynting vector $P = E \times H$ $$W = \int_s E \times H \cdot ds = \int_s E H \cdot ds$$ ➢ $$= \int_a^b \frac{V}{r \ln (b/a)} \left(\frac{I}{2\pi r}\right) 2\pi r \cdot dr$$ $$= \frac{VI}{\ln (b/a)} \ln [b/a]$$ ➢ $$W = VI$$ (4 M)
	PART * C
1	**A medium is characterized by $\sigma = 10^{-3}$, $\mu = \mu_0$ and $\varepsilon = 80\varepsilon_0$. If the frequency of 10 kHz. Calculate parameter of the wave. (8 M) (Nov 2018)** BTL 5 **Answer: Page 5.66 - P. Dananjayan** $$\sigma = 10^{-3}\ s/m \qquad \varepsilon = 80\,\varepsilon_0$$ $$\mu = \mu_0 \qquad f = 10 \times 10^3\ \text{Hz}$$ $$\frac{\sigma}{\omega \varepsilon} = \frac{10^{-3}}{2\pi \times 10 \times 10^3 \times 80 \times 8.854 \times 10^{-12}} \leq 1$$ $\therefore$ Medium is a dielectric medium Attenuation constant, $$\alpha = \frac{\sigma}{2}\sqrt{\frac{\mu}{\varepsilon}} = \frac{10^{-3}}{2}\sqrt{\frac{\mu_0}{80\,\varepsilon_0}}$$ $$= \frac{10^{-3}}{2} \cdot \frac{1}{\sqrt{80}} \cdot 120\,\pi = \mathbf{21.07 \times 10^{-3}\ nepers}$$ (4 M)

$$\beta = \omega\sqrt{\mu\varepsilon}\left[1+\frac{1}{2}\left(\frac{\sigma}{2\omega\varepsilon}\right)^2\right]$$

$$= 2\pi(10\times10^3)\sqrt{4\pi\times10^{-7}\times80\times8.854\times10^{-12}}$$

$$\left[1+\frac{1}{2}\left(\frac{10^{-3}}{2\times2\pi\times10^4\times80\times8.854\times10^{-12}}\right)^2\right]$$

$$\beta = \mathbf{0.12\ rad}$$

$$\lambda = \frac{2\pi}{\beta} = \mathbf{52.35\ m}$$

(4 M)

2

Derive the expression for characteristics Impedance. (15 M) BTL 1

Answer: Page 5.07 - P. Dananjayan

- $$\frac{\partial^2 E}{\partial x^2} = \mu\varepsilon\frac{\partial^2 E}{\partial t^2}$$

  The general solution of this differential equation is in the form

  $$E = f_1(x - v_0 t) + f_2(x + v_0 t)$$

  $$\text{where} \quad v_0 = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$$

- $$E = f(x - v_0 t)$$

  $$\nabla\times E = \begin{vmatrix} \vec{x} & \vec{y} & \vec{z} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ E_x & E_y & E_z \end{vmatrix}$$

  $$E_x = H_x = 0 \text{ and } \frac{\partial E}{\partial y} = \frac{\partial E}{\partial z} = 0$$

- $$\nabla\times E = -\frac{\partial E_z}{\partial x}\vec{y} + \frac{\partial E_y}{\partial x}\vec{z}$$

  (5 M)

  Comparing these two equations,

  $$\frac{\partial H_z}{\partial x}\vec{y} + \frac{\partial H_y}{\partial x}\vec{z} = \varepsilon\left[\frac{\partial E_y}{\partial t}\vec{y} + \frac{\partial E_z}{\partial t}\vec{z}\right] \quad [\because E_x = 0]$$

  Equating $\vec{y}$ and $\vec{z}$ terms

  $$-\frac{\partial H_z}{\partial x} = \varepsilon\frac{\partial E_y}{\partial t}$$

- $$\frac{\partial H_y}{\partial x} = \varepsilon\frac{\partial E_z}{\partial t}$$

	➢ From second Maxwell's equation for free space $$\nabla \times E = -\mu \frac{\partial E}{\partial t}$$ But $$\nabla \times E = -\frac{\partial E_z}{\partial x}\vec{y} + \frac{\partial E_y}{\partial x}\vec{z}$$ (5 M) ➢ Let the solution of this equation is given by $$E_y = f(x - v_0 t)$$ Differentiating $$\frac{\partial E_y}{\partial t} = \frac{\partial f}{\partial (x - v_0 t)} \cdot \frac{\partial (x - v_0 t)}{\partial t} = f'(x - v_0 t)(-v_0)$$ ➢ Simplify $f'(x - v_0 t)$ can be written as f'. $$\frac{\partial E_y}{\partial t} = -v_0 f'$$ But, $$-\frac{\partial H_z}{\partial x} = \varepsilon \frac{\partial E_y}{\partial t}$$ $$\frac{\partial H_z}{\partial x} = -\varepsilon(-v_0 f') = v_0 \varepsilon f'$$ ➢ $$H_z = \sqrt{\frac{\varepsilon}{\mu}} f = \sqrt{\frac{\varepsilon}{\mu}} E_y$$ $$\frac{E_y}{H_z} = \sqrt{\frac{\mu}{\varepsilon}}$$ $$\eta = \frac{E}{H} = \sqrt{\frac{\mu}{\varepsilon}}$$ (5 M)
3	**Define and derive skin depth. Calculate the skin depth for a medium with conductivity 100 mho/m, relative permeability 2, relative permittivity3 at 50 Hz, 1 Mhz and 1GHz. (8 M)** BTL 5 **Answer: Page 5.65 – P. Dananjayan** ➢ $\sigma = 100$ mho/m, $f = 50$ Hz; $\mu_r = 2$, $f = 1$ MHz; $\varepsilon_r = 3$, $f = 1$ GHz ➢ Skin depth $= \delta = \sqrt{\frac{2}{\omega\mu\sigma}}$ (3 M)

$$\text{At } f = 50\text{ Hz}, \quad \delta = \sqrt{\frac{2}{2\pi \times 50 \times 2 \times 100}} = \mathbf{0.564 \times 10^{-2}\ m}$$

$$\text{At } f = 1\text{ MHz}, \quad \delta = \sqrt{\frac{2}{2\pi \times 10^{6} \times 2 \times 100}} = \mathbf{0.4 \times 10^{-4}\ m}$$

$$\text{At } f = 1\text{ GHz}, \quad \delta = \sqrt{\frac{2}{2\pi \times 10^{9} \times 2 \times 100}} = \mathbf{0.126 \times 10^{-5}\ m}$$

(5 M)

4

State and prove poynting theorem. (8 M)(May 2019) BTL 1

Answer: Page 5.38 - P. Dananjayan

- Let us consider Maxwell's Curl Equations:

$$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

$$\nabla \times \vec{H} = \vec{J} + \frac{\partial \vec{D}}{\partial t}$$

- Using vector identity

$$\nabla . \left(\vec{E} \times \vec{H}\right) = \vec{H} . \nabla \times \vec{E} - \vec{E} . \nabla \times \vec{H}$$

- The above curl equations we can write

$$\nabla . \left(\vec{E} \times \vec{H}\right) = -\vec{H} . \frac{\partial \vec{B}}{\partial t} - \vec{E} . \left(\vec{J} + \frac{\partial \vec{D}}{\partial t}\right)$$

$$or,\ \nabla . \left(\vec{E} \times \vec{H}\right) = -\vec{H} . \frac{\partial \vec{B}}{\partial t} - \vec{E} . \vec{J} - \vec{E} . \frac{\partial \vec{D}}{\partial t}$$

$$\vec{H} . \frac{\partial \vec{B}}{\partial t} = \frac{\partial}{\partial t}\left(\frac{1}{2}\mu H^2\right)$$

- $$\vec{E} . \frac{\partial \vec{D}}{\partial t} = \frac{\partial}{\partial t}\left(\frac{1}{2}\mu E^2\right)$$ and

$$\therefore \nabla . \left(\vec{E} \times \vec{H}\right) = -\frac{\partial}{\partial t}\left(\frac{1}{2} \in E^2 + \frac{1}{2}\mu H^2\right) - \sigma E^2$$

- Applying Divergence theorem, we can write

$$\oint_S \left(\vec{E} \times \vec{H}\right) . d\vec{S} = -\frac{\partial}{\partial t}\int_V \left(\frac{1}{2} \in E^2 + \frac{1}{2}\mu H^2\right) dV - \int_V \sigma E^2 dV$$

.........................(6.36) (4 M)

- The term $\frac{\partial}{\partial t}\int_V \left(\frac{1}{2} \in E^2 + \frac{1}{2}\mu H^2\right) dV$ represents the rate of change of energy

	stored in the electric and magnetic fields and the term $\int_V \sigma E^2 dV$ represents the power dissipation within the volume. ➢ Hence right hand side of the equation (6.36) represents the total decrease in power with in the volume under consideration. ➢ The left hand side of equation (6.36) can be written as $\oint_S \left(\vec{E}\times\vec{H}\right).d\vec{S} = \oint_S \vec{P}.d\vec{S}$ ➢ where $\vec{P} = \vec{E}\times\vec{H}$ (W/mt^2)is called the Poynting vector and it represents the power density vector associated with the electromagnetic field. ➢ The integration of the Poynting vector over any closed surface gives the net power flowing out of the surface. ➢ Equation (6.36) is referred to as Poynting theorem and it states that the net power flowing out of a given volume is equal to the time rate of decrease in the energy stored within the volume minus the conduction losses. (4 M)

EC8453 LINEAR INTEGRATED CIRCUITS 3 0 0 3

OBJECTIVES:

- To introduce the basic building blocks of linear integrated circuits
- To learn the linear and non-linear applications of operational amplifiers
- To introduce the theory and applications of analog multipliers and PLL
- To learn the theory of ADC and DAC
- To introduce the concepts of waveform generation and introduce some special function ICs

UNIT I BASICS OF OPERATIONAL AMPLIFIERS 9

Current mirror and current sources, Current sources as active loads, Voltage sources, Voltage References, BJT Differential amplifier with active loads, Basic information about op-amps – Ideal Operational Amplifier - General operational amplifier stages -and internal circuit diagrams of IC 741, DC and AC performance characteristics, slew rate, Open and closed loop configurations – JFET Operational Amplifiers – LF155 and TL082.

UNIT II APPLICATIONS OF OPERATIONAL AMPLIFIERS 9

Sign Changer, Scale Changer, Phase Shift Circuits, Voltage Follower, V-to-I and I-to-V converters, adder, subtractor, Instrumentation amplifier, Integrator, Differentiator, Logarithmic amplifier,Antilogarithmic amplifier, Comparators, Schmitt trigger, Precision rectifier, peak detector, clipper and clamper, Low-pass, high-pass and band-pass Butterworth filters.

UNIT III ANALOG MULTIPLIER AND PLL 9

Analog Multiplier using Emitter Coupled Transistor Pair - Gilbert Multiplier cell – Variable transconductance technique, analog multiplier ICs and their applications, Operation of the basic PLL, Closed loop analysis, Voltage controlled oscillator, Monolithic PLL IC 565, application of PLLfor AM detection, FM detection, FSK modulation and demodulation and Frequency synthesizing and clock synchronisation.

UNIT IV ANALOG TO DIGITAL AND DIGITAL TO ANALOG CONVERTERS 9

Analog and Digital Data Conversions, D/A converter – specifications - weighted resistor type, R-2R Ladder type, Voltage Mode and Current-Mode *R - 2R* Ladder types - switches for D/A converters, high speed sample-and-hold circuits, A/D Converters – specifications - Flash type - Successive Approximation type - Single Slope type – Dual Slope type - A/D Converter using Voltage-to-Time Conversion - Over-sampling A/D Converters, Sigma – Delta converters.

UNIT V WAVEFORM GENERATORS AND SPECIAL FUNCTION ICS 9

Sine-wave generators, Multivibrators and Triangular wave generator, Saw-tooth wave generator, ICL8038 function generator, Timer IC 555, IC Voltage regulators – Three terminal fixed and adjustable voltage regulators - IC 723 general purpose regulator - Monolithic switching regulator, Low Drop – Out(LDO) Regulators - Switched capacitor filter IC MF10, Frequency to Voltage and Voltage to Frequency converters, Audio Power amplifier, Video Amplifier, Isolation Amplifier, Opto- couplers and fibre optic IC.

TOTAL:45 PERIODS

OUTCOMES:

Upon completion of the course, the student should be able to:

- Design linear and non linear applications of OP – AMPS
- Design applications using analog multiplier and PLL
- Design ADC and DAC using OP – AMPS
- Generate waveforms using OP – AMP Circuits
- Analyze special function ICs.

TEXT BOOKS:

1. D.Roy Choudhry, Shail Jain, -Linear Integrated Circuits‖, New Age International Pvt. Ltd., 2018, Fifth Edition. (Unit I – V)
2. Sergio Franco, -Design with Operational Amplifiers and Analog Integrated Circuits‖, 4th Edition, Tata Mc Graw-Hill, 2016 (Unit I – V)

REFERENCES:

Ramakant A. Gayakwad, -OP-AMP and Linear ICs‖, 4th Edition, Prentice Hall / Pearson Education, 2015.

Robert F.Coughlin, Frederick F.Driscoll, -Operational Amplifiers and Linear Integrated Circuits‖, Sixth Edition, PHI, 2001.

B.S.Sonde, -System design using Integrated Circuits‖ , 2nd Edition, New Age Pub, 2001.

Gray and Meyer, -Analysis and Design of Analog Integrated Circuits‖, Wiley International,5th Edition, 2009.

William D.Stanley, -Operational Amplifiers with Linear Integrated Circuits‖, Pearson Education,4th Edition,2001.

S.Salivahanan & V.S. Kanchana Bhaskaran, -Linear Integrated Circuits‖, TMH,2nd Edition, 4th Reprint, 2016.

REGULATION: 2017 **ACADEMIC YEAR: 2019 - 2020**

Subject Code:EC8453 **Year/Semester: II /04**

Subject Name: LINEAR INTEGRATED CIRCUITS **Subject Handler: W.Nancy**

UNIT I - BASICS OF OPERATIONAL AMPLIFIERS

Current mirror and current sources, Current sources as active loads, Voltage sources, Voltage References, BJT Differential amplifier with active loads, Basic information about op-amps – Ideal Operational Amplifier - General operational amplifier stages -and internal circuit diagrams of IC 741, DC and AC performance characteristics, slew rate, Open and closed loop configurations – JFET Operational Amplifiers – LF155 and TL082.

PART * A

Q.No.	Questions
1.	**Define an Integrated circuit.** BTL1 An integrated circuit(IC) is a miniature, low cost electronic circuit consisting of active and passive components fabricated together on a single crystal of silicon. The active components are transistors and diodes and passive components are resistors and capacitors.
2	**What are the basic processes involved in fabricating ICs using planar technology?** BTL1 • Silicon wafer (substrate) preparation • Epitaxial growth • Oxidation • Photolithography • Diffusion • Ion Implantation • Isolation technique Metallization • Assembly processing & packaging
3	**List out the steps used in the preparation of Si – wafers**. BTL1 • Crystal growth &doping • Ingot trimming grinding • Ingot slicing • Wafer policing etching • Wafer cleaning
4	**Define virtual ground of OP-Amp.** BTL1 A virtual ground is a ground which acts like a ground. It is a point that is at the fixed ground potential (0v), though it is not practically connected to the actual ground or common terminal of the circuit.
5	**What are the advantages and limitations of ion implantation?** BTL1 **Advantages:** • Accurate control over doping • Very good reproducibility • Precise resistance value • A room temperature process **Limitations:**

	• Annealing at higher temperature is required for avoiding the crystal damage • The possibility of doping implanting through various layers of wafer.
6	**Why IC 741 is not used for high frequency applications?** BTL2 IC741 has a low slew rate because of the predominance of capacitance present in the circuit at higher frequencies. As frequency increases the output gets distorted due to limited slew rate.
7	**In practical op-amps, what is the effect of high frequency on its performance?** BTL2 The open-loop gain of op-amp decreases at higher frequencies due to the presence of parasitic capacitance. The closed-loop gain increases at higher frequencies and leads to instability.
8	**Define input offset voltage**. BTL1 A small voltage applied to the input terminals to make the output voltage as zero when the two input terminals are grounded is called input offset voltage.
9	**Define input offset current. State the reasons for the offset currents at the input of the op-amp**. BTL1 The difference between the bias currents at the input terminals of the op-amp is called as input offset current. The input terminals conduct a small value of dc current to bias the input transistors. Since the input transistors cannot be made identical, there exists a difference in bias currents.
10	**Define sensitivity**. BTL1 Sensitivity is defined as the percentage or fractional change in output current per percentage or fractional change in power-supply voltage.
11	**What are the limitations in a temperature compensated zener-reference source**? BTL2 A power supply voltage of at least 7 to 10 V is required to place the diode in the breakdown region and that substantial noise is introduced in the circuit by the avalanching diode.
12	**Define CMRR of an op-amp. (DEC 09)** BTL1 The relative sensitivity of an op-amp to a difference signal as compared to a common –mode signal is called the common –mode rejection ratio. It is expressed in decibels. CMRR= Ad/Ac
13	**What are the applications of current sources?** BTL1 Transistor current sources are widely used in analog ICs both as biasing elements and as load devices for amplifier stages.
14	**Justify the reasons for using current sources in integrated circuits.** BTL4 • Superior insensitivity of circuit performance to power supply variations and temperature. • More economical than resistors in terms of die area required providing bias currents of small value. • When used as load element, the high incremental resistances of current source results in high voltage gain at low supply voltages.
15	**What is the advantage of widlar current source over constant current source?** BTL1 Using constant current source output current of small magnitude (micro amp range) is not attain able due to the limitations in chip area. Widlar current source is useful for obtaining small output currents. Sensitivity of widlar current source is less compared to constant current source.
16	**Mention the advantages of Wilson current source.** BTL1 • Provides high output resistance. • Offers low sensitivity to transistor base currents.

17	**Mention the advantages of integrated circuits over discrete components. (May2010)** BTL1 • Miniaturization and hence increased equipment density. • Cost reduction due to batch processing. • Increased system reliability due to the elimination of soldered joints. • Improved functional performance. • Matched devices. • Increased operating speeds. • Reduction in power consumption.
18	**Define sheet resistance. (May 2010)** BTL1 Sheet resistance is defined as the resistance in ohms /square offered by the diffused area.
19	**What is the use of buried n+ layer in monolithic IC transistor? (MAY 2010)** BTL1 The buried n+ layer provides a low resistance path in the active collector region for the flow of current.
20	**What is active load? Where it is used and why? (MAY/JUNE 2010)** BTL1 The active load realized using current source in place of the passive load in the collector arm of differential amplifier makes it possible to achieve high voltage gain without requiring large power supply voltage.
21	**Why open loop OP-AMP configurations are not used in linear applications? (May/June 2010)** BTL2 The open loop gain of the op-amp is not a constant and it varies with changing the temperature and variations in power supply. Also the bandwidth of the open loop op-amp is negligibly small. For this reasons open loop OP-AMP configurations are not used in linear applications.
22	**What are the two common methods for obtaining integrated capacitors? (May 2010)** BTL2 • Monolithic junction capacitor • Thin-film capacitor
23	**Define slew rate. (MAY 2010)** BTL1 The slew rate is defined as the maximum rate of change of output Voltage caused by a step input voltage. An ideal slew rate is infinite which means that op- amp's output voltage should change instantaneously in response to input step voltage.
24	**What causes slew rate? (DEC 09)** BTL1 There is a capacitor with-in or outside of an op-amp to prevent oscillation. The capacitor which prevents the output voltage from responding immediately to a fast changing input.
25	**What happens when the common terminal of V+ and V- sources is not grounded? (DEC 09)** BTL1 If the common point of the two supplies is not grounded, twice the supply voltage will get applied and it may damage the op-amp.
	PART * B
1	**Describe the AC performance characteristics of an operational amplifier. (8M)** BTL2 **Answer: page 112 – 115 LIC D. Roy Choudhury** Frequency Response (2M) Infinite Bandwidth at ideal condition. At higher frequencies practical op-amp gain rolls off. High frequency op-amp circuit figure 1.18 (2M)

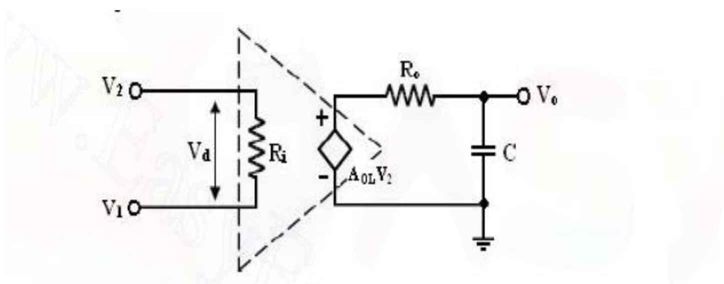
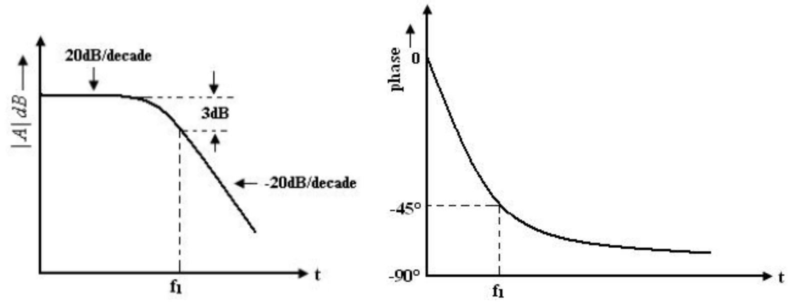


Fig 1.18 Equivalent circuit of practical circuit

Magnitude characteristics (2M)
Phase Characteristics (2M)

The magnitude and phase angle characteristics:

1. For frequency f<< f_1 the magnitude of the gain is 20 log A_{OL} in db.
2. At frequency f = f_1 the gain in 3 dB down from the dc value of A_{OL} in db. This frequency f_1 is called corner frequency.
3. For f>> f_1 the fain roll-off at the rate off -20dB/decade or -6dB/decade.



2

What is slew rate? Discuss the methods of improving slew rate. (10M) (Nov/Dec 2008), (May/June 2009), (Nov/Dec 2009) BTL2

Answer: page 123 – 125 LIC D. Roy Choudhury

- Slew rate limits Op-amp speed
- Capacitor prevents output voltage from responding immediately. (2M)
  $\frac{dV_C}{dt} = \frac{I}{C}$ (3M)
- Maximum rate of change of output voltage
- Slew rate = 0.5 $v/10^{-6}s$ (2M)
- SR = 2fVm $v/10^{-6}s$ (3M)
  $f_{max}\,(Hz) = \frac{slew\ rate}{6.28XV_m} X\ 10^6$

3

a**) What is an active load? Explain differential amplifier with active load. (6M) (May/June 2009)**

b) **Explain pole-zero compensation (7M) (Nov/Dec 2008)** (BTL2)

Answer: page 77 – 78, 120 – 122 LIC D. Roy Choudhury

- Differential amplifier with active load (4M)
- Circuit behaves as a transconductance amplifier.
- Gain proportional to load resistor Rc.
- Two limitations to increase Rc.
- Requires large chip area

	• Quiescent drop across it increases. • $I_L = I_1 - I_2 = g_m(V_1 - V_2) = g_m V_d$ (2M) **Pole zero compensation** (4M) • Transfer function A alters • Add both pole and a zero • Zero at higher frequency than pole • $Z_1 = R_1$ *and* $Z_2 = R_2 + 1/(j\omega C2)$ (2M) • $A' = \frac{V_0}{V_I} = \frac{V_0}{V_2} \cdot \frac{V_2}{V_i}$ (1M)
4	**Describe the DC performance characteristics of operational amplifier. (13M) (Nov/Dec 2014)** BTL 2 **Answer: page 104 – 111 LIC D. Roy Choudhury** • Input Bias current (3M) $I_B = \frac{I_B^+ + I_B^-}{2}$ Input Offset Voltage (3M) $V_O = (1 + \frac{R_f}{R_1})V_{ios}$ Input Offset current (3M) $I_{os} = I_B^+ - I_B^-$ $V_o = R_f I_{os}$ Thermal drift (4M) Bias current, offset current, offset voltage change with temperature. Current drift expressed $nA/°C$ Voltage drift expressed $mV/°C$ Careful PCB, forced air cooling – reduce thermal drift
5	**Explain the working of Widlar current source.(8M)(Nov/Dec 2008)(Nov/Dec 2009)** BTL2 **Answer: page 68 – 69 LIC D. Roy Choudhury** • limitation of basic current mirror – not suitable for low value current source (2M) • R1 required high – impossible to fabricate in IC • Widlar current source suitable for low value of currents (2M) • Circuit differs only in resistance Re in Q2 • Current Io smaller than Ic1 • Due to Re base emitter voltage Vbe2 <<< Vbe1 (2M) • Basic current mirror circuit, $I_0 = I_{ref}$ $I_{ref} = \frac{V_{cc}}{R_1}$ (2M)
6	**Discuss the frequency compensation in operational amplifier. (13M) (May/June 2009)** BTL2 **Answer: page 119 – 122 LIC D. Roy Choudhury** • Dominant pole compensation • External frequency compensation method (1M) $A' = \frac{V_o}{V_i}$ (2M) $f_d = \frac{1}{2\pi RC}$ (2M) • $f_d < f_1 < f_2 < f_3$ (2M) • Pole zero compensation • External frequency compensation method (1M)

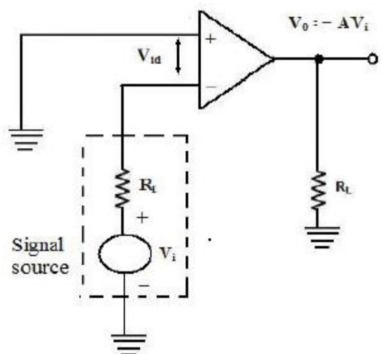
- Transfer function A alters
- Add both pole and a zero (1M)
- Zero at higher frequency than pole (1M)
- $Z_1 = R_1 \; and \; Z_2 = R_2 + 1/jwc_2$ (2M)
- A' $= \frac{V_0}{V_I} = \frac{V_0}{V_2} \cdot \frac{V_2}{V_i}$ (1M)

7

Draw the inverting and non-inverting amplifier circuits of an op-amp in closed loop configuration. Obtain the expressions for the closed loop gain in these circuits. (10M) (Nov/Dec 2017) BTL2

Answer: page 43 – 48 LIC D. Roy Choudhury

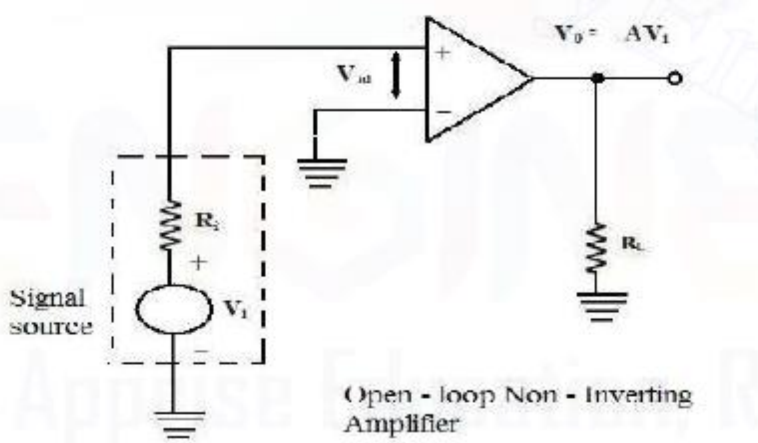
Inverting amplifier (5M)



Open - loop Inverting Amplifier

$A_{CL} = \frac{Vo}{Vi} = -\frac{R_f}{R_1}$ where, A = closed loop gain

Non – Inverting amplifier (5M)



Open - loop Non - Inverting Amplifier

$A_{CL} = \frac{Vo}{Vi} = 1 + \frac{R_f}{R_1}$ where A = closed loop gain

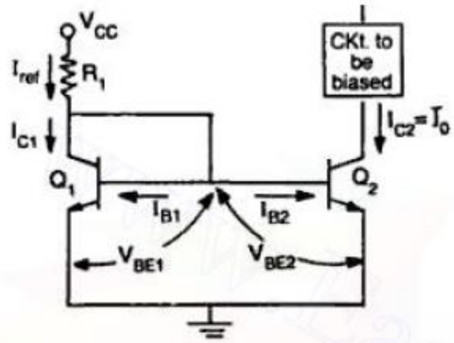
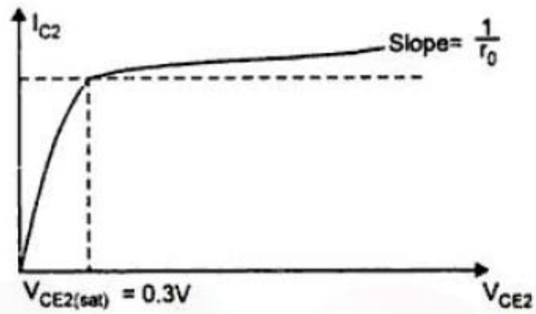
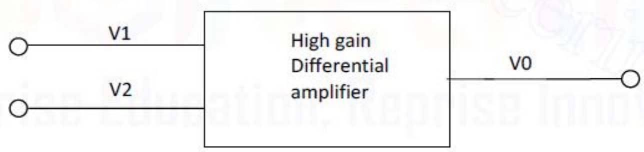
8

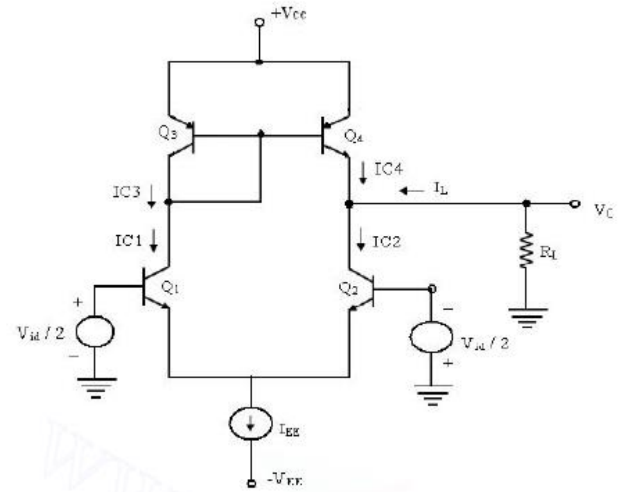
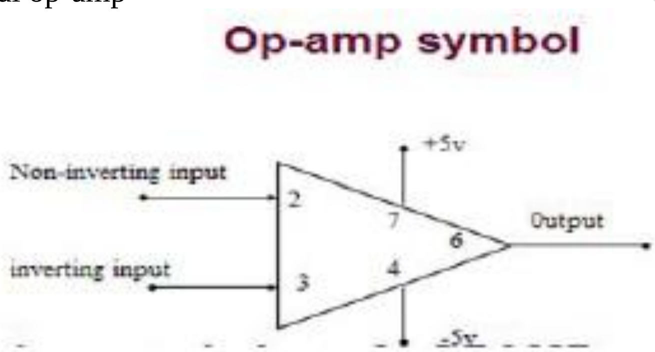
What is a current mirror? Give the current mirror circuit analysis. (8M) (Nov/Dec 2009) BTL2

Answer: page 65 – 67 LIC D. Roy Choudhury

Basic current mirror circuit figure 1.1

Output current characteristics figure 1.2 (6M)

	  **Fig. 1.1 Current mirror circuit** **Fig 1.2 Current source output current characteristics** Collector current independent of collector voltage Bases and emitter of Q1,Q2 tied together. $I_0 = I_{ref}$ (2M)
	PART *C
1	**Discuss about the principle of operation differential amplifier using BJT.(15M) (Apr/May 2018)** (BTL 2) **Answer: page 53 – 61 LIC D. Roy Choudhury** Basic differential amplifier using BJT figure 1.12 (6M)  **Fig. 1.12 Block diagram of Differential amplifier** Types of operation Common mode and Differential mode operation (9M) Current mirror with active load figure 1.13

	 **Fig. 1.13 BJT differential amplifier with current mirror active load**
2	**Explain about Ideal Op-amp in detail with suitable diagrams.(15M) (Apr/May 2018)** BTL 2 **Answer: page 41 – 48 LIC D. Roy Choudhury** Ideal op-amp (6M)  Ideal characteristics (1M) Open loop voltage gain A=∞ (2M) Input impedance Ri = ∞ (2M) Output impedance Ro = 0 (2M) Bandwidth BW = ∞ (1M) Zero offset V0 = 0, when V1=0, V2=0 Vd = V1 – V2 (1M)
3	**With a help of a diagram, explain the various stages present in an operational amplifier. (15M) (Nov/Dec 2017)** (BTL 2) **Answer: page 41 – 48 LIC D. Roy Choudhury** • Differential amplifier (1M) • Level translator (1M) • Gain Stage (3M) • Output stage, input stage (2M) • Bias Circuit (3M) • Diagram figure 1.17 (5M)

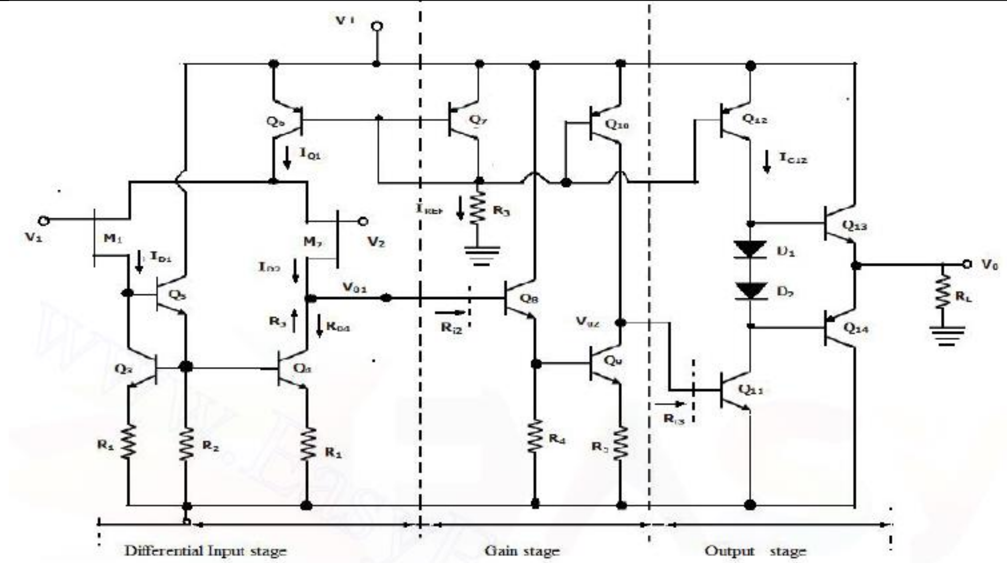


Fig. 1.17 Internal stages of Op-amp

Subject Code:EC8453 **Year/Semester: II /04**
Subject Name: LINEAR INTEGRATED CIRCUITS **Subject Handler: W.Nancy**

UNIT II - APPLICATIONS OF OPERATIONAL AMPLIFIERS	
Sign Changer, Scale Changer, Phase Shift Circuits, Voltage Follower, V-to-I and I-to-V converters, adder, subtractor, Instrumentation amplifier, Integrator, Differentiator, Logarithmic amplifier,Antilogarithmic amplifier, Comparators, Schmitt trigger, Precision rectifier, peak detector, clipper and clamper, Low-pass, high-pass and band-pass Butterworth filters.	
PART * A	
Q.No.	**Questions**
1.	**Mention some of the linear applications of op – amps. (DEC 09)** BTL 2 • Adder, sub tractor, • Voltage –to current converter, • current –to- voltage converters, • Instrumentation amplifier, • Analog computation • power amplifier
2	**Mention some of the non – linear applications of op-amps.** BTL 2 • Rectifier, peak detector, • clipper, clamper, • sample and hold circuit, • log amplifier, anti –log amplifier
3	**What are the areas of application of non-linear op- amp circuits?** BTL 1 • Industrial instrumentation • Communication • Signal processing
4	**What is voltage follower?(MAY 2010)** BTL 1 A circuit in which output follows the input is called voltage follower.
5	**What is the need for an instrumentation amplifier?** BTL 1 In a number of industrial and consumer applications, the measurement of physical quantities is usually done with the help of transducers. The output of transducer has to be amplified So that it can drive the indicator or display system. This function is performed by an instrumentation amplifier.
6	**List the features of instrumentation amplifier.** BTL 1 • High gain accuracy • High CMRR • High gain stability with low temperature co-efficient 4 low DC offset • Low output impedance
7	**What are the applications of V-I converter?** BTL 1 • Low voltage dc and ac voltmeter • LED • Zener diode tester
8	**Define Band pass filter. (MAY 2010)** BTL 1 The band pass filter is the combination of high and low pass filters, and this allows a specified

	range of frequencies to pass through.
9	**Write transfer function of op amp as an integer. (MAY 2010)** BTL 1 The transfer function of the integer is $\vert A \vert$ =1/ωR1cf
10	**What do you mean by a precision diode?** BTL 1 The major limitation of ordinary diode is that it cannot rectify voltages below the cut – in voltage of the diode. A circuit designed by placing a diode in the feedback loop of an op – amp is called the precision diode and it is capable of rectifying input signals of the order of milli volt.
11	**Write down the applications of precision diode.** BTL 1 • Half - wave rectifier • Full - Wave rectifier • Peak – value detector • Clipper • Clamper
12	**Define Logarithmic and antilogarithmic amplifier. (MAY 2010)** BTL 1 When a logarithmic PN junction is used in the feedback network of op-amp, the circuit exhibits log or antilog response. The logarithmic amplifier is a current to voltage converter with the transfer characteristics v0=vi In(If/Ii). Antilog amplifier is a decoding circuit which converts the logarithmically encoded signal back to the original signal levels as given by v_1=vR10-kvi.
13	**Differentiate Schmitt trigger and comparator.** BTL 4 • It compares the input signal with references voltage then yields the output voltage • It need not consist of feedback • comparator output need not to be square wave
14	**List the applications of Log amplifiers.** BTL 1 • Analog computation may require functions such as lnx, log x, sin hx etc. These functions can be performed by log amplifiers • Log amplifier can perform direct dB display on digital voltmeter and spectrum analyzer • Log amplifier can be used to compress the dynamic range of a signal
15	**What are the limitations of the basic differentiator circuit?** BTL 1 • At high frequency, a differentiator may become unstable and break into oscillations • The input impedance decreases with increase in frequency , thereby 0making the circuit sensitive to high frequency noise.
16	**Write down the condition for good differentiation.** BTL 1 • For good differentiation, the time period of the input signal must be greater than or equal to Rf C1 • T > R f C1 Where, Rf is the feedback resistance • Cf is the input capacitance
17	**What is a comparator? (MAY 2010)** BTL 1 A comparator is a circuit which compares a signal voltage applied at one input of an op amp with a known reference voltage at the other input. It is an open loop op - amp with output + Vsat.
18	**What are the applications of comparator?** BTL 1 • Zero crossing detectors • Window detector

	• Time marker generator • Phase detector
19	**What is a Schmitt trigger? (DEC 09,MAY 10)** BTL 1 Schmitt trigger is a regenerative comparator. It converts sinusoidal input into a square wave output. The output of Schmitt trigger swings between upper and lower threshold voltages, which are the reference voltages of the input waveform.
20	**What is a multivibrator?** BTL 1 Multi vibrators are a group of regenerative circuits that are used extensively in timing applications. It is a wave shaping circuit which gives symmetric or asymmetric square output. It has two states stable or quasi- stable depending on the type of multivibrator**.**
21	**What do you mean by monostable multivibrator?** BTL 1 • Monostable multivibrator is one which generates a single pulse of specified duration in response to each external trigger signal. It has only one stable state. • Application of a trigger causes a change to the quasi-stable state. • An external trigger signal generated due to charging and discharging of the capacitor produces the transition to the original stable state.
22	**What is an astable multivibrator?** BTL 1 Astable multivibrator is a free running oscillator having two quasi-stable states. Thus, there are oscillations between these two states and no external signal are required to produce the change in state.
23	**What are the characteristics of a comparator?** BTL 1 • Speed of operation • Accuracy • Compatibility of the output
24	**What is a filter?** BTL 1 Filter is a frequency selective circuit that passes signal of specified band of frequencies and attenuates the signals of frequencies outside the band.
25	**What are the demerits of passive filters?** BTL 1 Passive filters works well for high frequencies. But at audio frequencies, the inductors become problematic, as they become large, heavy and expensive. For low frequency applications, more number of turns of wire must be used which in turn adds to the series resistance degrading inductor's performance ie, low Q, resulting in high power dissipation.
	PART * B
1	**With neat sketch explain the operation of a 3 op-amp instrumentation amplifier. (13M) (Nov/Dec 2014)** BTL 1 **Answer: page 141 – 144 LIC D.Roy Choudhury** • High gain accuracy (1M) • High CMRR (1M) • High gain stability with low temperature coefficient (1M) • Low dc offset (1M) • Low output impedance (1M) • $V_0 = \frac{R_2}{R_1}(V_1 - V_2)$ (2M) Instrumentation Amplifier figure 2.18, 2.19 (6M)

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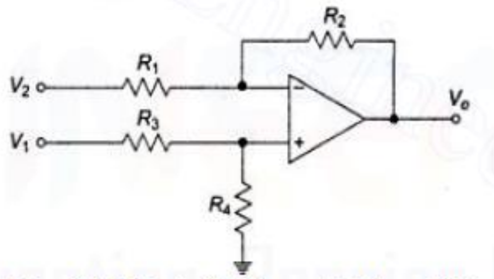

Fig. 2.18 Basic Differential Amplifier

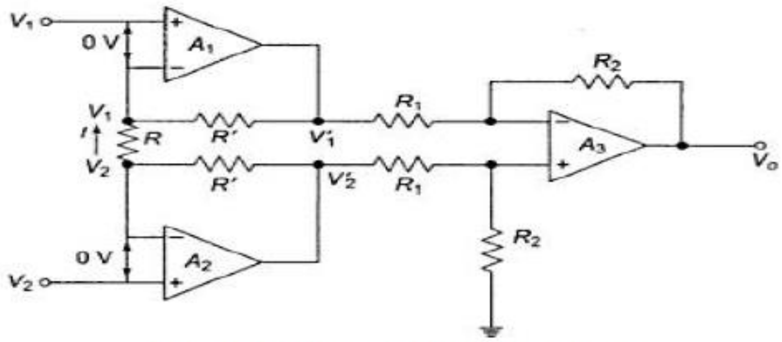

Fig. 2.19 Instrumentation Amplifier
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With neat diagram explain logarithmic amplifier and antilogarithmic amplifier. (13M) (May/ June 2014) BTL1
Answer: page 155 – 159 LIC D.Roy Choudhury
Direct DB display on digital voltmeter, spectrum analyzer. (2M)
Compress dynamic range of signal. (1M)
Diagram: (5M)

2.11 Log and Antilog Amplifier:

Log Amplifier:

$$V_o = V_i ln\left(I_f / I_i\right)$$

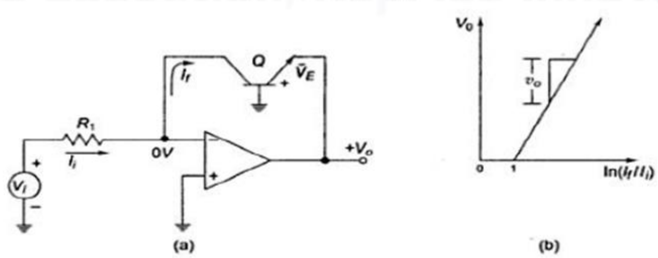

Fig 2.28 Fundamental log-amp Circuit and its characteristics

$$V_o = -\frac{kT}{q} ln\left(\frac{V_i}{R_1 I_S}\right) = -\frac{kT}{q} ln\left(\frac{V_i}{V_R}\right)$$

Anti – log Amplifier: (5M)
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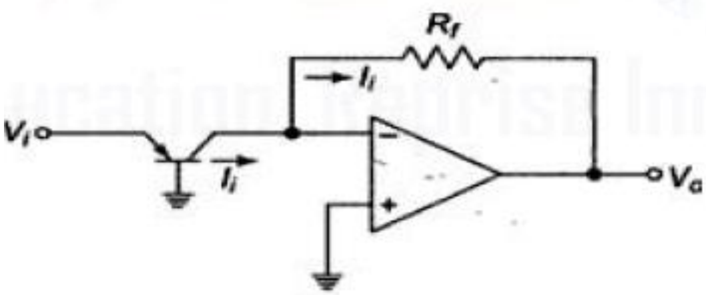


$I_i = I_c = I_s(e^{\frac{\eta V_{BE}}{kT}})$ and $V_0 = R_f\, I_s(e^{\frac{\eta V_{BE}}{kT}})$

3 **With neat diagram explain the application of op-amp as precision rectifier, clipper and clamper. (13M) (May/ June 2014)** BTL2

Answer: page 148 – 153 LIC D.Roy Choudhury

Typical applications of precision diode

Half wave rectifier and waveform figure 2.41 (3M)

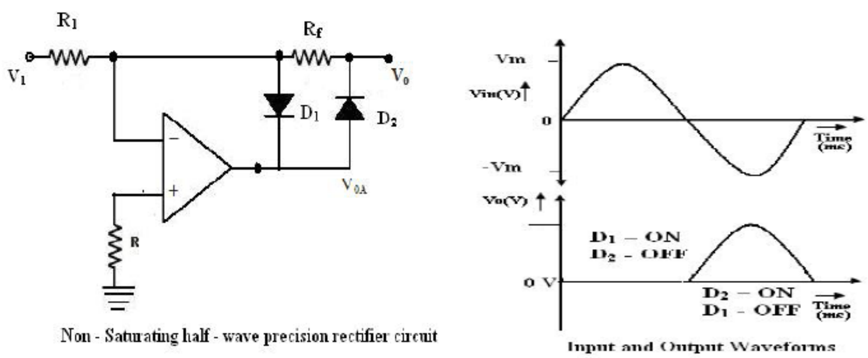


Fig. 2.41 Half wave rectifier and its operation

The circuit operation can mathematically be expressed as

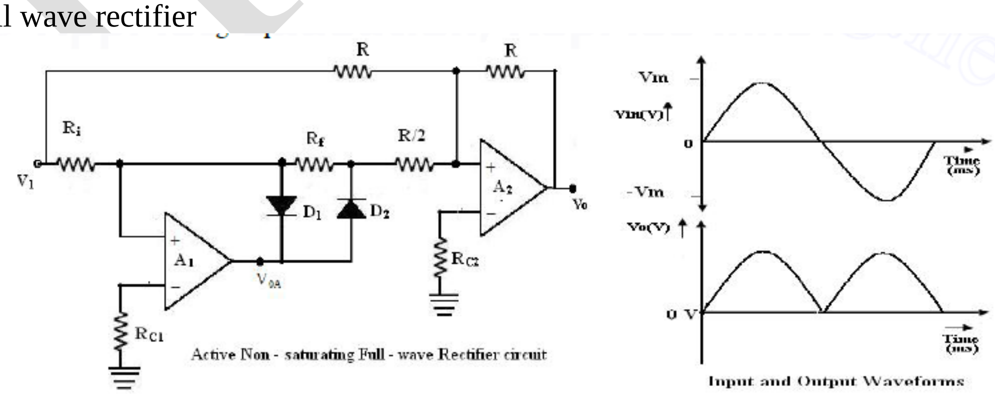
$V_0 = 0$ when $V_i > 0$ and

$V_0 = R_f/R_i V_1$ for $V_i < 0$

The voltage V_{OA} at the op amp output is $V_{OA} = -0.7V$ for $V_i > 0$

$V_{OA} = R_f/R_i V_1 + 0.7V$ for $V_{i<0}$

Full wave rectifier (3M)



Clipper and waveform figure 2.44,2.45 (7M)

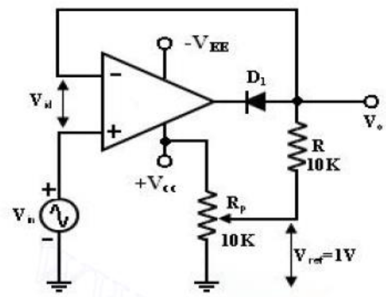


Fig. 2.44 Positive Clipper

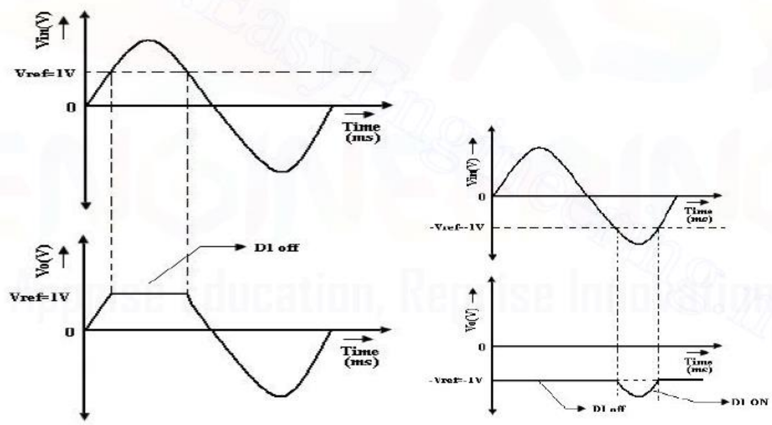


Fig 2.45 Positive clipper input output waveforms

Clamper and waveform figure 2.48,2.49

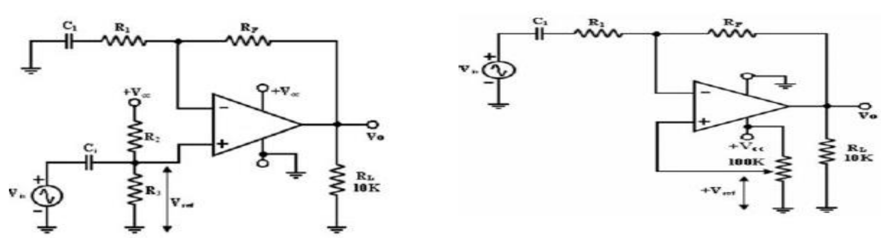


Fig.2.48 Positive –Negative campers

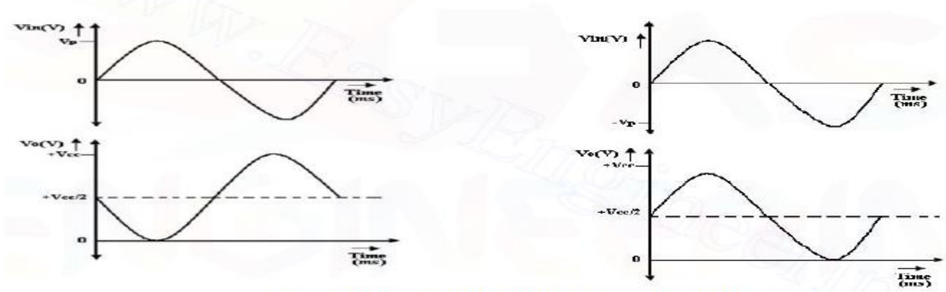
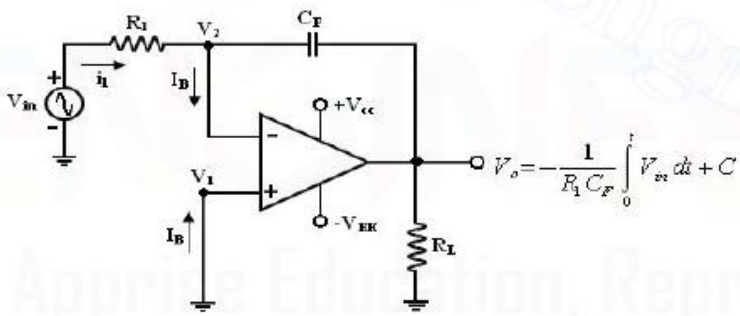
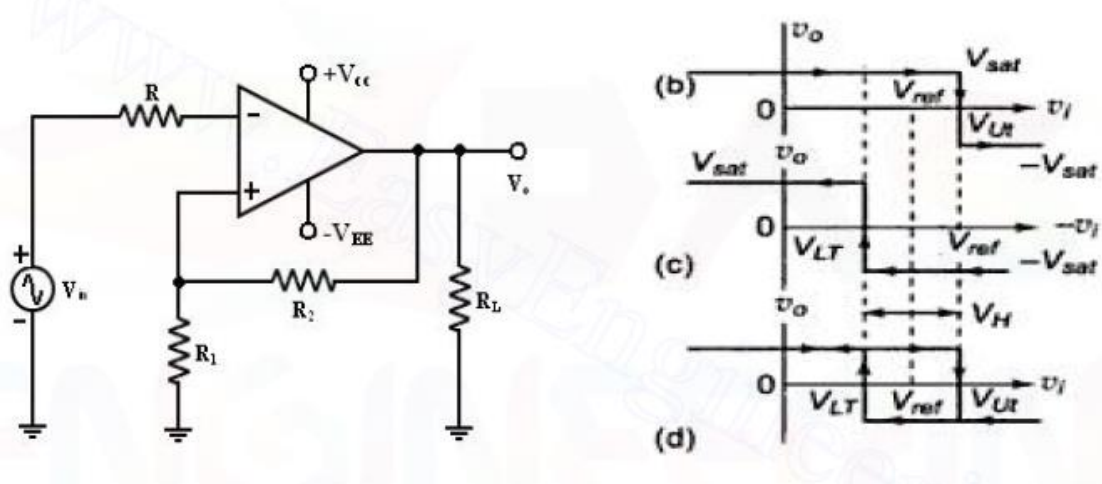
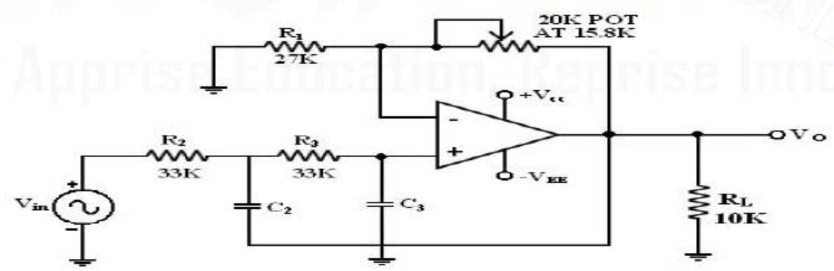
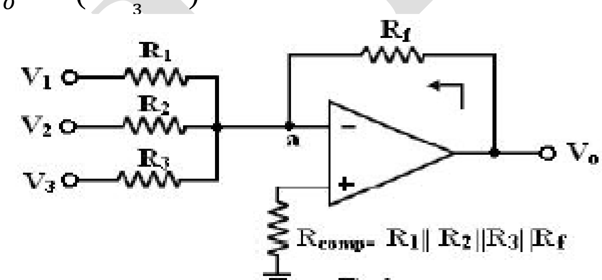


Fig.2.49 Input and output waveform with +Vref

4	**What is an active integrator? Explain the working of an active integrator. (8M) (Nov/Dec 2009)** BTL2 **Answer: page 168 – 171 LIC D.Roy Choudhury**

	Integrator – simple low pass RC circuit (1M) Inverting integrator (1M) $A = \frac{1}{wR_1C_f}$ (1M) Integrator circuit figure 2.21 (5M)  **Fig 2.21 Integrator Circuit** $i_1 = I_B + i_f$ Since I_B is negligible small, $i_1 = i_F$
5	**With a neat circuit diagram explain the working of op-amp based Schmitt trigger. (8M) (Nov/Dec 2009)** BTL2 **Answer: page 212 – 214 LIC D.Roy Choudhury** $V_{UT} = \frac{V_{ref}R_1}{R_1+R_2} + \frac{R_2V_{sat}}{R_1R_2}$ (1M) $V_{UT} = \frac{V_{ref}R_1}{R_1+R_2} - \frac{R_2V_{sat}}{R_1R_2}$ (1M) $V_H = V_{UT} - V_{LT}$ (2M) $V_H = \frac{2R_2V_{sat}}{R_1+R_2}$ Schmitt trigger figure 2.38 (4M)  **Fig.2.38 Schmitt Trigger circuit and hysteresis phenomenon**

6	**Design an op-amp based second order active low pass filter with cut off frequency 2KHz. (8M) (Nov/Dec 2011)** BTL3 **Answer: page 265 – 268 LIC D.Roy Choudhury** $V_o = A_o V_B$ (1M) V_B voltage at node B Step response, dampening coefficient, cause its effects Low pass filter figure 2.55 (3M)  **Fig. 2.55 second order LP Butterworth filter** Design: (4M) • Choose a value for a high cut off freq. (fHz). • To simplify the design calculations, set R2 = R3 = R and C2 = C3 = C then choose a value of C<=1µf. • Calculate the value of R R =1/2πfhC • Finally, because of the equal resistor (R2 = R3) and capacitor (C2 = C3) values, the pass band volt gain AF = 1 + RF / R1 of the second order had to be = to 1.586. RF = 0.586 R1. • Hence choose a value of R1 <=100kΩ. • Calculate the value of RF.
7	**Write in detail about summing amplifier. (8M)** BTL2 **Answer: page 135 – 137 LIC D.Roy Choudhury** **Inverting summing amplifier figure 2.13** (4M) V_o = - $(\frac{V1+V2+V3}{3})$  **Fig. 2.13 inverting summer** **Non inverting summing amplifier figure 2.14** (4M) $V_o = (1 + \frac{Rf}{R})V_a$

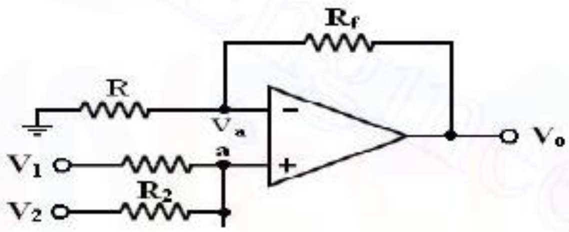


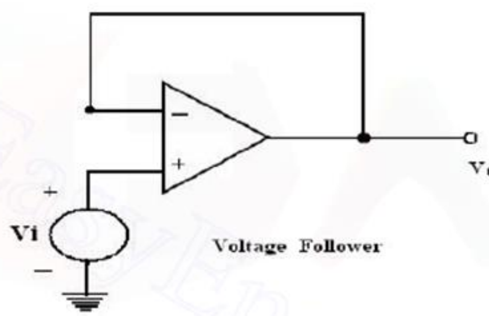
Fig.2.14 Non inverting summer

8

Explain voltage follower with neat sketch. (8M) BTL2

Answer: page 49 – 50 LIC D.Roy Choudhury

Rf = 0, R1 = ∞ (1M)
Non inverting amplifier (1M)
Output voltage follows input voltage (1M)
Buffer for impedance matching (1M)
Connect a high impedance source to a low impedance load (1M)
Diagram : (3M)



PART *C

1

Sketch the basic circuit using op-amp to perform the mathematical operation of differentiation and explain. What are the limitations of an ordinary op-amp differentiator? Draw and explain the circuit of a practical differentiator that will eliminate these limitations. (15M) (May/June 2012) BTL3**.**

Answer: page 164 – 170 LIC D.Roy Choudhury

Differentiator circuit and waveform figure 2.24,2.25 (7M)
Contains capacitor at input

$V_o = -R_f C_1 \frac{dv_i}{dt}$

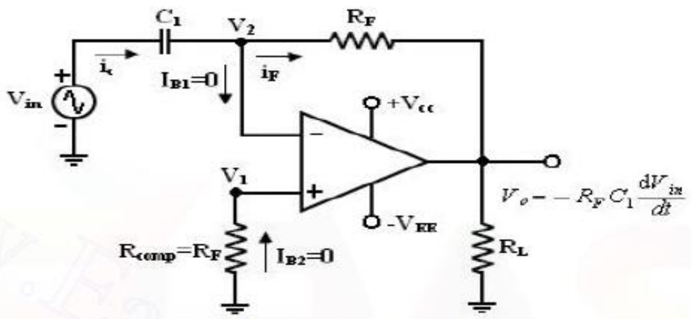


Fig 2.24 Basic Differentiator

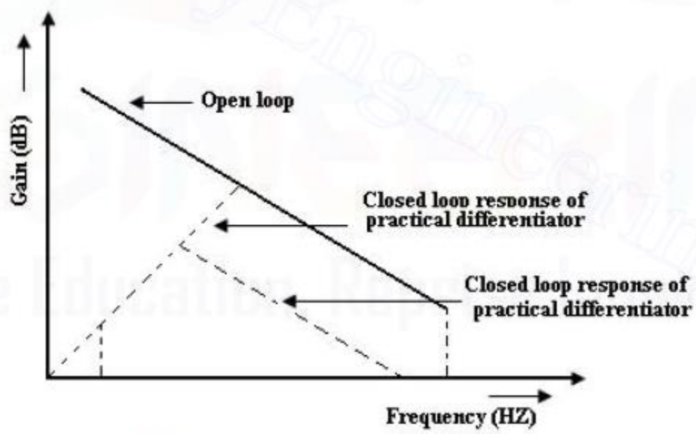


Fig. 2.25 Frequency response of differentiator

Integrator circuit figure 2.21 (8M)

Integrator – simple low pass RC circuit

Inverting integrator

$A = \frac{1}{wR_1C_f}$

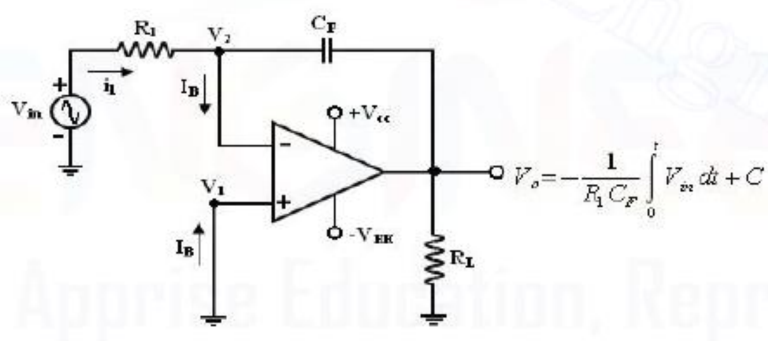


Fig 2.21 Integrator Circuit

$$i_1 = I_B + i_f$$

Since I_B is negligible small, $i_1 = i_F$

2 **a) Explain the working of an op-amp based regenerative comparator circuit? (8M) (May/June 2012), (Nov/Dec 2011).**

b) Design an op-amp based second order active low pass filter with cut off frequency 2KHz. (7M) BTL3

Answer: page 212 – 215,265 - 267 LIC D.Roy Choudhury

$V_{UT} = \frac{V_{ref}R_1}{R_1+R_2} + \frac{R_2V_{sat}}{R_1R_2}$ (1M)

$V_{LT} = \frac{V_{ref}R_1}{R_1+R_2} - \frac{R_2V_{sat}}{R_1R_2}$ (1M)

$V_H = V_{UT} - V_{LT}$ (1M)

$V_H = \frac{2R_2V_{sat}}{R_1+R_2}$ (1M)

Schmitt trigger figure 2.38 (4M)

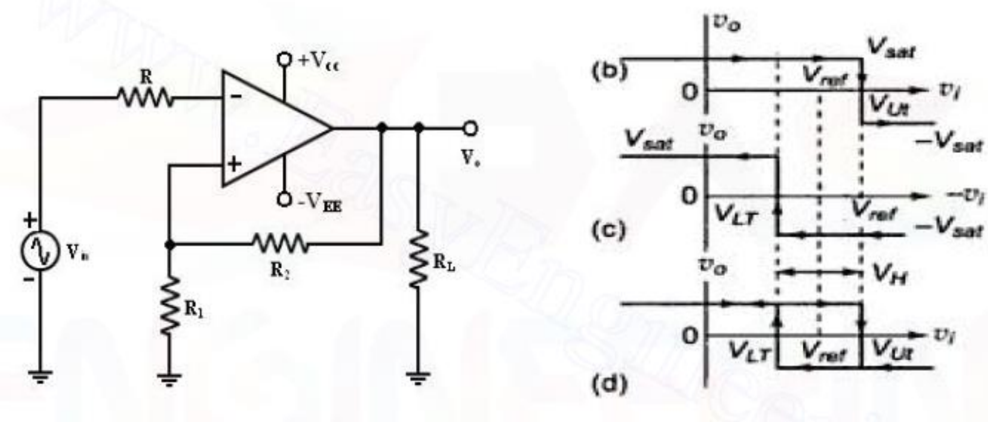


Fig.2.38 Schmitt Trigger circuit and hysteresis phenomenon

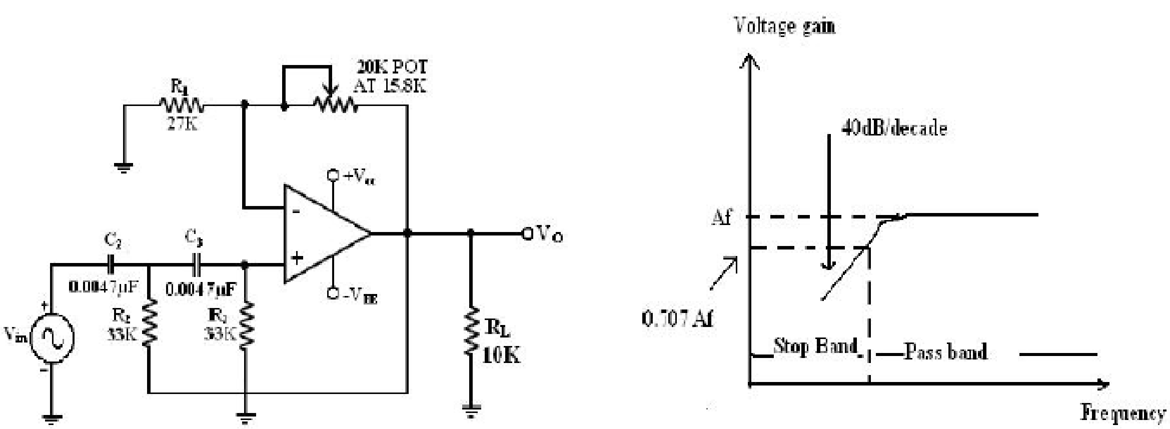
II ORDER HPF:

$V_o = A_oV_B$ (1M)

V_B voltage at node B (1M)

Step response, dampening coefficient, cause its effects (1M)

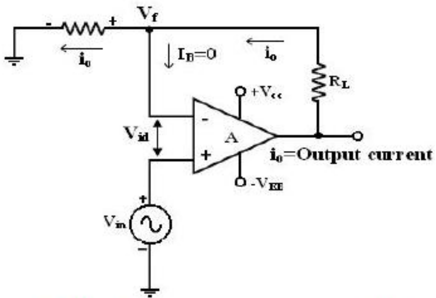
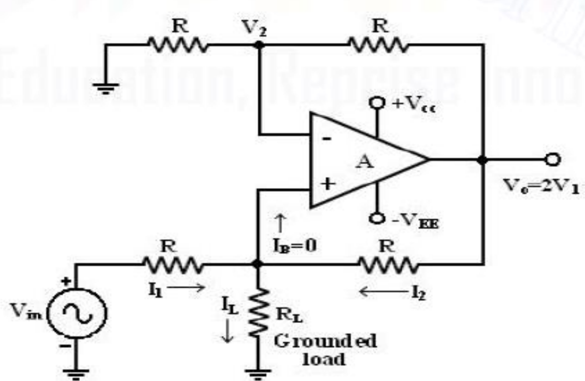
Diagram: (4M)



3 **a)Draw and explain the circuit of a voltage to current converter if the load is (i) floating (4M) (ii) Grounded (4M) (May/June 2012)**

b) Draw and explain the circuit of a current to voltage converter. (7M) BTL3

Answer: page 146 – 147 LIC D.Roy Choudhury

	Floating load figure 2.7 (4M) Output voltage Vo = 2V1 Vo = Vi + Vo – Ilr Where Vi = iLR Application – LED, zener diode tester, low voltage dc, ac voltmeter  Fig. 2.7 Voltage to Current Converter with floating loads (V/I): Writing KVL for the input loop, Voltage $V_{id} = V_f$ and $I_B = 0$, $V_i = R_L i_o$ where $i_o = \frac{V_i}{R_L}$ With grounded load: **(4M)**  Current to voltage converter figure 2.9 (7M)

$R = R_f$

$I_1 + I_2 = I_L$

$(V_i + V_a)/R + (V_o - V_a)/R = I_L$

$V_o = (V_i + V_o - I_L R)/2$ and gain $= 1 + R/R = 2$.

$\therefore V_i = I_L R \;;\; I_L = V_i/R$

Current to Voltage Converter (I –V):

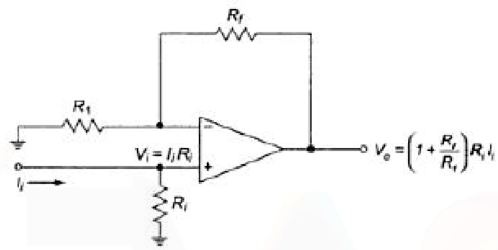


Fig. 2.9 Non inverting current to voltage convertor

Subject Code: EC8453 **Year/Semester: II /04**
Subject Name: LINEAR INTEGRATED CIRCUITS **Subject Handler: W.Nancy**

UNIT III - ANALOG MULTIPLIER AND PLL	
Analog Multiplier using Emitter Coupled Transistor Pair - Gilbert Multiplier cell – Variable trans conductance technique, analog multiplier ICs and their applications, Operation of the basic PLL, Closed loop analysis, Voltage controlled oscillator, Monolithic PLL IC 565, application of PLL for AM detection, FM detection, FSK modulation and demodulation and Frequency synthesizing and clock synchronisation.	
PART * A	
Q.No.	**Questions**
1.	**List the basic building blocks of PLL.** BTL1 • Phase detector/comparator • Low pass filter • Error amplifier • Voltage controlled oscillator
2	**Define FSK modulation.(MAY 2010)** BTL1 FSK is a type of frequency modulation in which the binary data or code is transmitted by means of a carrier frequency that is shifted between two fixed frequency namely mark(logic1) and space frequency(logic 0).
3	**What is analog multiplier?(MAY 2010)** BTL1 A multiplier produces an output $\boldsymbol{V_0}$, which is proportional to the product of two inputs $\boldsymbol{V_x}$ and $\boldsymbol{V_y}$. $\boldsymbol{V_0}$ =K $\boldsymbol{V_x}$ $\boldsymbol{V_y}$
4	**List out the various methods available for performing for analog multiplier.** BTL1 • Logarithmic summing technique • Pulse height /width modulation technique • Variable trans conductance technique • Multiplication using gilbert cell • Multiplication technique using trans conductance technique
5	**Mention some areas where PLL is widely used. (DEC 2009)** BTL1 • Radar synchronizations • Satellite communication systems • Air borne navigational systems • FM communication systems • Computers.
6	**What are the three stages through which PLL operates?** BTL1 • Free running • Capture • Locked/ tracking
7	**Define lock-in range of a PLL. (MAY 2010)** BTL1 The range of frequencies over which the PLL can maintain lock with the incoming signal is called the lock-in range or tracking range. It is expressed as a percentage of the VCO free running frequency.

8	**Define capture range of PLL. (MAY 2010)** BTL1 The range of frequencies over which the PLL can acquire lock with an input signal is called the capture range. It is expressed as a percentage of the VCO free running frequency.
9	**Write the expression for FSK modulation.(MAY 2010)** BTL1 The expression for FSK modulation is, **Δvf=f2-f1/k0**
10	**Define free running mode .(MAY 2010)** BTL1 An interactive computer mode that allows more than one user to have simultaneous use of a program.
11	**For perfect lock, what should be the phase relation between the incoming signal and VCO output signal?** BTL2 The VCO output should be 90 degrees out of phase with respect to the input signal.
12	**Give the classification of phase detector.** BTL1 • Analog phase detector . • Digital phase detector
13	**What is a switch type phase detector?** BTL1 An electronic switch is opened and closed by signal coming from VCO and the input signal is chopped at a repetition rate determined by the VCO frequency. This type of phase detector is called a half wave detector since the phase information for only one half of the input signal is detected and averaged.
14	**What are the problems associated with switch type phase detector?** BTL1 • The output voltage V_e is proportional to the input signal amplitude. This is undesirable because it makes phase detector gain and loop gain dependent on the input signal amplitude. • The output is proportional to cosφ making it non linear.
15	**What is a voltage controlled oscillator?** BTL1 Voltage controlled oscillator is a free running multi vibrator operating at a set frequency called the free running frequency. This frequency can be shifted to either side by applying a dc control voltage and the frequency deviation is proportional to the dc control voltage
16	**Define Voltage to Frequency conversion factor.** BTL1 Voltage to Frequency conversion factor is defined as, Kv = fo / Vc= 8fo /Vcc Where, Vc is the modulation voltage fo frequency shift.
17	**What is the purpose of having a low pass filter in PLL?** BTL1 • It removes the high frequency components and noise. • Controls the dynamic characteristics of the PLL such as capture range, lock-in range, band-width and transient response. • The charge on the filter capacitor gives a short- time memory to the PLL
18	**Discuss the effect of having large capture range.** BTL2 The PLL cannot acquire a signal outside the capture range, but once captured, it will hold on till the frequency goes beyond the lock-in range. Thus, to increase the ability of lock range, large capture range is required. But, a large capture range will make the PLL more susceptible to noise and undesirable signal.
19	**Mention some typical applications of PLL.** BTL1 • Frequency multiplication/division

	• Frequency translation • AM detection • FM demodulation • FSK demodulation.
20	**What is a compander IC? Give some examples.(DEC 2009)** BTL1 The term commanding means compressing and expanding. In a communication system, the audio signal is compressed in the transmitter and expanded in the receiver. Examples: LM 2704- LM 2707; NE 570/571.
21	**What are the merits of companding?** BTL1 • The compression process reduces the dynamic range of the signal before it is transmitted. • Companding preserves the signal to noise ratio of the original signal and avoids non linear distortion of the signal when the input amplitude is large. • It also reduces buzz,bias and low level audio tones caused by mild interference.
22	**List the applications of analog multipliers.(May/June 2013)** BTL1 • Analog computer • Analog signal processing • Automatic gain control • True RMS converter • Analog filter (especially voltage-controlled filters) • PAM-pulse amplitude modulation
23	**In what way VCO is different from other oscillator. (May/June 2012)** BTL2 • To adjust the output frequency to match (or perhaps be some exact multiple of) an accurate external reference. • Where the oscillator drives equipment that may generate radio-frequency interference, adding a varying voltage to its control input can disperse the interference spectrum to make it less objectionable. See spread spectrum clock.
24	**List the applications of NE565. (Nov/Dec2010)** BTL1 • Frequency multiplier • FM Demodulator is the applications of NE565.
25	**Why the VCO is called voltage to frequency converter? (Nov/Dec 2012)** BTL1 The VCO provides the linear relationship between the applied voltage and the oscillation frequency. Applied voltage is called control voltage. The control of frequency with the help of control voltage is also called voltage to frequency conversion. Hence VCO is also called voltage to frequency converter.
	PART * B
1	**Explain the working of voltage controlled oscillator.(8M) (Nov/Dec 2009), (April/May 2010)** BTL2 **Answer: page 334 – 336 LIC D. Roy Choudhury** IC signetics NE/SE566 (4M)

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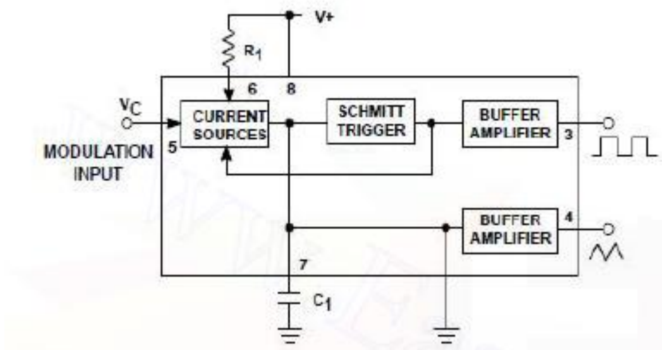

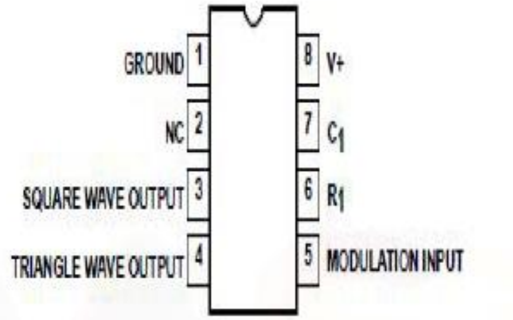

Application – converts EEGs, EKGs to AF range. (4M)
Fo changes with change in Rt, Ct, voltage at pin 5.
Voltage to frequency conversion factor
$K_v = \frac{\Delta f_o}{\Delta V_c}$
$K_v = \frac{8 f_o}{V_c}$
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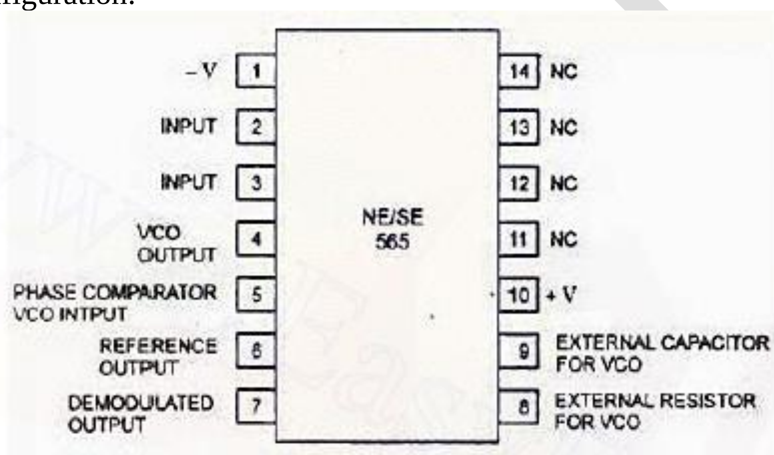
Draw the pin configuration of PLL IC 565. (8M) BTL1
Answer: page 337 – 342 LIC D. Roy Choudhury
Pin configuration: (4M)


14-Pin DIP Package

The important electrical characteristics of 565 PLL,
Operating frequency range: 0.001Hz to 500 Khz.
Operating voltage range: ±6 to ±12v (4M)
Input level required for tracking: 10mv rms min to 3 Vpp max
Input impedance: 10 K ohms typically.
Output sink current: 1mA
Output source current: 10 Ma

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Brief about PLL application Frequency multiplication / Division. (8M) BTL2
Answer: page 342 – 343 LIC D. Roy Choudhury

Divide by N network
Frequency divider insert between the VCO & phase comparator. (2M)
Output of the divider locks to f IN.

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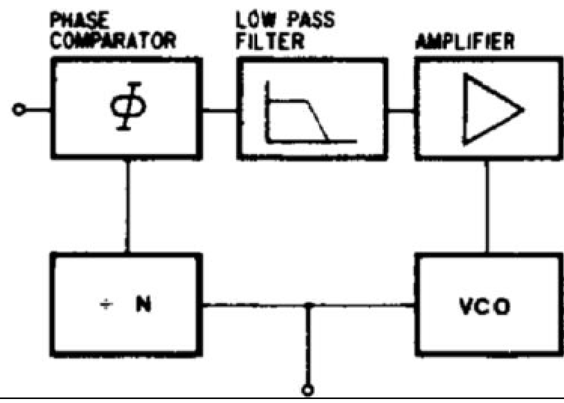
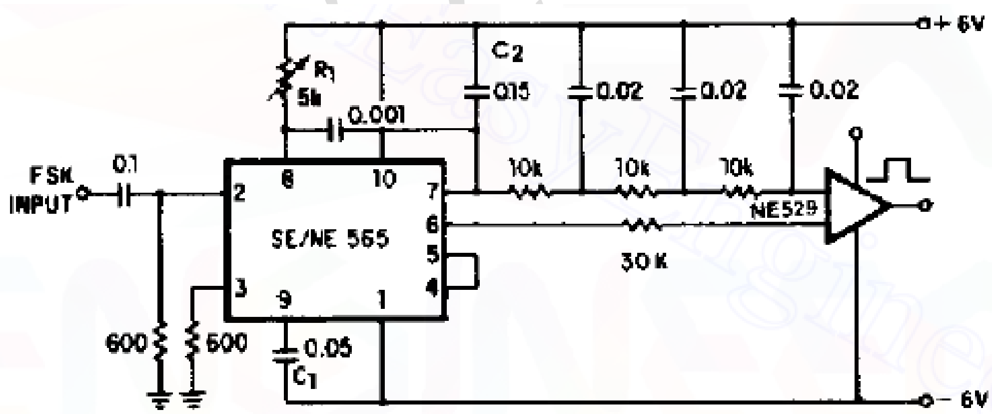
	• VCO runs at multiple of input frequency. (2M) • Desired amount of multiplication obtains by selecting a proper divide-by-N network, • where N is an integer. Diagram: (4M) 
4	**Elaborate FSK demodulator with neat diagram. (8M)** BTL2 **Answer: page 344 – 345 LIC D. Roy Choudhury**. • Capacitive coupling - at input to remove dc line. (1M) • At input of 565, loop locks to input frequency & tracks it between 2 frequencies. • R1 & C1 determine the free running frequency of VCO, • 3 stages RC ladder filter - to remove carrier component from output. (2M) Diagram: (4M)  **Applications:** (1M) • Digital data communication, computer peripheral • Binary data transmits by means of carrier frequency - shifts between two preset frequencies. • This type of data transmission called frequency shift keying (FSK) technique. • The binary data retrieved by FSK demodulator.
5	**Describe the working principle of a analog multiplier using emitter coupled transistor pair. (13M) (Nov/Dec 2014)** BTL2 **Answer: page 338 – 339 LIC D. Roy Choudhury** • Gilbert multiplier cell - modification of the emitter coupled cell (2M) • Allows four – quadrant multiplication.

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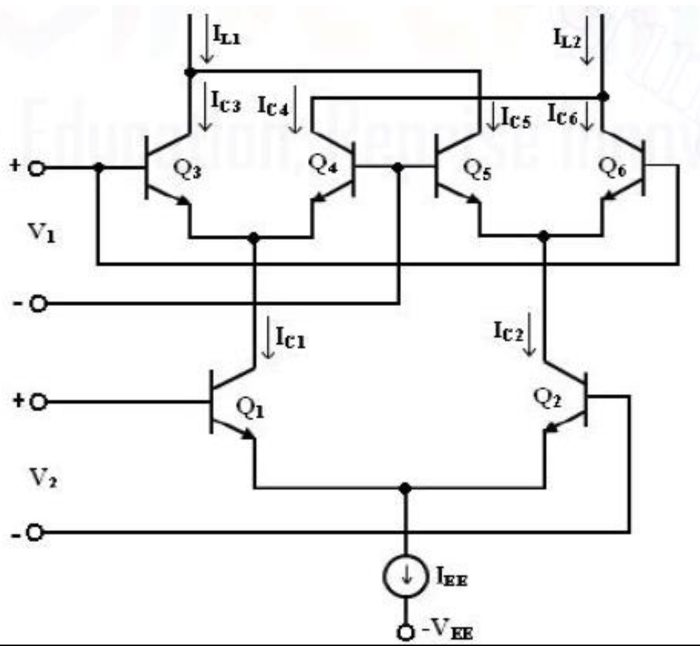
- It forms the basis of the integrated circuit balanced Multipliers. (2M)
- Two cross- coupled emitter- coupled pairs in series connection with an emitter coupled pair form the structure of the Gilbert multiplier cell. (3M)

Circuit Diagram: (6M)



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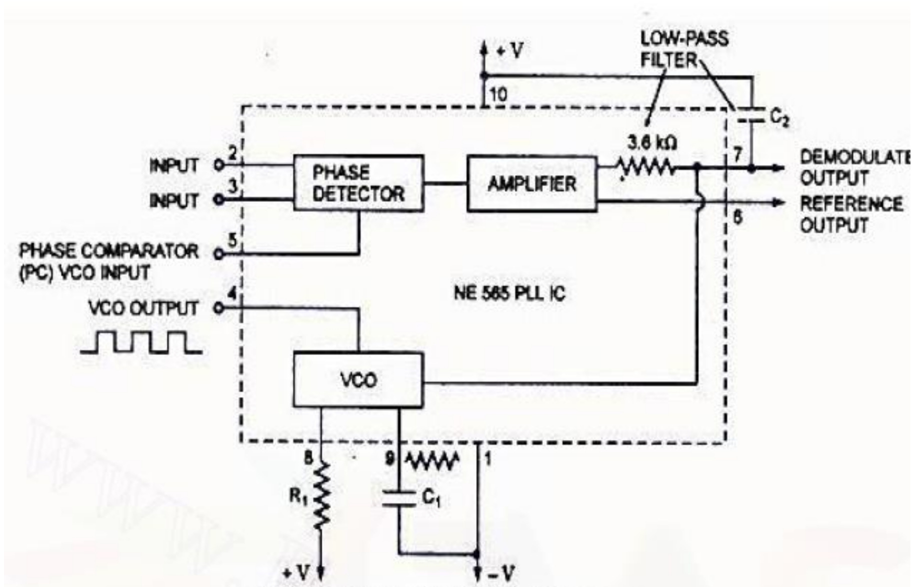
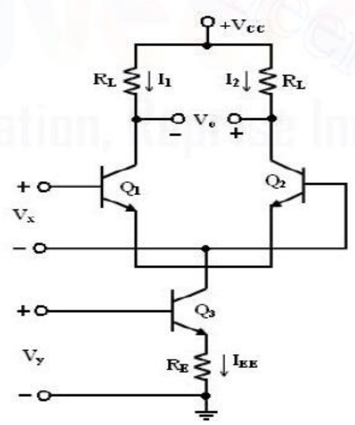
Explain in detail the block diagram PLL. (13M) BTL2
Answer: page 338 – 339 LIC D. Roy Choudhury
Circuit Diagram: (7M)

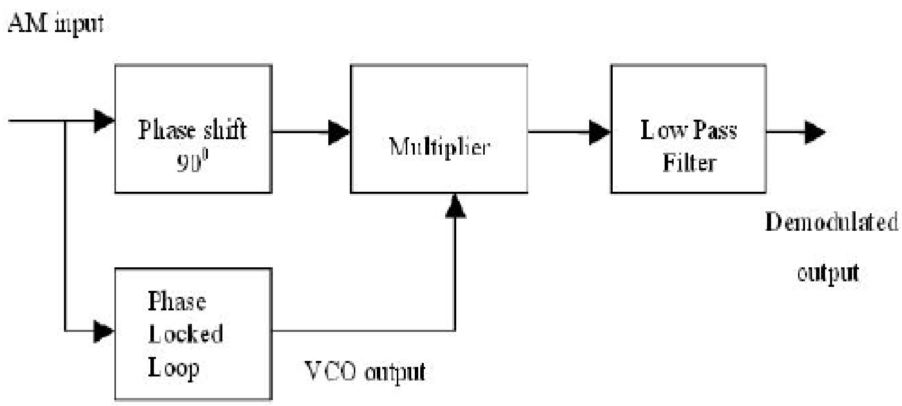
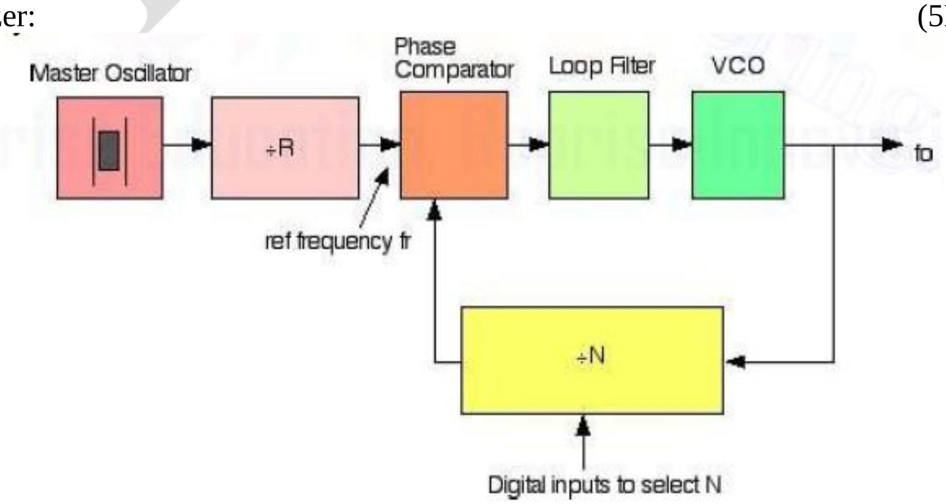


NE/SE 565 PLL Block Diagram

- Center frequency of the PLL - free running frequency of the VCO, given by
- fOUT = 1.2/ 4*R*1*C*1 (2M)
- where R1&C1 - an external resistor & a capacitor connected to pins 8 & 9.
- VCO free-running frequency fOUT adjusts externally with R1 & C1 to be at center of

</td></tr>
</table>

	input frequency range. (2M) • C1 can be any value; R1 must have a value between 2 k ohms and 20 K ohms. • Capacitor C2 connected between 7 & +V. • Filter capacitor C2 should be large enough to eliminate variations in the demodulated output voltage in order to stabilize VCO frequency. (2M)
7	**Explain the working principle of operational Transconductance Amplifier. (8M)** BTL2 **Answer: page 342 – 344 LIC D. Roy Choudhury** • Makes use of dependence characteristic of transistor transconductance parameter on emitter current bias applied. (1M) • Simple differential circuit arrangement depicting the principle is shown in figure. • Relationship between V0, Vx given by V0 = gm RL VX (2M) • where gm = IEE /VT transconductance of stage. (1M) • Application of second input Vy to reference current source of differential amplifier varies gm. • Thus, if RE IEE >>VBE, bias voltage Vy relates to IEE by relation Vy = IEE RE. • Then, overall voltage transfer expression, • V0 = gm RLVx = (Vy/VTRE)VxRL = VxVy RL/ VTRE Diagram: (4M) **3.3 Variable Transconductance Technique:**  **Fig. 3.9 Differential stage of the Tran conductance multiplier**
8	**Define capture range and lock range . (3M)** **Explain the process of capturing the lock and also derive for capture range and lock range.(10M)** BTL2 **Answer: page 339 – 342 LIC D. Roy Choudhury** • Lock range(Tracking range): (2M) The lock range - range of frequencies over which PLL system follows changes in input frequency fIN. • Capture range: (1M) Capture range - frequency range in which PLL acquires phase lock. • Always smaller than lock range. (1M) • If divider divides by *M*, it allows the VCO to multiply the reference frequency by *N* / *M*. • In some cases reference frequency constrains by other issues, - then reference divider -

	useful. (2M) • Frequency multiplication - attains by locking PLL to 'N'th harmonic of signal. (2M) • Let input to phase detector be $xc(t)$ (2M) • Output of voltage- controlled oscillator (VCO) - $xr(t)$ with frequency $\omega r(t)$. (3M)
	PART *C
1	**Explain with neat block diagrams, how PLL is used as (i) AM Detector (5M) (ii) FM Detector (5M) (iii) Frequency synthesizer (5M) (May/June 2012)** BTL2 **Answer: page 342 – 344 LIC D. Roy Choudhury** AM Detector: (5M)  FM Detector: (5M) • If PLL locks to a FM signal, VCO tracks instantaneous frequency of input signal. • Filtered error voltage which controls the VCO, maintains lock with input signal to get demodulated FM output. • VCO transfer characteristics determine linearity of demodulated output. • Since, VCO in IC PLL - highly linear, possible to realize highly linear FM demodulators. Frequency synthesizer: (5M)  • Ability of a frequency synthesizer to generate multiple frequencies is the divider between

the output and feedback input.

- This usually in form of a digital counter, with output signal acts as a clock signal.
- The counter preset to some initial count value,
- counts down at each cycle of clock signal.
- When it reaches zero, the counter output changes state and count value reloads.

2

a) List and define the various performance parameters of a multiplier IC. (5M) (May/June 2012).b) How the multiplier is used as voltage divider? (5M) (May/June 2012). c) How the multiplier is used as frequency doubler? (5M) (May/June 2012) BTL2

Answer: page 159 – 164 LIC D. Roy Choudhury

Multiplier IC figure 3.10 (5M)

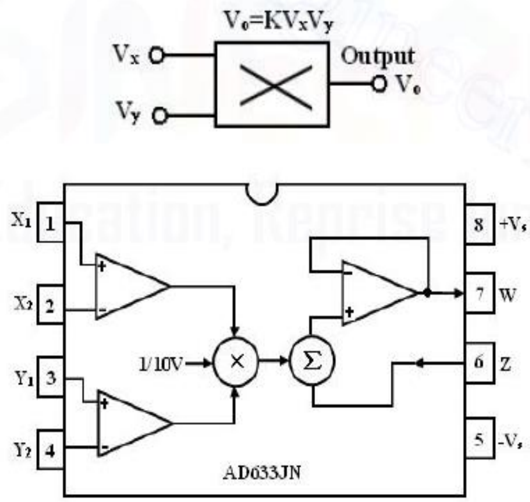


Fig. 3.10 Multiplier IC and its symbol

- Circuit whose output voltage at any instant proportional to product of instantaneous value of two individual input voltages.
- Important applications of these multipliers - multiplication, division, squaring,
- square – rooting of signals, modulation, demodulation.
- Available as integrated circuits consists of op-amps and other circuit elements.
- The Schematic of a typical analog multiplier, namely, AD633 is shown in figure.

Voltage divider figure 3.14 (5M)

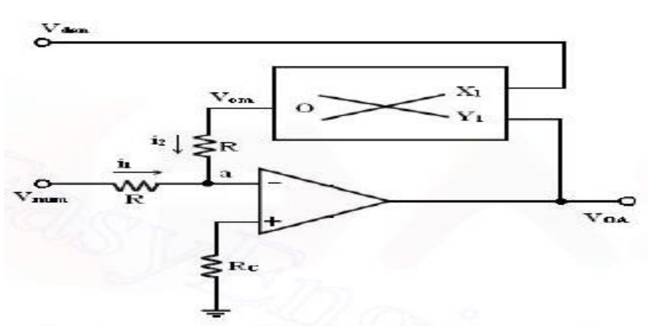
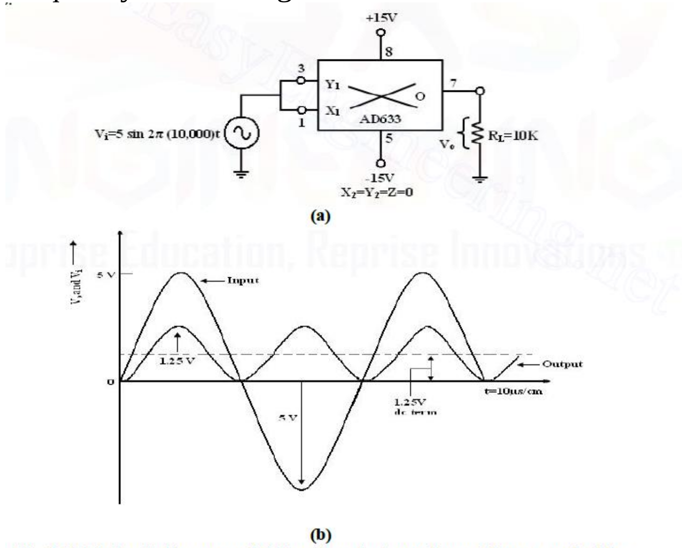
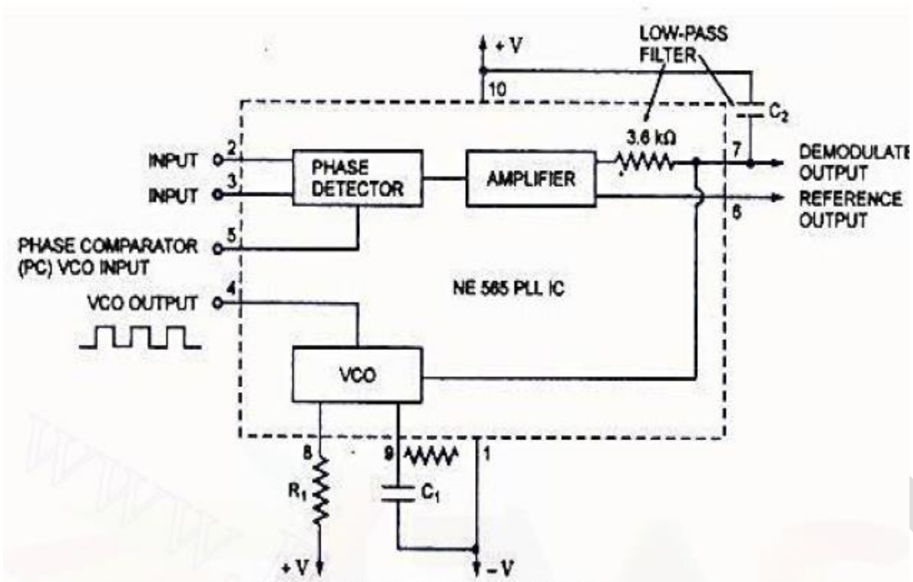


Fig 3.14 divider circuit

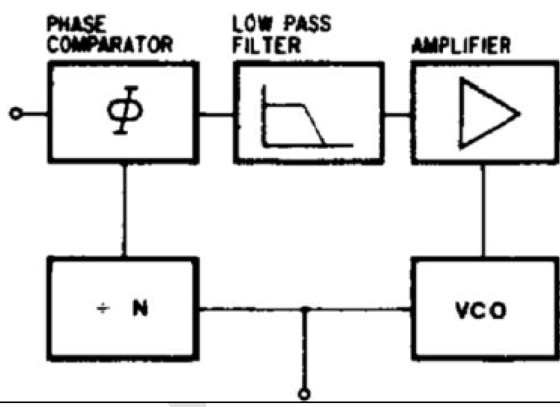
	• No input signal current flow into nverting input terminal of op-amp, - virtual ground. • Therefore, at the junction a, i1 +i2 =0, • current i1 = Vnum / R, where R = input resistance. • current i2 = Vom /R. With virtual ground existing at a, • *i*1+*i*2 = Vnum / R + Vom /R = 0 • *KV OA V den = - V num or* • *voA=- vnum/Kvden* • where *Vnum* and *Vden* numerator, denominator voltages respectively. Frequency Doubler figure 3.13 (5M)  Fig. 3.13 (a) circuit diagram and (b) input –output waveform of frequency doubler • Squaring circuit connects for frequency doubling operation. • Sine-wave signal Vi has a peak amplitude of Av, frequency of f Hz. • Output waveforms ripple with twice input frequency in rectified output of input signal. • This forms principle of application of analog multiplier as rectifier of ac signals.
3	**i)Discuss the principle of operation of NE 565 PLL circuit. (10M)** **ii)How can PLL be modeled as a frequency multiplier.(5M)** BTL4 **Answer: page 337 – 338,342 - 343 LIC D. Roy Choudhury** • Center frequency of PLL - free running frequency of VCO, given by • fOUT = 1.2/ 4*R*1*C*1 (2M) • where R1&C1 - an external resistor & capacitor connected to pins 8 & 9. • VCO free-running frequency fOUT adjusts externally with R1 & C1 (2M) C1 can be any value; R1 must have a value between 2 k ohms and 20 K ohms. • Capacitor C2 connected between 7 & +V. Diagram: (6M)



NE/SE 565 PLL Block Diagram

ii) Frequency multiplier (5M)

- Divide by N network
- Frequency divider insert between the VCO & phase comparator.
- Output of the divider locks to f IN.
- VCO runs at multiple of input frequency.
- Desired amount of multiplication obtains by selecting a proper divide-by-N network,
- where N is an integer.



Subject Code:EC8453 **Year/Semester: II /04**
Subject Name: LINEAR INTEGRATED CIRCUITS **Subject Handler: Mrs.W.Nancy**

UNIT IV - ANALOG TO DIGITAL AND DIGITAL TO ANALOG CONVERTERS

Analog and Digital Data Conversions, D/A converter – specifications - weighted resistor type, R-2R Ladder type, Voltage Mode and Current-Mode *R - 2R* Ladder types - switches for D/A converters, high speed sample-and-hold circuits, A/D Converters – specifications - Flash type - Successive Approximation type - Single Slope type – Dual Slope type - A/D Converter using Voltage-to-Time Conversion - Over-sampling A/D Converters, Sigma – Delta converters.

PART * A

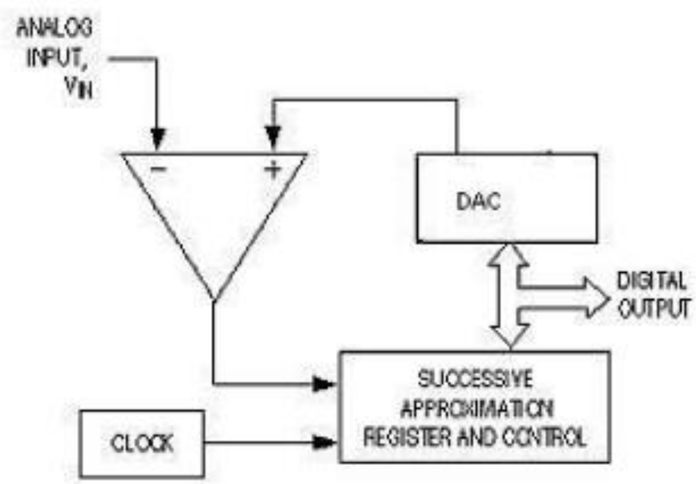
Q.No.	Questions
1.	**Give the operation of basic sample and hold circuit.** BTL1 A typical sample and hold circuit stores electric charge in a capacitor and contains at least one fast FET switch and at least one operational amplifier. To sample the input signal the switch connects the capacitor to the output of a buffer amplifier. The buffer amplifier charges or discharges the capacitor so that the voltage across the capacitor is practically equal, or proportional to, input voltage. In hold mode the switch disconnects the capacitor from the buffer. The capacitor is invariably discharged by its own leakage currents and useful load currents, which makes the circuit inherently volatile, but the loss of voltage (voltage drop) within a specified hold time remains within an acceptable error margin.
2	**State the advantages and applications of sample and hold circuits.** BTL1 A sample and hold circuit is one which samples an input signal and holds on to its last sampled value until the input is sampled again. This circuit is mainly used in digital interfacing, analog to digital systems, and pulse code modulation systems.
3	**List the drawbacks of binary weighted resistor technique of D/A conversion.**BTL1 • Wide range of resistor values needed. • Difficulty in achieving and maintaining accurate ratios over a wide range of variations
4	**What is the advantage and disadvantages of flash type ADC?** BTL1 Flash type ADC is the fastest as well as the most expensive. The disadvantage is the number of comparators needed almost doubles for each added bit (For a n-bit convertor 2(n-1) comparators, 2n resistors are required).
5	**The basic step of a 9 bit DAC is 10.3 mV. If 000000000 represents 0Volts, what is the output for an input of 101101111?** BTL2 The output voltage for input of 101101111 is = 10.3 mV (1*28+0*27+1*26+1*25+0*24+1*23+1*22+1*21+1*20) = 10.3 * 10-3 * 367 = 3.78 V
6	**Find the resolution of a 12 bit DAC converter.** BTL1 Resolution (volts) = VFS/(212-1) = I LSB increment VFS – Full scale voltage
7	**What are the advantages and disadvantages of R-2R ladder DAC?** BTL1 **Advantages:** • Easier to build accurately as only two precision metal films are required. • Number of bits can be expanded by adding more sections of same R/2R values.

8	**What are the disadvantages of R-2R ladder DAC?** BTL1 In this type of DAC, when there is a change in the input, changes the current flow in the resistor which causes more power dissipation which creates non-linearity in DAC.
9	**Define Start of Conversion.** BTL1 This is the control signal for start of conversion which initiates A/D conversion process.
10	**Define End of Conversion.** BTL1 This is the control signal which is activated when the conversion is completed.
11	**What are the types of ADC?** BTL1 • Flash (comparator) type converter • Counter type converter • Tracking or servo converter • Successive approximation type converter
12	**What are the types of DAC?** BTL1 • Weighted resistor DAC • R-2R Ladder • Inverted R-2R Ladder
13	**What is the difference between direct ADC and integrating type ADC?** BTL1 The integrating type of ADC's do not need a sample/Hold circuit at the input. It is possible to transmit frequency even in noisy environment or in an isolated form.
14	**Define Resolution.** BTL1 The resolution of a converter is the smallest change in voltage which may be produced at the output or input of the converter. Resolution (in volts)= VFS/2n-1=1 LSB increment. The resolution of an ADC is defined as the smallest change in analog input for a one bit change at the output.
15	**What is meant by Accuracy?** BTL1 It is the maximum deviation between the actual converter output & the ideal converter output.
16	**What is the purpose of DAC Monotonicity?** BTL1 A monotonic DAC is one whose analog output increases for an increase in digital input.
17	**Define Conversion time.** BTL1 It is defined as the total time required to convert an analog signal into its digital output. It depends on the conversion technique used & the propagation delay of circuit components. The conversion time of a successive approximation type ADC is given by T(n+1) where T---clock period Tc---conversion time no of bits.
18	**Define Relative accuracy.** BTL1 Relative Accuracy is the maximum deviation after gain & offset errors have been removed. The accuracy of a converter is also specified in form of LSB increments or % of full scale voltage.
19	**Define dither.** BTL1 Dither is very small amount of noise to add a before the A/D conversion.

20	**Define sampling period and hold period.** BTL1 Time duration of capacitor to sample and hold the equal value of voltage input period is called as sampling period and the time duration of voltage across the capacitor at constant time duration is called as hold period.
21	**Define the term settling time.** BTL1 It represents the time it takes for the output to settle within a specified band+-(1/2) LSB of its final value. It depends upon the switching time of the logic circuitry due to internal parasitic capacitances and inductances. Settling time ranges from 100ns to 10μs depending on word length and type of circuit used.
22	**Define conversion time.** BTL1 It is the time taken for the D/A converter to produce the analog output for the given binary input signal. It depends on the response time of switches and the output of the Amplifier. D/A converters speed can be defined by this parameter. It is also called as setting time.
23	**Define slew rate and state its significance. (Apr/May 2010)** BTL1 The circuit of successive approximation ADC consists of a successive approximation register (SAR), to find the required value of each bit by trial & error. With the arrival of START command, SAR sets the MSB bit to 1. The O/P is converted into an analog signal & it is compared with I/P signal. This O/P is low or high. This process continues until all bits are checked.
24	**What is the fastest ADC and why? (Nov/Dec 2010)** BTL1 The circuit of successive approximation ADC consists of a successive approximation register (SAR), to find the required value of each bit by trial & error. With the arrival of START command, SAR sets the MSB bit to 1. The O/P is converted into an analog signal & it is compared with I/P signal. This O/P is low or high. This process continues until all bits are checked.
25	**An 8 bit DAC has a resolution of 20mV/bit. What is the analog output voltage for the digital input code 00010110(the MSB is the left most bit)?(Apr/May 2010)** BTL2 The output voltage for input 00010110 is $=20 *0* 2^8 * 0* 2^7 * 0* 2^6 *1* 2^5 * 0* 2^4 *1* 2^3 *1* 2^2 * 0* 2^1$ =20 * 44 =880 Mv
	PART * B
1	**With neat internal diagram, explain the following** **(i) Dual slope ADC (7M)** **ii) Successive Approximation ADC. (6M)** BTL1 **Answer: page 361 – 365 LIC D.Roy Choudhury** Dual slope : (7M) In Integrating ADC, current, proportional to input voltage, charges a capacitor for a fixed time interval T charge. (2M) At the end of this interval, the device resets its counter and applies an opposite-polarity negative reference voltage to the integrator input. (2M) Because of this, the capacitor is discharged by a constant current until the integrator output voltage zero again. (1M) The T discharge interval is proportional to the input voltage level and the resultant final count

provides the digital output, corresponding to the input signal. (2M)

Successive Approximation ADC: (6M)



2

i)Estimate the working of R-2R ladder type DAC. (10M)

ii)Compare binary weighted DAC with R-2R ladder network DAC. (3M) BTL1

Answer: page 352 – 353,349 - 351 LIC D.Roy Choudhury

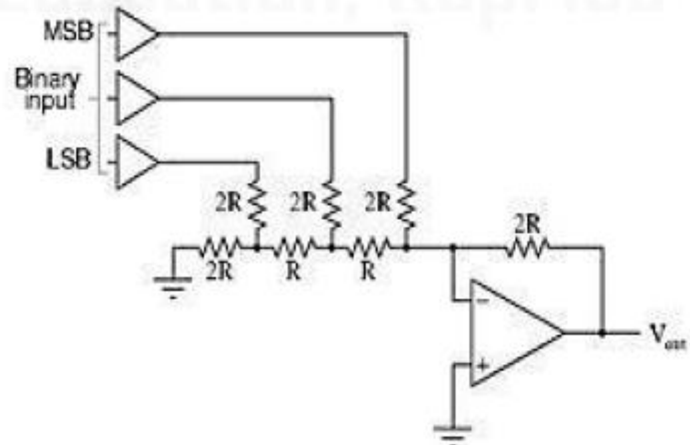
Tabulation : (3M)

Table 4.2 operation of a R-2R ladder DAC

Binary	Output voltage
000	0.00 V
001	-1.25 V
010	-2.50 V
011	-3.75 V
100	-5.00 V
101	-6.25 V
110	-7.50 V
111	-8.75 V

Vout = - (VMSB + Vn + VLSB) = - (VRef + VRef/2 + VRef/ 4) (2M)

Diagram: (5M)

	 Enhancement of binary-weighted resistor DAC - R-2R ladder network. (1M) DAC utilizes Thevenin's theorem in arriving at desired output voltages. Disadvantage of the former DAC design - its requirement of several different precise input resistor values. (1M) one unique value per binary input bit. R-2R network consists of resistors with only two values - R and 2xR. (1M) If each input supplied either 0 volts or reference voltage, the output voltage will be an analog equivalent of the binary value of the three bits. VS_2 corresponds to the most significant bit (MSB) while VS_0 corresponds to the least significant bit (LSB).
3	**With circuit schematic explain analog switches using FET. (13M)** BTL1 **Answer: page 361 – 365 LIC D.Roy Choudhury** Two types of analog switches. (1M) Series and Shunt switch. (2M) Switch operation is shown for both the cases VGS=0 VGS= VGs (off) (2M) Diagram: (8M)

4

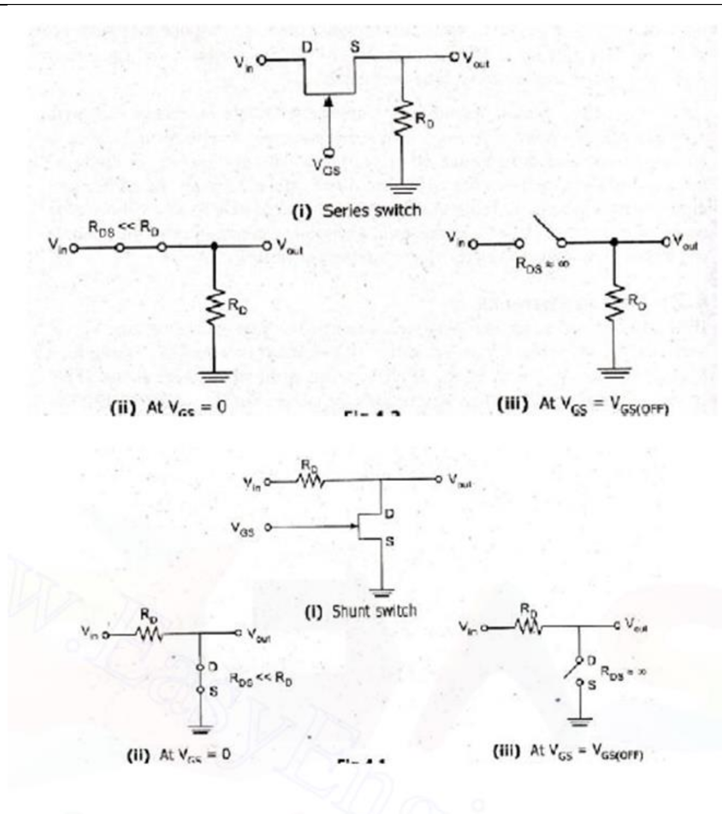


Fig 4.13 Series and shunt Analog switches

4

i)Categorize the different sources of error in DAC. (7M)
ii)Analyze the types of errors in DAC. (6M) BTL4
Answer: page 349 – 355 LIC D.Roy Choudhury

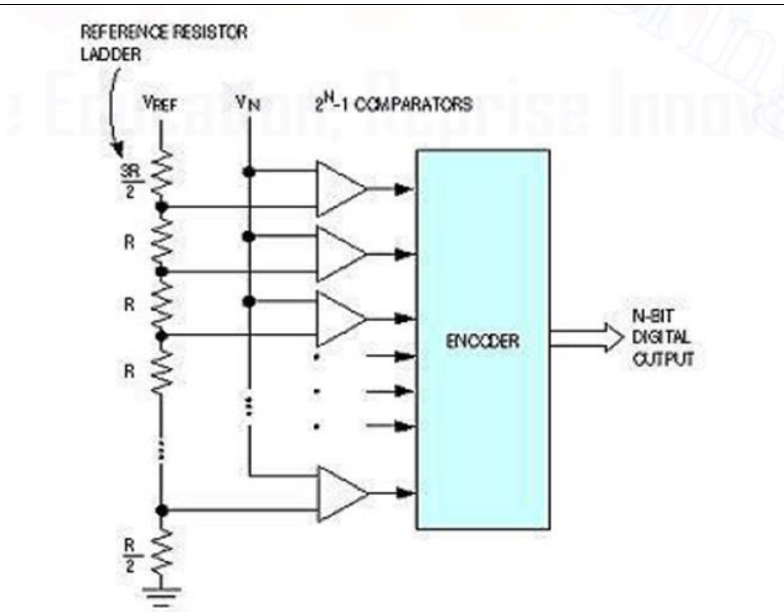
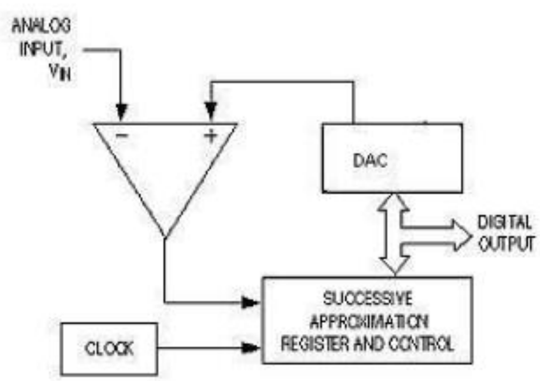
Sampling rate (3M)

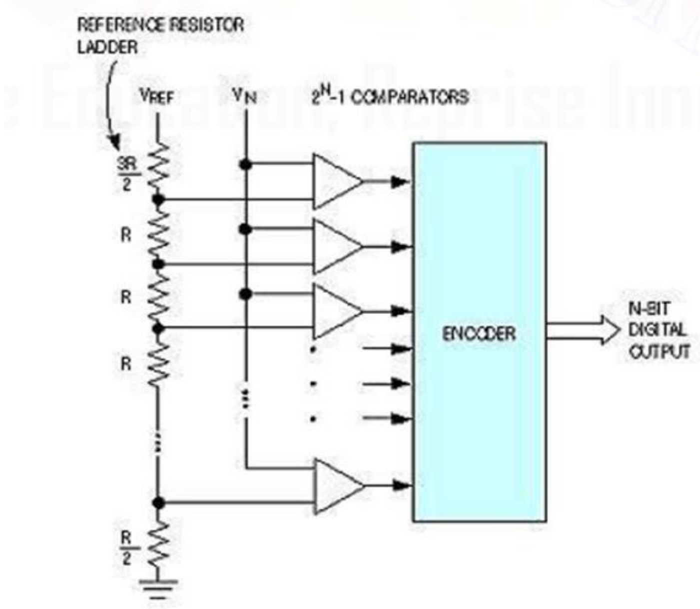
- The analog signal is continuous in time and it is necessary to convert this to a flow of
- digital values.
- It is therefore required to define the rate at which new digital values are sampled from the analog signal.
- The rate of new values is called the sampling rate or sampling frequency of the converter.
- The accuracy is limited by quantization error.

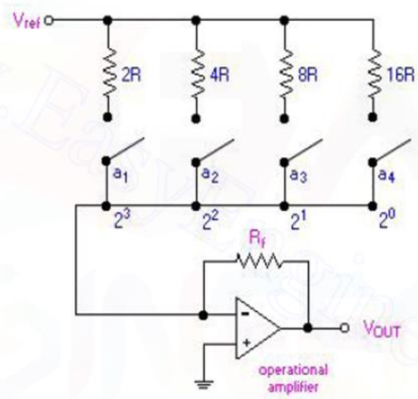
Accuracy (4M)

- An ADC has several sources of errors.
- Quantization error and (assuming the ADC is intended to be linear) non-linearity is intrinsic to any analog-to-digital conversion.
- There is also a so called *aperture error* which is due to a clock jitter and is revealed when digitizing a time-variant signal (not a constant value).

	• These errors are measured in a unit called the *LSB*, which is an abbreviation for least significant bit. Quantization error (3M) • Quantization error is due to the finite resolution of the ADC, and is an unavoidable imperfection in all types of ADC. • The magnitude of the quantization error at the sampling instant is between zero and half of one LSB. • In the general case, the original signal is much larger than one LSB. • When this happens, the quantization error is not correlated with the signal, and has a uniform distribution. Non-linearity (3M) • These errors can sometimes be mitigated by calibration, or prevented by testing. • Important parameters for linearity are integral non-linearity (INL) and differential non-linearity (DNL). • These non-linear ties reduce the dynamic range of the signals that can be digitized by the ADC, also reducing the effective resolution of the ADC.
5	**Show the operation of any two direct type of ADC. (13M)** BTL2 **Answer: page 361 – 365 LIC D.Roy Choudhury** Process extremely fast with a sampling rate of up to 1 GHz. (1M) Resolution however, limited because of large number of comparators, reference voltages required. (1M) Input signal fed simultaneously to all comparators. (1M) Priority encoder then generates a digital output that corresponds with the highest activated comparator. (1M) Diagram: (3M)

	 **Fig.4.14 Flash ADC** Successive Approximation method: Bit-weighting conversion, similar to a binary. (1M) Analogue value rounded to the nearest binary value below, Because the approximations are successive (not simultaneous), conversion takes one clock-cycle for each bit of resolution desired. (1M) Circuit Diagram: (4M) 
6	**Discuss in detail about the following Digital to Analog & Analog to Digital conversion techniques.** **i)Flash type ADC (6M)**

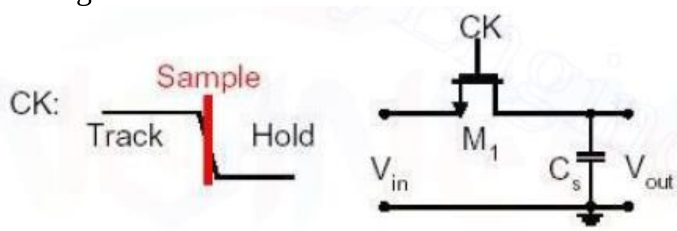
	ii)Weighted Resistor DAC. (7M) BTL1 **Answer: page 358 – 360,349 - 351 LIC D.Roy Choudhury** Process extremely fast with a sampling rate of up to 1 GHz. (1M) Resolution however, limited because of large number of comparators, reference voltages required. (1M) Input signal fed simultaneously to all comparators. (1M) Priority encoder then generates a digital output that corresponds with the highest activated comparator. (1M) Diagram: (2M)  **Fig.4.14 Flash ADC** **Weighted Resistor DAC:** For a n-bit DAC, the relationship between Vout and the binary input is as follows: (2M) $$V_{OUT} = -\frac{V_{ref} R_f}{R} \sum_{i=1}^{n} \frac{a_i}{2^i}$$ The LSB, which is also the incremental step, has a value of - 0.625 V while the MSB or the full scale has a value of - 9.375 V. (1M) Diagram: (4M)



7

i)Draw the diagram of sample and hold circuit. (7M)
ii)State how you will reduce its hold mode drop. (6M) BTL2
Answer: page 153 - 154 LIC D.Roy Choudhury

Circuit Diagram: (4M)



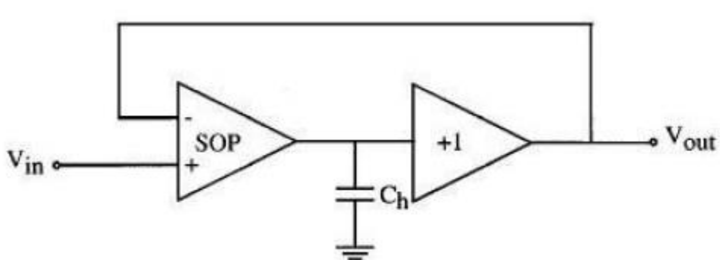
During sample mode, the SOP behaves just like a regular op-amp, in which the value of the output follows the value of the input. (1M)

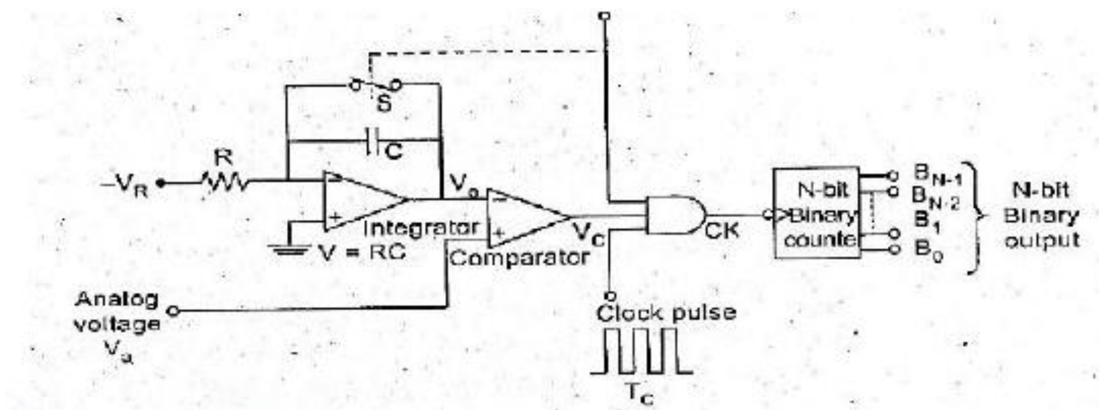
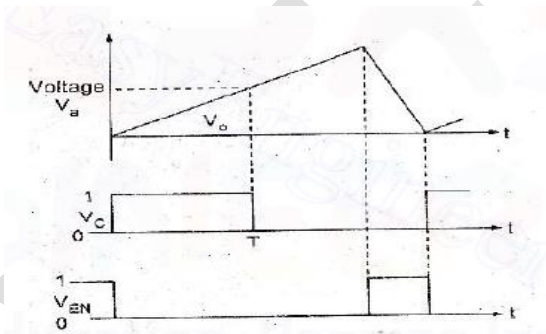
During hold mode, the MOS transistors at the output node of the SOP are turned off while they are still operating in saturation, thus preventing any channel charge from flowing into the output of the SOP. (2M)

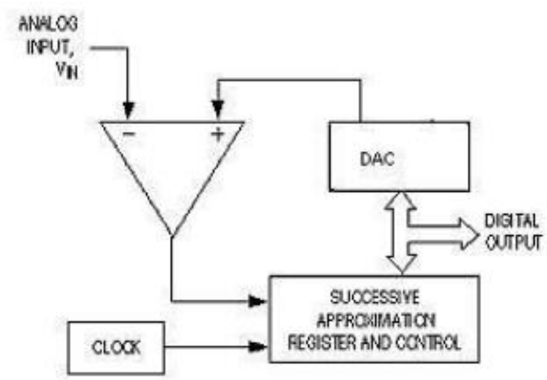
In addition, the SOP is shut off and its output is held at high impedance, allowing the charge on *Ch* to be preserved throughout the hold mode. (2M)

On the other hand, the output buffer of this S/H circuit is always operational during sample and hold mode and is always providing the voltage on *Ch* to the output of the S/H circuit. (1M)

Circuit Diagram : (3M)



8	**Explain the working of a voltage to time converter and voltage to frequency converter.(7M) Construct the working of dual slope ADC and explain. (6M)** BTL2 **Answer: page 363 - 365 LIC D.Roy Choudhury** Analog voltage required to be converted to a proportional time period. (1M) As shown in diagram a negative reference voltage -VR is applied to an integrator, whose output is connected to the inverting input of the comparator. output of the comparator is at 1 as long as the output of the integrator Vo is less than Va. Voltage to time converter: (3M)  Voltage to time conversion process: (3M)  Dual slope : In Integrating ADC, current, proportional to input voltage, charges a capacitor for a fixed time interval T charge. (2M) At the end of this interval, the device resets its counter and applies an opposite-polarity negative reference voltage to the integrator input. (2M) Because of this, the capacitor is discharged by a constant current until the integrator output voltage zero again. (1M) The T discharge interval is proportional to the input voltage level and the resultant final count

	provides the digital output, corresponding to the input signal. (1M)
	PART *C
1	**With example explain the successive Approximation ADC Technique. (11M)** **Discuss the important specification of Data Converters. (4M)** **Answer: Page 361 - 363 LIC D.Roy Choudhury** Successive Approximation: (6M)  bit-weighting conversion, similar to a binary. (1M) Analogue value rounded to the nearest binary value below, (1M) Because the approximations are successive (not simultaneous), (2M) conversion takes one clock-cycle for each bit of resolution desired. (1M) ii)Data converters: input n bit binary word D (1M) reference voltage Vr (1M) analog output signal (1M) output of DAC – voltage or current (1M)
2	**Derive the Inverted or Current mode R-2R Ladder Digital to analog converter and explain. Examine the inverted R-2R ladder (refer above question) has R=Rf=10kΩ and V_R=10V. Calculate the total current delivered to the op-amp and the output voltage when the binary input is 1110. (15M)** BTL3 Currents given as (4M) $i1 = V_{REF}/2R = (V_{REF}/R)\ 2\text{-}1$, $i2 = (V_{REF})/2)/2R = (V_{REF}/R)\ 2\text{-}2$……… $in = (V_{REF}/R)\ 2\text{-}n$. Relationship between the currents given as (4M) i2 = i1/2

$i_3 = i_1/4$

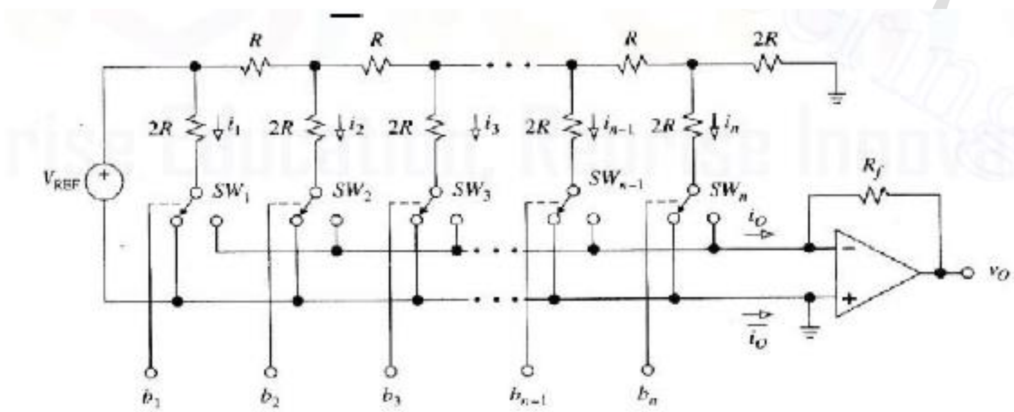
$i_4 = i_1/8$

$i_n = i_1/ 2^{n-1}$

Using bits to identify status of switches,

letting V_0 = -Rf *io* gives

$V_0 = -(R_f/R)\,V_{REF}\,(b_1 2^{-1} + b_2 2^{-2} + \ldots\ldots\ldots.. + b_n 2^{-n})$ (7M)



3

(i)Compare single slope ADC and dual slope ADC.(3M) BTL4
(ii)Explain the working of dual slope A/D converter.(7M) BTL2
(iii)For a particular dual slope ADC, t1 is 83.33ms and the reference voltage is 100mv. Calculate t2 if V1 is 100 mv and 2. 200 mv. (5M) BTL3

Answer: page 363 - 366 LIC D.Roy Choudhury

In Integrating ADC, current, proportional to input voltage, charges a capacitor for a fixed time interval T charge. (2M)

At the end of this interval, the device resets its counter and applies an opposite-polarity negative reference voltage to the integrator input. (2M)

Because of this, the capacitor is discharged by a constant current until the integrator output voltage zero again. (2M)

The T discharge interval is proportional to the input voltage level and the resultant final count provides the digital output, corresponding to the input signal. (3M)

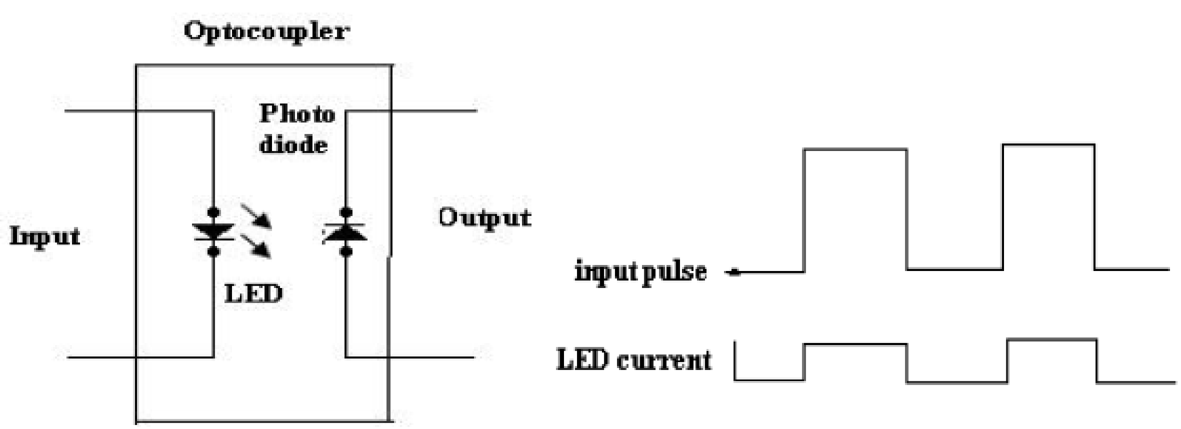
$\boldsymbol{T_1 = t_2 - t_1 = \frac{2^n\ counts}{clock\ rate}}$ (3M)

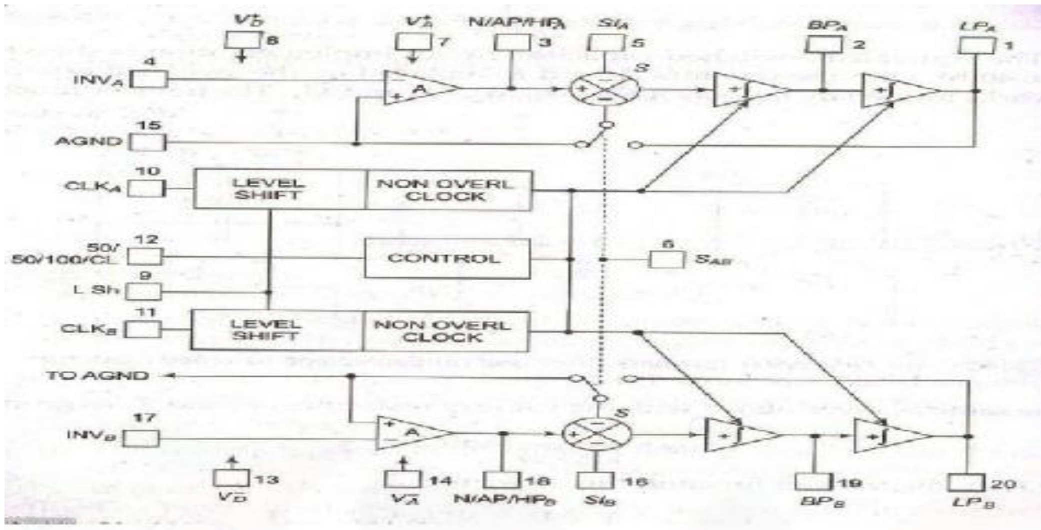
$\boldsymbol{t_3 - t_2 = \frac{digital\ count\ N}{clock\ rate}}$ (3M)

UNIT V - WAVEFORM GENERATORS AND SPECIAL FUNCTION ICs	
Sine-wave generators, Multivibrators and Triangular wave generator, Saw-tooth wave generator, ICL8038 function generator, Timer IC 555, IC Voltage regulators – Three terminal fixed and adjustable voltage regulators - IC 723 general purpose regulator - Monolithic switching regulator, Low Drop – Out(LDO) Regulators - Switched capacitor filter IC MF10, Frequency to Voltage and Voltage to Frequency converters, Audio Power amplifier, Video Amplifier, Isolation Amplifier, Opto- couplers and fibre optic IC.	
PART * A	
Q.No.	**Questions**
1.	**What are the operating modes of a 555 timer?** BTL1 • Monostable mode • Astable mode
2	**List out the applications of 555 timer.** BTL1 • Oscillator • pulse generator • ramp and square wave generator d. mono-shot multivibrator • burglar alarm • traffic light control.
3	**Define sink current.** BTL1 When the output is low, the load current that flows through cted between Vcc and o/p terminal is called sink current.
4	**Define source current.** BTL1 When the output is high, the load current that flows through the load connected between ground and o/p terminal is called source current.
5	**What is the use of reset pin of 555 timer?** BTL1 This is an interrupt for the timing device when pin 4 is grounded, it stops the working of device and makes it off.
6	**What is the purpose of control voltage pin (5) of 555 timer?** BTL1 This pin is the inverting input terminal of comparator. This is reference level for comparator with which threshold is compared. If reference level is other than 2/3 VCC, then external input is to be given to pin 5. Pulse width modulation is possible due to pin 5.
7	**List out the major blocks in functional diagram of 555 timer.** BTL1 The IC 555 timer combines the following elements. • A relaxation oscillator • RS flip-flop • Two comparators • Discharge transistor
8	**List the types of regulators?** BTL1

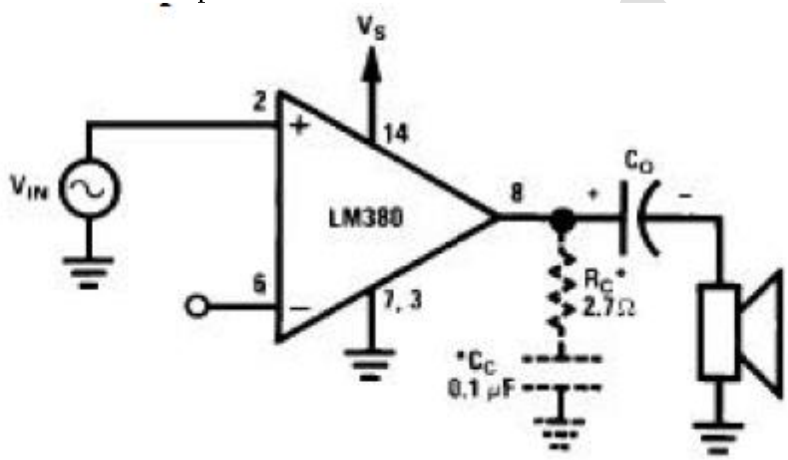
	• Linear regulator • Switched regulator
9	**Write the expression for pulse width of 555 timer in monostable mode.** BTL1 Pulse width W = 1.1 RC seconds R – resistor in ohms, C – capacitor in farads
10	**Write the expression for total time period of 555 timer in astable mode.** BTL1 T = 0.693 (RA + 2 RB) C seconds Where RA,RB are resistors C is capacitor
11	**What is the frequency of oscillation of free running mode of 555 timer?** BTL1 F = 1.44/ (RA + 2 RB) C Hz Where RA,RB are resistors C is capacitor
12	**List out the applications of 555 timer in astable mode.** BTL1 • missing pulse detector • Linear ramp generator • Frequency divider • Pulse width modulation.
13	**List out the applications of 555 timer in monostable mode.** BTL1 • FSK generator • Pulse-position modulator
14	**Define voltage regulators and give the types.** BTL1 • A voltage regulator is an electronic circuit that provides a stable dc voltage independent of the load current, temperature, and ac line voltage variations. • The classification of voltage regulators: Series / Linear regulators Switching regulators.
15	**What do you mean by linear voltage regulators?** BTL1 Series or linear regulator uses a power transistor connected in series between the unregulated dc input and the load and it conducts in the linear region .The output voltage is controlled by the continuous voltage drop taking place across the series pass transistor.
16	**Define switched voltage regulators.** BTL1 Switching regulators are those which operate the power transistor as a high frequency on/off switch, so that the power transistor does not conduct current continuously. This gives improved efficiency over series regulators.
17	**What are the advantages of adjustable voltage regulators over the fixed voltage regulators?** BTL1 • Improved line and load regulation by a factor of 10 or more. • Because of the improved overload protection, greater load current can be drawn. • Improved reliability.

18	**List out the parameters related to the fixed voltage regulators.** BTL1 • Line regulation • Load regulation • Ripple rejection • Output impedance • Maximum power dissipation • Rated output current
19	**Define dropout voltage of a fixed voltage regulator.** BTL1 It is the minimum voltage that must exist between input and output terminals. For most of regulators, it is 2 to 3 volts.
20	**What is an opto-coupler IC? Give examples.** BTL1 • Opto-coupler IC is a combined package of a photo-emitting device and a photosensing device. • Examples for opto-coupler circuit : LED and a photo diode, LED and photo transistor, LED and Darlington. • Examples for opto-coupler IC : MCT 2F , MCT 2E
21	**Mention the advantages of opto-couplers.** BTL1 • Better isolation between the two stages. • Impedance problem between the stages is eliminated. • Wide frequency response.
22	**Why do switching regulators have better efficiency then series regulators? (May/June 2012)** BTL1 In switching regulators, the transistor is operated in cut off region or saturation region. In cut off region, there is no current and hence power dissipation is almost zero. In the saturation region there is negligible voltage drop across it hence the power dissipation is almost zero.
23	**List the important parts of regulated power supply. (April/May2010)** BTL1 • Reference voltage circuit • Error amplifier • Series pass transistor • Feedback network
24	**What are the advantages of a switch mode power supplies? (April/May2010)** BTL1 • Smaller size • Lighter weight (from the elimination of low frequency transformers which have a high weight) • Lower heat generation due to higher efficiency.
25	**What are the disadvantages of linear voltage regulators? (Nov/Dec2011)** BTL1 The input step down transformer is bulky and expensive because of low line frequency. Because of low line frequency, large values of filter capacitors are required to decrease the ripple. Efficiency is reduced due to the continuous power dissipation by the transistor as it operates in the linear region.
	PART * B
1	**Write a short notes on** **Opto couplers (4M)** **Switched capacitor filter (4M)**

	Audio power amplifier (5M) BTL2 **Answer: page 288 – 293,193 LIC D.Roy Choudhury** **Opto couplers:** Opto couplers or Opto isolators is a combination of light source & light detector in the same package. (2M) They are used to couple signal from one point to other optically, by providing a complete electric isolation between them. This kind of isolation is provided between a low power control circuit & high power output circuit, to protect the control circuit. **Characteristics of opto coupler:** (i) Current Transfer Ratio: (1M) It is defined as the ratio of output collector current (Ic) to the input forward current (If) CTR = Ic/If * 100%. Its value depends on the devices used as source & detector. (ii) Isolation voltage between input & output: It is the maximum voltage which can exist differentially between the input & output without affecting the electrical isolation voltage is specified in K Vrms with a relative humidity of 40 to 60%. (iii) Response Time: Response time indicates how fast an opto coupler can change its output state. Response time largely depends on the detector transistor, input current & load resistance. (iv) Common mode Rejection: Even though the opto couplers are electrically isolated for dc & low frequency signals, an impulsive input signal (the signal which changes suddenly) can give rise to a displacement current Ic= Cf*dv/dt. Diagram: (2M)  Switched capacitor filter: (4M)



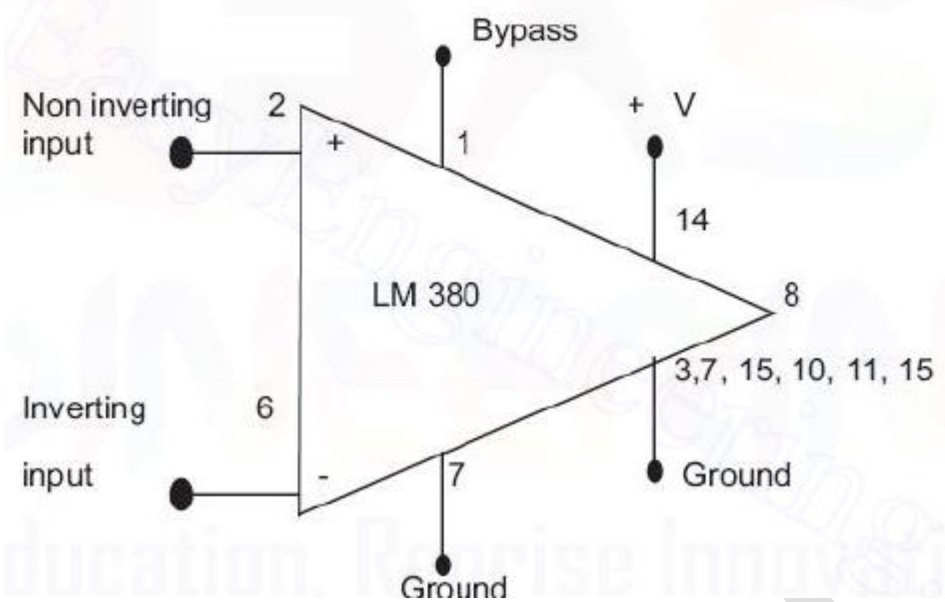
Audio Power amplifier: (5M)



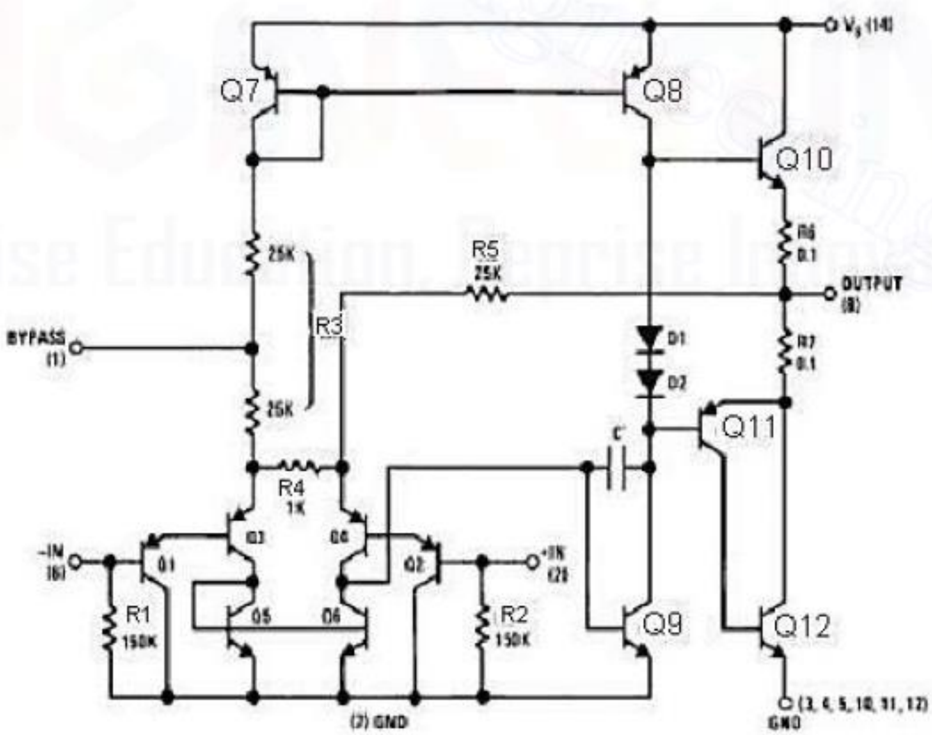
LM380 circuit description:
It is connected of 4 stages,

- PNP emitter follower
- Different amplifier
- Common emitter
- Emitter follower

2 **Demonstrate the functional diagram of LM 380 power amplifier. (13M)** BTL4
llustrate the essential characteristics of power amplifier.
Answer: page 188 - 193 LIC D.Roy Choudhury
Diagram : (6M)

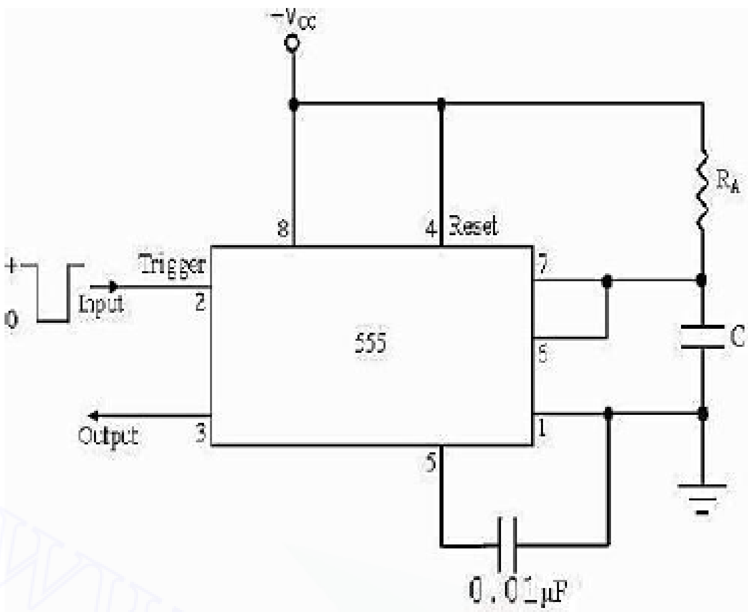
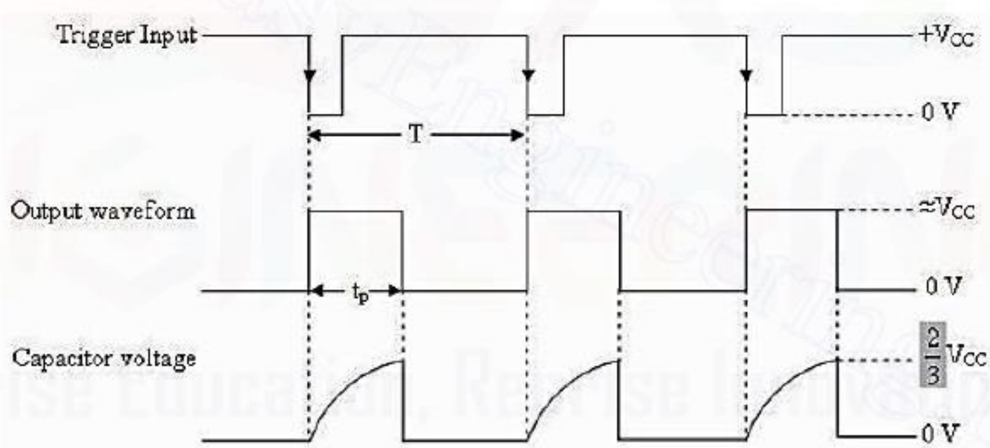


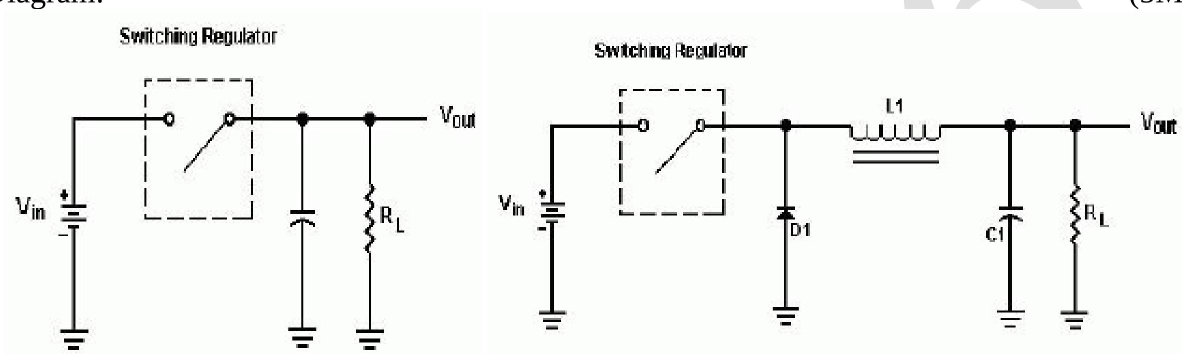
Circuit Diagram: (7M)



Features of LM380:

- Internally fixed gain of 50 (34dB)
- Output is automatically self centering to one half of the supply voltage.
- Output is short circuit proof with internal thermal limiting.
- Input stage allows the input to be ground referenced or ac
- Wide supply voltage range (5 to 22V).
- High peak current capability.

	• High impedance.
3	**What are 555 timers? Explain the working of 555 timer as Monostable Multivibrator. Derive an expression for the frequency of oscillation with relevant waveforms. (10M)** BTL1 **Answer: page 312 - 317 LIC D.Roy Choudhury** Initially when the output is low, i.e. the circuit is in a stable state, transistor Q1 is ON & capacitor C is shorted to ground. (2M) The output remains low. During negative going trigger pulse, transistor Q1 is OFF, which releases the short circuit across the external capacitor C & drives the output high. (2M) Now the capacitor C starts charging toward Vcc through RA. (2M) When the voltage across the capacitor equals 2/3 Vcc, upper comparator switches from low to high. i.e. Q = 0, the transistor Q1 = OFF ; the output is high. Diagram & waveform: (4M)  
4	**Analyze and explain the operation of switching regulator with neat diagram. (8M)** **Examine the operation of frequency to voltage converters. (5M)** BTL4 **Answer: page 255 – 257 LIC D.Roy Choudhury**

	Switching regulator: (3M) • Unregulated dc supply voltage at the input between 9.5V & 40V • Adjustable regulated output voltage between 2 to 3V. • Maximum load current of 150 mA (ILmax = 150mA). • With the additional transistor used, ILmax upto 10A is obtainable. • Positive or Negative supply operation • Internal Power dissipation of 800mW. • Built in short circuit protection. • Very low temperature drift. • High ripple rejection. Diagram: (5M)  Frequency to voltage converters: (5M) F-V convertor produces an output voltage whose amplitude is a function of input signal frequency. V0=kf fi kf is sensitivity of F-V convertor It is basically a FM discriminator.

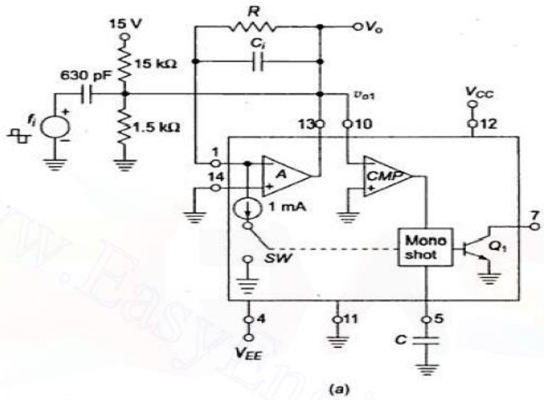


Fig.5.45 Frequency To Voltage Convertor using VFC32 (V-F)

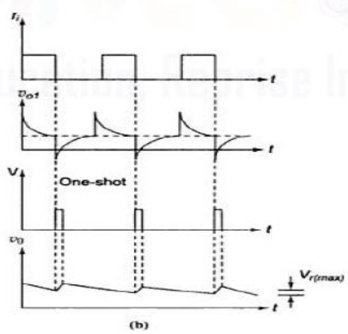


Fig.5.46 F-V Convertor using VF32 and input and output characteristics

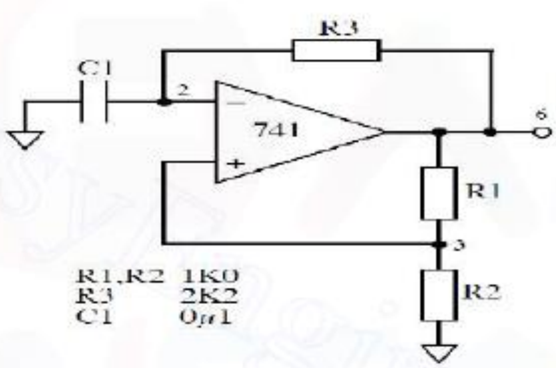
5

Show the working of Astable Multivibrator using op-amp. (8M)
Recall any one application of Astable Multivibrator. (5M) BTL2
Answer: page 318 – 323,312 - 317 LIC D.Roy Choudhury

Astable multivibrator:

The two states of circuit are only stable for a limited time and the circuit switches between them with the output alternating between positive and negative saturation values. (2M)

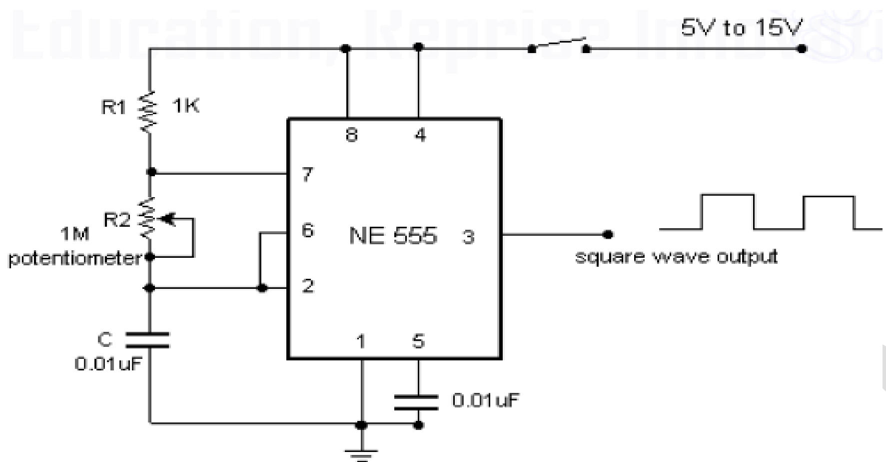
Diagram: (6M)



Square wave oscillator: (5M)

Without reducing RA = 0 ohm, the astable multivibrator can be used to produce square wave output. Simply by connecting diode D across Resistor RB.

The capacitor C charges through RA & diode D to approximately 2/3Vcc & discharges through

<table>
<tr><td></td><td>RB & Q1 until the capacitor voltage equals approximately 1/3Vcc, then the cycle repeats.
To obtain a square wave output, RA must be a combination of a fixed resistor & potentiometer so that the potentiometer can be adjusted for the exact square wave.
</td></tr>
<tr><td>6</td><td>(i)Define voltage regulator and explain the working of Linear Voltage regulator with neat circuit diagram using op-amps. (8M)
(ii)List any two important features of linear voltage regulator IC723. (5M) BTL1
Answer: page 241-248 LIC D.Roy Choudhury
Factors affecting the output voltage: (3M)
• IL (Load Current)
• VIN (Input Voltage)
• T (Temperature)
IC Voltage Regulators: (5M)
They are basically series regulators.
Important features of IC Regulators:
• Programmable output
• Facility to boost the voltage/current
• Internally provided short circuit current limiting
• Thermal shutdown
• Floating operation to facilitate higher voltage output

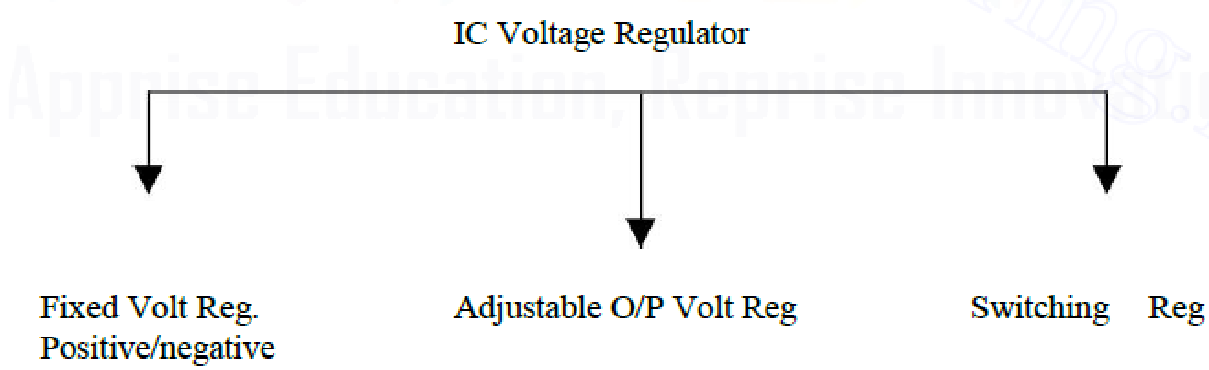
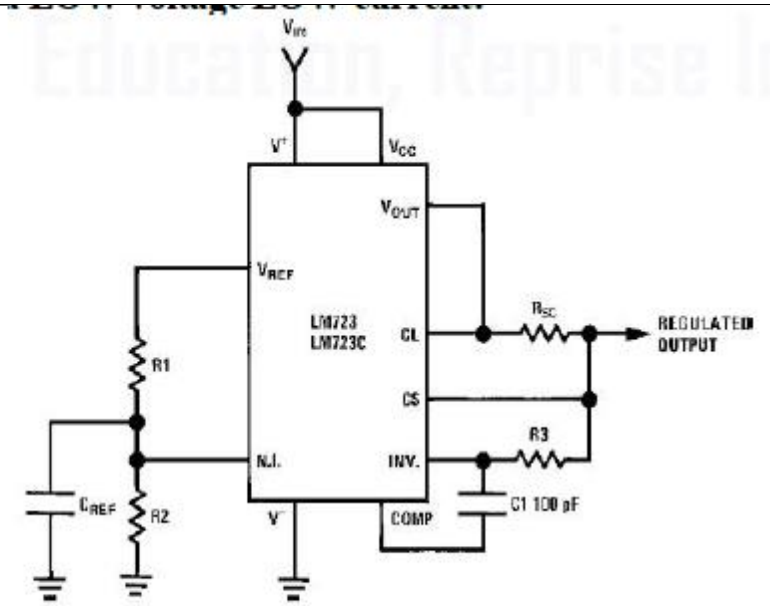



Diagram: (5M)</td></tr>
</table>



7

Illustrate the function of 555 timer in Astable mode. (13M) BTL4
Derive the expression for the pulse width.

Diagram: (7M)

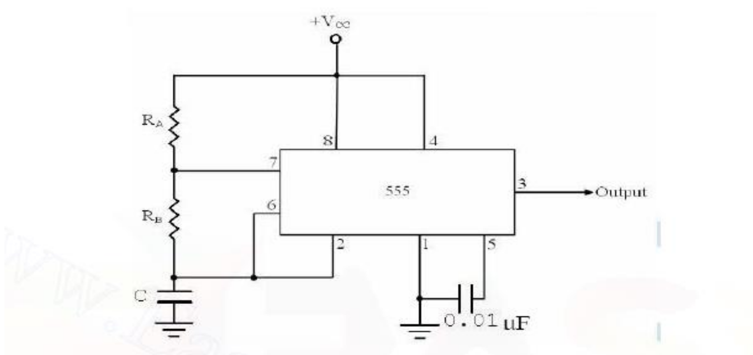


Fig.5.24 Astable Multivibrator

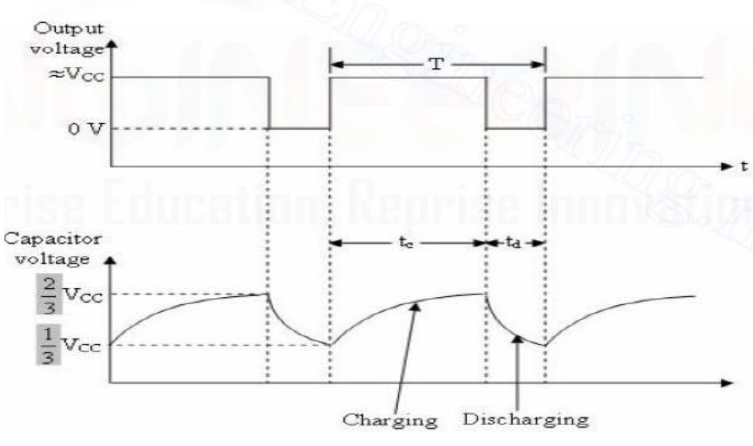
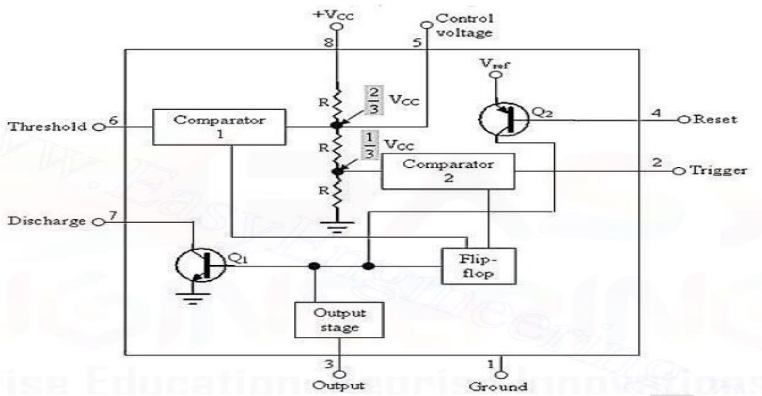


Fig. 5.25 Waveforms of Astable multivibrator

Astable multivibrator, often called a free running multivibrator, is a rectangular wave generating

	circuit. (2M) Unlike the monostable multivibrator, this circuit does not require an external trigger to change the state of the output, hence the name free running. (2M) However, the time during which the output is either high or low is determined by 2 resistors and capacitors, which are externally connected to the 555 timer. (2M)
8	**Explain IC 555 timer. (8M)** BTL2 Diagram: (5M)  In the Stable state: (3M) • The output of the control FF is high. This means that the output is low because of power amplifier which is basically an inverter. Q = 1; Output = 0 • At the Negative going trigger pulse: • The trigger passes through (Vcc/3) the output of the lower comparator goes high & sets the FF. Q = 1; Q = 0 • At the Positive going trigger pulse: It passes through 2/3Vcc, the output of the upper comparator goes high and resets the FF. Q = 0; Q = 1 • The reset input (pin 4) provides a mechanism to reset the FF in a manner which overrides the effect of any instruction coming to FF from lower comparator.
	PART *C
1	**With a neat diagram explain blocks and function of IC723. (15M)** BTL4 Features of IC723: (9M) Unregulated dc supply voltage at the input between 9.5V & 40V Adjustable regulated output voltage between 2 to 3V. Maximum load current of 150 mA (ILmax = 150mA). With the additional transistor used, ILmax upto 10A is obtainable. Positive or Negative supply operation Internal Power dissipation of 800mW. Built in short circuit protection. Very low temperature drift. High ripple rejection. (6M) Diagram:

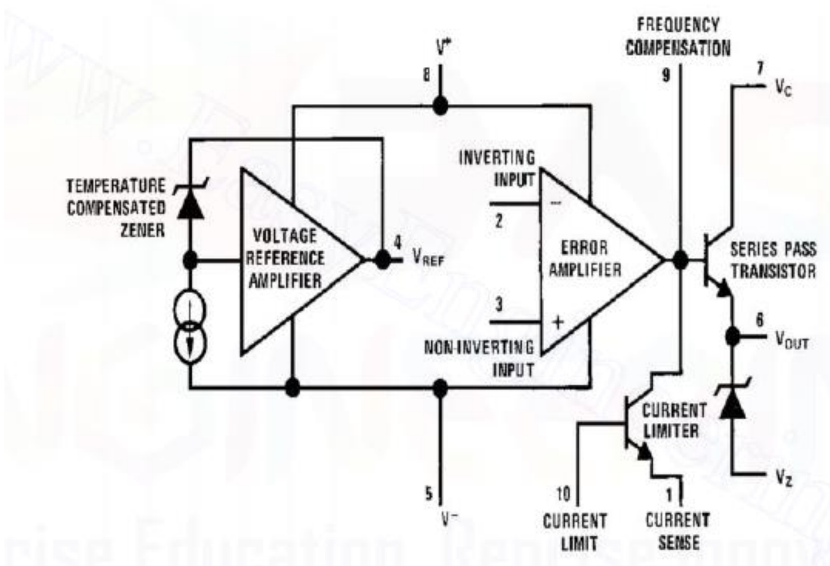


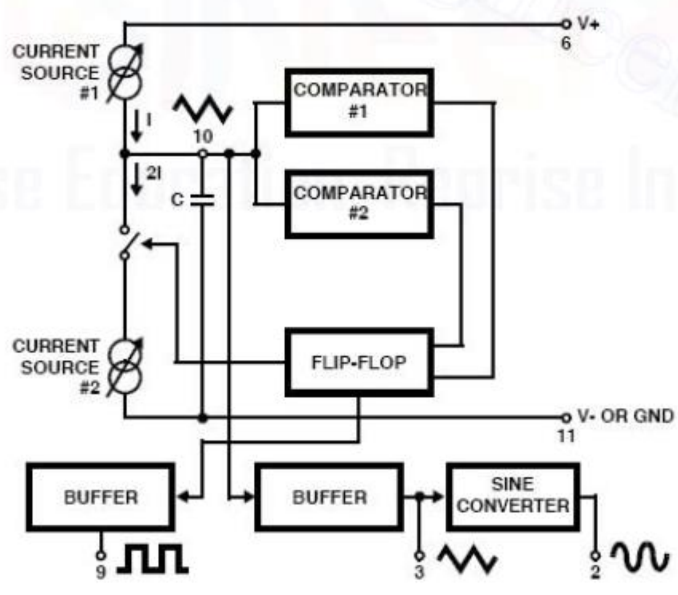
Fig. 5.29 Functional block diagram of IC723

2

Develop the basic principle of function generator? Draw the schematic of ICL 8038 function generator and discuss its features. (7M)

(ii)Solve the expression for the frequency of a triangular waveform generator and explain the circuit. (8M) BTL4

Diagram: (7M)



Important features of IC 8038:

- All the outputs are simultaneously available.
- Frequency range : 0.001Hz to 500kHz
- Low distortion in the output wave forms.
- Low frequency drifts due to change in temperature.

- Easy to use.

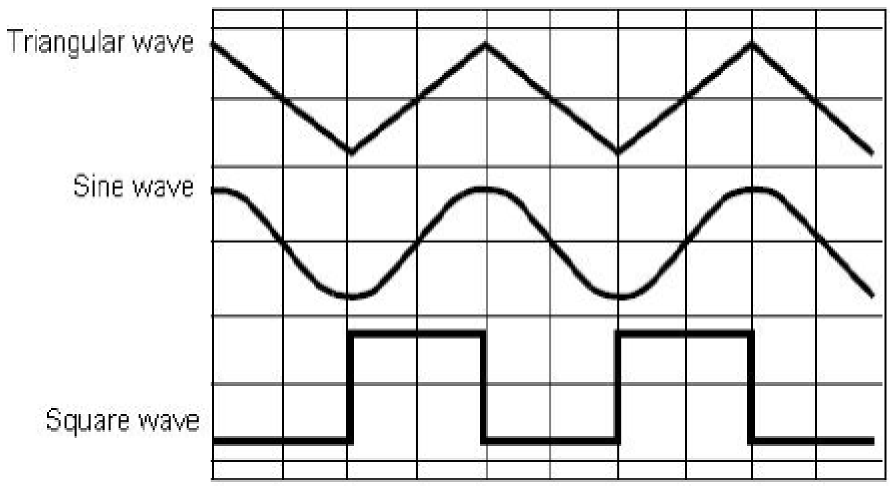


Diagram: (8M)

5.2.3 Triangular Wave Generator Circuit:

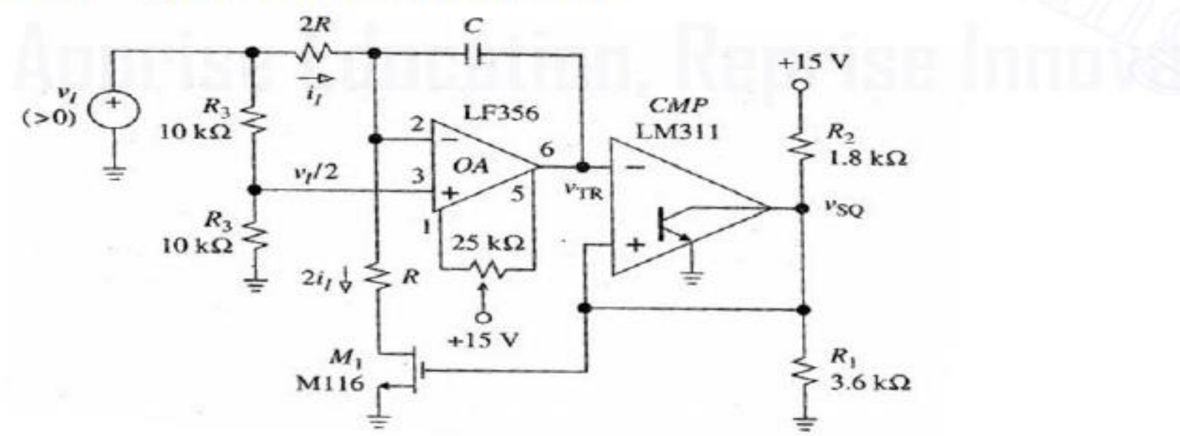


Fig. 5.9 Circuit diagram of Triangular waveform generator

3

Write some applications of IC 555 Timer Monostable Mode of Operation. BTL4

(a) Frequency Divider: (5M)

- The 555 timer as a monostable mode.
- It can be used as a frequency divider by adjusting the length of the timing cycle tp with respect to the time period T of the trigger input.
- To use the monostable multivibrator as a divide by 2 circuit, the timing interval tp must be a larger than the time period of the trigger input.
- [Divide by 2, tp > T of the trigger] By the same concept, to use the monostable multivibrator as a divide by 3 circuit, tp must be slightly larger than twice the period of the input trigger signal & so on, [divide by 3tp > 2T of trigger]

(b) Pulse width modulation: (5M)

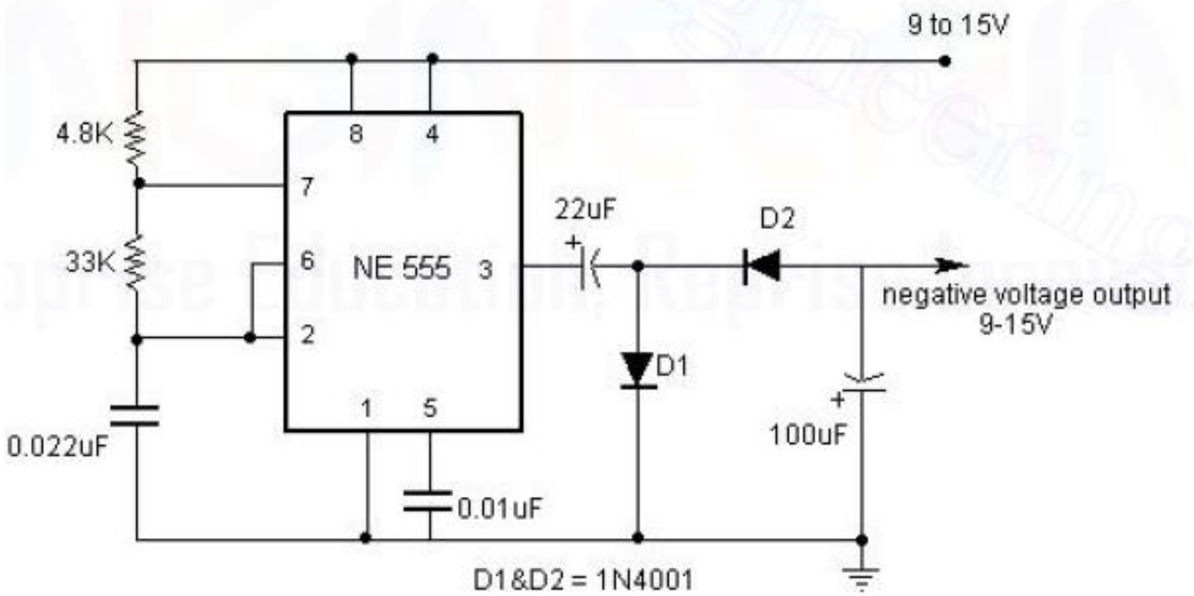


Fig.5.20 Pulse Width Modulation

- Pulse width of a carrier wave changes in accordance with the value of a
- incoming (modulating signal) is known as PWM.
- It is basically monostable multivibrator. A modulating signal is fed in to the control voltage (pin 5).
- Internally, the control voltage is adjusted to 2/3 Vcc externally applied modulating signal changes the control voltage level of upper comparator.
- As a result, the required to change the capacitor up to threshold voltage level changes, giving PWM output.

(c) Pulse Stretcher: (5M)

- This application makes use of the fact that the output pulse width (timing interval) of the monostable multivibrator is of longer duration than the negative pulse width of the input trigger. As such, the output pulse width of the monostable multivibrator can be viewed as a stretched version of the narrow input pulse, hence the name “Pulse stretcher”.
- Often, narrow –pulse width signals are not suitable for driving an LED display, mainly because of their very narrow pulse widths. In other words, the LED may be flashing but not be visible to the eye because its on time is infinitesimally small compared to its off time.
- The 55 pulse stretcher can be used to remedy this problem. The LED will be ON during the timing interval tp = 1.1RAC which can be varied by changing the value of RA & C.

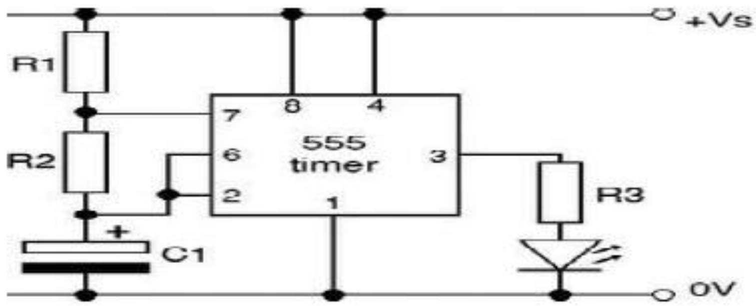


Fig.5.23 Pulse Stretcher

GE8291 ENVIRONMENTAL SCIENCE AND ENGINEERING L T P C
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OBJECTIVES:

- ✓ To the study of nature and the facts about environment.
- ✓ To find and implement scientific, technological, economic and political solutions to environmental problems.
- ✓ To study the interrelationship between living organism and environment.
- ✓ To appreciate the importance of environment by assessing its impact on the human world; envision the surrounding environment, its functions and its value.
- ✓ To study the dynamic processes and understand the features of the earth‘s interior and surface.
- ✓ To study the integrated themes and biodiversity, natural resources, pollution control and waste management.

UNIT I ENVIRONMENT, ECOSYSTEMS AND BIODIVERSITY 14

Definition, Scope and Importance of Environment – Need for Public Awareness - Concept of an Ecosystem – Structure and Function of an Ecosystem – Producers, Consumers and Decomposers – Energy Flow in the Ecosystem – Ecological Succession – Food Chains, Food Webs and Ecological Pyramids – Introduction, Types, Characteristic Features, Structure and Function of the (A) Forest Ecosystem (B) Grassland Ecosystem (C) Desert Ecosystem (D) Aquatic Ecosystems (Ponds, Streams, Lakes, Rivers, Oceans, Estuaries) – Introduction to Biodiversity Definition: Genetic, Species and Ecosystem Diversity – Bio geographical Classification of India – Value of Biodiversity: Consumptive Use, Productive Use, Social, Ethical, Aesthetic and Option Values – Biodiversity at Global, National and Local Levels – India as a Mega-Diversity Nation – Hot-Spots of Biodiversity – Threats to Biodiversity: Habitat Loss, Poaching of Wildlife, Man-Wildlife Conflicts – Endangered and Endemic Species of India – Conservation of Biodiversity: In-Situ and Ex-Situ Conservation of Biodiversity. Field Study of Common Plants, Insects, Birds Field Study of Simple Ecosystems – Pond, River, Hill Slopes, etc.

UNIT II ENVIRONMENTAL POLLUTION 8

Definition – Causes, Effects and Control Measures of: (A) Air Pollution (B) Water Pollution (C)Soil Pollution (D) Marine Pollution (E) Noise Pollution (F) Thermal Pollution (G) Nuclear Hazards – Soil Waste Management: Causes, Effects and Control Measures of Municipal Solid Wastes – Role of an Individual in Prevention of Pollution – Pollution Case Studies – Disaster Management: Floods, Earthquake, Cyclone and Landslides. Field Study of Local Polluted Site – Urban / Rural / Industrial / Agricultural.

UNIT III NATURAL RESOURCES 10

Forest Resources: Use and Over-Exploitation, Deforestation, Case Studies - Timber Extraction, Mining, Dams and Their Effects on Forests and Tribal People – Water Resources: Use and Over-Utilization of Surface and Ground Water, Floods, Drought, Conflicts Over Water, Dams-Benefits and Problems – Mineral Resources: Use and Exploitation, Environmental Effects of Extracting and Using Mineral Resources, Case Studies – Food Resources: World Food Problems, Changes Caused by Agriculture and Overgrazing, Effects of Modern Agriculture, Fertilizer-Pesticide Problems, Water Logging, Salinity, Case Studies – Energy Resources: Growing Energy Needs, Renewable and Non Renewable Energy Sources, Use of Alternate Energy Sources. Case Studies – Land Resources: Land as a Resource, Land Degradation, Man Induced Landslides, Soil Erosion and Desertification – Role of an Individual in Conservation of Natural Resources – Equitable Use of Resources for Sustainable Lifestyles. Field Study of Local Area to Document Environmental Assets – River / Forest / Grassland / Hill / Mountain.

UNIT IV SOCIAL ISSUES AND THE ENVIRONMENT 7

From Unsustainable to Sustainable Development – Urban Problems Related to Energy – Water Conservation, Rain Water Harvesting, Watershed Management – Resettlement and Rehabilitation of People; its Problems and Concerns, Case Studies – Role of Non-Governmental Organization- Environmental Ethics: Issues and Possible Solutions – Climate Change, Global Warming, Acid Rain, Ozone Layer Depletion, Nuclear Accidents and Holocaust, Case Studies. – Wasteland Reclamation – Consumerism and Waste Products – Environment Production Act– Air (Prevention And Control Of Pollution) Act – Water (Prevention And Control Of Pollution) Act – Wildlife Protection Act – Forest Conservation Act – Enforcement Machinery Involved in Environmental Legislation- Central and State Pollution Control Boards- Public Awareness.

UNIT V HUMAN POPULATION AND THE ENVIRONMENT 6

Population Growth, Variation Among Nations – Population Explosion – Family Welfare Programme – Environment and Human Health – Human Rights – Value Education – HIV / AIDS – Women and Child Welfare – Role of Information Technology in Environment and Human Health – Case Studies.

TOTAL: 45 PERIODS

OUTCOMES:

Environmental Pollution or problems cannot be solved by mere laws. Public participation is an important aspect which serves the environmental Protection. One will obtain knowledge on the

- ✓ Public awareness of environmental is at infant stage.
- ✓ Ignorance and incomplete knowledge has lead to misconceptions
- ✓ Development and improvement in std. of living has lead to serious environmental disasters

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Subject Code: GE8291 **Year/Semester: I&II /02&04**
Subject Name: ENVIRONMENTAL SCIENCE AND ENGINEERING
Subject Handler: Dr. N. BHUVANA & Dr. C. KAVITHA

UNIT I - ENVIRONMENT, ECOSYSTEMS AND BIODIVERSITY

Definition, scope and importance of environment – need for public awareness - concept of an ecosystem – structure and function of an ecosystem – producers, consumers and decomposers – energy flow in the ecosystem – ecological succession – food chains, food webs and ecological pyramids – Introduction, types, characteristic features, structure and function of the (a) forest ecosystem (b) grassland ecosystem (c) desert ecosystem (d) aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries) – Introduction to biodiversity definition: genetic, species and ecosystem diversity – biogeographical classification of India – value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values – Biodiversity at global, national and local levels – India as a mega-diversity nation – hot-spots of biodiversity – threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts – endangered and endemic species of India – conservation of biodiversity: In-situ and ex-situ conservation of biodiversity. Field study of common plants, insects, birds; Field study of simple ecosystems – pond, river, hill slopes, etc.

Q. No.	PART – A
1.	**State the significance and scope of environmental education. May 2011** BTL1 • People will understand the concept of need of development without destruction of environment. • Motivate the active participants in environmental protection and improvement. • Develop a concern and respect for the environment.
2	**Give some important physical hazards and their health effects.** BTL2 • The substance (or) activities that threaten your physical safety. **E.g**. Heat, Cold, Radiation, noise. • **Health effects** – Damage of cells, Skin cancer, Damage of ear drum etc.
3	**Define environment and ecosystem. April 2011, April 2019** BTL1 • **Environment**: The sum of total of all the living and non-living things around us influencing one another. • **Ecosystem**: A group of organisms interacting among themselves and with environment for exchanging energy and matter.
4	**Explain the concept of an ecosystem. (Chen AU Jun 2007, Apr 2011, Dec2013)** BTL2 A group of organism interacting among themselves and with the environment. May be natural like a pond, a lake, a river, an ocean, or a forest or may be manmade like an aquarium, cropland, garden, dam etc.
5	**What are the components of ecosystem?** BTL1 i) Abiotic or Non-living component - Physical components and Chemical components **ii)** Biotic or Living component – Autotrophs (Producers), Heterotrophs (Consumers), Saprotrophs (Decomposers-Microconsumers)
6	**Define Ecological succession. (NOV/DEC 2013, April 2019)** BTL1

	The progressive replacement of one community by another till the development of stable community in a particular area.
7	**Name the types of consumers.** BTL4 • Herbivores (or) Primary Consumers (plant eater) • Carnivores (or) Secondary Consumers (meat eater) • Omnivores (or) Tertiary Consumers (meat + plant eater)
8	**What are Decomposers?** BTL1 Organisms which feed on dead organisms, plants and animals and decompose them into simpler compounds. Examples – Bacteria, fungi etc.
9	**What are autotrophic and heterotrophic components of an ecosystem? Give examples (Coim. A.U. Dec 2009)** BTL1 • **Autotrophic components** Self-nourishing organisms. The members of autotrophic components are producers. They derive energy from sunlight and make organic compounds from inorganic substances. Examples: Green plants, algae, bacteria, etc., • **Heterotrophic components** Components that dependent on others for food. The members of heterotrophic components are consumers and decomposers. Herbivores, carnivores (or) omnivores. • **Saprotrops:** They are decomposers - bacteria, fungi, etc.
10	**Define the terms producers and consumers. (A.U. May 2008, Dec 2011)** BTL1 • **Producers**-Synthesize their food themselves through photosynthesis. • **Consumers**-Organisms which cannot prepare their own food and depends directly or indirectly on the producers.
11	**Define primary production and secondary production. (Chen A.U. Dec 2008)** BTL1 • **Primary production** - The conversion of radiant energy into organic substances by photosynthesis by producers (Plants). • **Secondary production**- Distribution of energy in the form of food to the consumer (or) the energy stored by the consumer.
12	**What is Ecological pyramids?** BTL1 Graphical representation of structures and function of tropic levels of an ecosystem, starting with producers at the bottom and each successive tropic level forming the apex is known as ecological pyramids.
13	**Name different types of ecosystems**. **(Chen AU Jan 2006)** BTL1 • Natural ecosystem: 1) Terrestrial ecosystem 2) Aquatic ecosystem a. Forest ecosystems b. Grassland ecosystems c. Desert ecosystems d. Pond ecosystem. e. Lake ecosystem f. River ecosystem g. Marine ecosystem • Man-made ecosystem
14	**What are the characteristics of desert ecosystem? (Chen A.U. Dec 2008, June 2018)** BTL1 • The desert air is dry and the climate is hot. • Annual rainfall is less that 25cm. • The soil is very poor in nutrients and organic matter. • Vegetation is poor
15	**What is meant by keystone species? (Chen A.U. Dec 2008, June 2018)** BTL1 Within a habitat each species connects and depends on other species. But, while each species

	contribute to habitat functioning, some species do more than others in the overall scheme of things. Without the work of these key species, the habitat changes significantly. These species are called keystone species. When a keystone species disappears from its habitat, that habitat changes drastically.
16	**What are the types of grassland ecosystem? (Chen A.U. Dec 2010)** BTL1 There are three types of grassland ecosystem based on the climate condition. i) Tropical grassland ii)Temperate grassland iii) Polar grassland
17	**What are food chains? Mention their type**. **(Chen A.U. Dec 2010)** BTL1 **Food chain-**The sequence of eating and being eaten in an ecosystem. **Types :** i) Grazing food chain (from the living green plants goes to grazing herbivores, and on to carnivores) **ii)** Detritus food chain (Primary source of energy is dead organic matter called 'detritus' which are fallen leaves, plant parts or dead animal bodies)
18	**Define Biodiversity (or) What is biodiversity and its significance? (Chen AU Dec 2005, Jun 2006,Apr 2011,Apr 2015)** BTL1 • The variety and variability among all groups of living organisms and the ecosystem in which they occur. **Significance:** • Very important for human life, as we depend on plants, micro-organisms, earth's animals for our food, medicine and industrial products. • Also important for forestry, fisheries and agriculture, which depend on rich variety of various biological resources available in nature. • Protects the fresh air, clean water and productive land. • Loss of biodiversity has serious economic and social costs for any country
19	**Define genetic diversity, species diversity and ecosystem diversity. (TNV AU Dec 2008, Chen AU Dec 2007, May 2008, Dec2010, 2011)** BTL1 • **Genetic diversity**-Diversity of genes within a species. • **Species diversity**–Diversity among species in an ecosystem. • **Ecosystem diversity**-Diversity at the ecological or habitat level.
20	**What are biodiversity hot-spots? (Chen AU Apr 2011)** BTL1 The geographic areas which possess the high endemic species. The two important biodiversity hot spots in India- 1. Eastern Himalayas 2. Western Ghats.
21	**What are the criteria for recognizing hot spots? (Chen AU Dec 2011)** BTL1 • The Richness of the endemic species is the primary criterion for recognizing hot spots • The hot spots should have a significant percentage of specialized species. • The site is under threat. • It should contain important gene pools of plants of potentially useful plants.
22	**India is a mega diversity nation–Account. (Chen A.U. Dec 2008, Dec 2009)** BTL4 India is one among the 12 mega diversity countries in the world. It has 89,450 animal species accounting for 7.31% of the global faunal species and 47,000 plant species which accounts for 10.8% of the world floral species. The loss of biodiversity or endemism is about 33%.
23	**Give few examples for endangered and endemic species of India. (Chen A.U. Dec 2008)** BTL3 **Endangered species**

	i) **Reptiles:** Tortoise, python; ii) **Mammals:** Indian wolf, Red fox, Tiger; iii) **Primates:** Hoolock gibbon, Golden monkey; iv) **Plants :** Rauvol serpentina, Santalum **Endemic Species** i) **Flora:** Sapria Himalayan, Ovaria lurida ; **ii) Fauna:** Monitor lizards, Indian salamander
24	**Define endangered and endemic species. (Chen A.U. Dec 2006, Apr 2011, Dec 2014)** BTL2 **Endangered Species**-Species which number has been reduced to a critical level. Unless protected and conserved, it becomes immediate danger of extinction. **Endemic species**-The species which found only in a particular region.
25	**Define in-situ conservation and ex-situ conservation** BTL1 **In-situ conservation** - Protection of fauna and flora within their natural habitat, where the species normally occurs is called in-situ conservation. **Ex-situ conservation -** Protection of fauna and flora outside their natural habitats
26	**Enumerate the human activities which destroy the biodiversity**. **(Chen AU Jan 2006)** BTL2 • The farmers prefer hybrid seeds; as a result many plant species become extinct. • For the production of drugs the pharmaceutical companies collect wild plants, so several medicinal plants now become extinct. • Tropical forest is the main sources of world's medicine. Every year these forests are disappearing due to agriculture, mining and logging
27	**Define food web.** BTL1 A network of food chains where different types of organisms are connected at different tropic levels.
28	**Write the food chain in forest ecosystem.** BTL4 Grasshopper→ Woodpecker →Snake → Owl
29	**Write the food chain in lake ecosystem.** BTL4 Algae → Ciliates →Small fish → Large fish
30	**What is biome?** BTL1 Set of ecosystems which are exposed to same climatic conditions and having dominant species with similar life cyclic, climatic adoptions and physical structure.
31	**What is photosynthesis? (or) How the carbohydrates are produced by plants?** BTL1 Chlorophyll present in the leaves of plants converts CO_2 and H_2O in the presence of sunlight into carbohydrates. $$6CO_2 + 12H_2O \xrightarrow{hr} C_6H_{12}O_6 + 6O_2 + 6H_2O$$
32	**List the different processes of ecological succession.** BTL1 i) Nudation ii) Invasion iii) Competition iii) Reaction iv) Stabilizations
33	**Define extinct, threatened and vulnerable species. (Chen A.U. Dec 2006, Apr 2011, Dec 2014)** BTL2 • **Extinct species –** The species no longer found in the world. • **Threatened Species** Becoming rare and that may become in danger of extinction if current trends continue. • **Vulnerable Species**- Species which population facing continuous decline due to habitat destruction or over exploitation.
34	**Mention the types of lakes.** BTL4 • **Oligotrophic lakes:** Have low nutrient concentrations. • **Eutrophic lakes**: Over nourished by nutrients like N and P. • **Dystrophic lakes**: Have low pH, high humic acid content and brown waters.

	• **Volcanic lakes**: Receive water from magma after volcanic eruptions. • **Meromictic lakes**: Rich in salts. • **Artificial lakes:** Created due to construction of dams
35	**List the different zones of oceans.** BTL4 • **Coastal zone:** Relatively warm, nutrient rich shallow water, High primary productivity. • **Open sea**: Deeper part of the ocean. Vertically divided into three regions. i) **Euphotic zone:** Receives abundant light and shows high photosynthetic activity ii) **Bathyal zone:** Receives dim light and is usually geologically active. iii) **Abyssal zone:** Dark zone and is very deep (2000 to 5000 meters)
36.	**How do the desert plants adopt to the climate? (MAY 2018)** BTL4 Most of the plants have the ability to lack of rainfall. They have widespread roots which are close to the surface. This enables the roots to absorb water quickly, before it evaporates. Plants like cactus survives because of their thick waxy layer on the outside of its stems and leaves. This helps to retain water and protect tissues severe sunlight.
37.	**Define nitrogen cycle and oxygen cycle.** BTL1 **Nitrogen cycle**-Exchange of nitrogen between the lithosphere and atmosphere in cyclic manner. **Oxygen cycle**-Exchange of O_2 between the lithosphere and atmosphere and hydrosphere in a cyclic manner. Cyclic process of Photosynthesis and respiration.
38.	**What is an indicator species? (MAY 2018)** BTL1 An indicator species is an organism whose presence, absence or abundance reflects a specific environmental condition. Indicator species can signal a change in the biological condition of a particular ecosystem, and thus may be used as a proxy to diagnose the health of an ecosystem**.** Example: Plants or lichens sensitive to heavy metals or acids in precipitation may be indicators of air pollution**.**
	PART – B
1.	
	What is environment? List its types. Explain its scope and significance of environment studies. (13M) BTL2 **Answer: Page: 1.2–1.4-A. Ravikrishnan** **Definition-** The sum of all living and non-living things around us influence one another. (2 M) **Types-** i) Natural environment – naturally created all biotic and non-biotic components. ii) Man-made environment- Created by man. (2 M) **Scope of environmental studies** i) Awareness and sensitivity + related problems. ii) Motivate active participation. iii) Identification and solving environmental problems. iv) Awareness on conservation of natural resources. (4 M) **Significance or importance** i) Environment issues being of internal importance. ii) Problems cropped in the wake of development. iii) Explosively increase in pollution. iv) Need for an alternative solution.

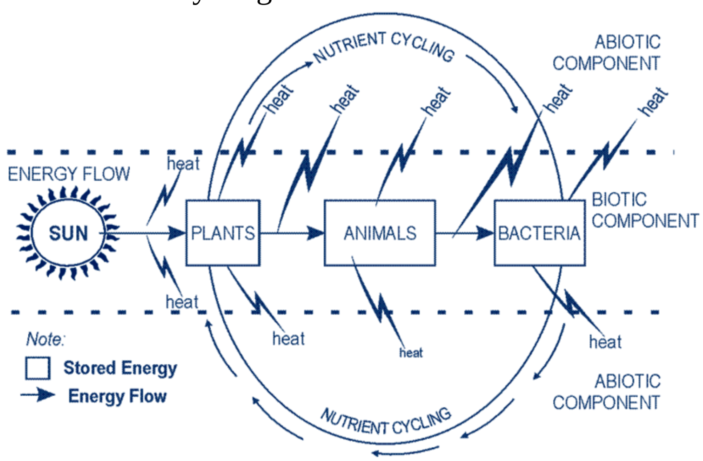
v) Need to save Humanity from extinction.
vi) Need for Wise planning of development. (5 M)

2.

Explain the flow of energy through the atmosphere and its utilities in an ecosystem. (8M)(AU Dec. 2008) BTL2

Answer: Page: 2.10–2.11-**A. Ravikrishnan**
Atmosphere → Sunlight major source of energy → Plants (Photosynthesis) Primary Consumer → Secondary consumer → Decomposer
First law of thermodynamics. Plants (Photosynthesis)
Second law of thermodynamics. Primary Consumer → Secondary consumer → Decomposer

- Loss of energy takes place through respiration, running, hunting etc
- Biotic components and abiotic components are linked together through energy flow and nutrient cycling. (5 M)



(3 M)

3.

Explain abiotic and various biotic components of an Ecosystem with neat sketch. (13M) (A.U. Dec 2007, Jan 2018) BTL2

Answer: Page:2.6–2.8-**A. Ravikrishnan**
Abiotic-Nonliving components-Physical and chemical components. (2 M)
Biotic components-Living organisms.

i) **Autotrophs-Producers (Plants)**–Self nourishing Organisms. (3 M)
ii) **Consumers (Animals) (Heterotrophs)**–Cannot make their own food. Herbivores-Carnivores-Omnivores. (3 M)
iii) **Decomposers (Micro-Organisms) (Saprotrops)-** Feed on dead organisms. (3 M)

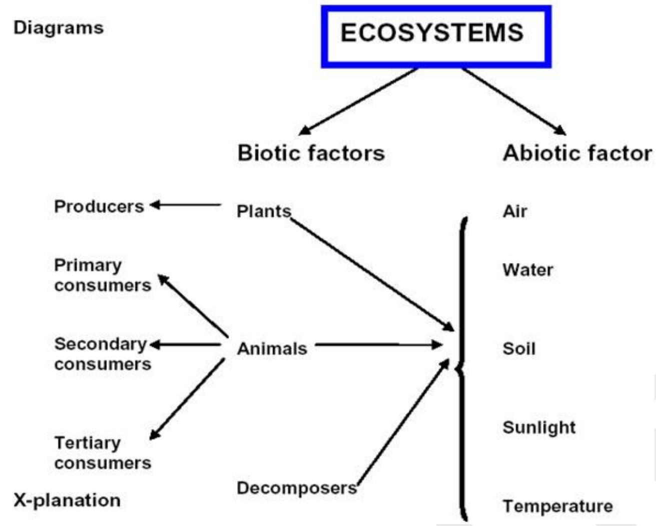


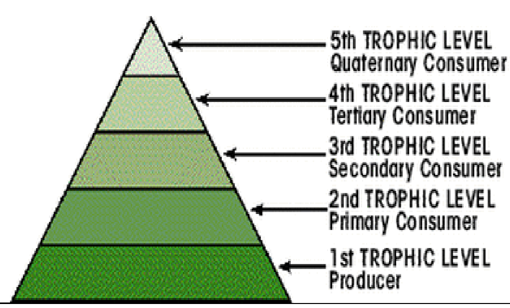
Diagram – (2M)

4.

Write down the ecological succession and ecological pyramid. (13M) (A.U. Dec 2010, Apr 2015, May 2006, Dec 2019) BTL1

Answer: Page: 2.16 – 2.17-A. Ravikrishnan

- **Ecological succession-** The progressive replacement of one community by another till the development of stable community in a particular area. (1 M)
- **Stages of ecological succession** (1 M)
- (i) Pioneer community – First group of organism established their community in the area.
- Seral or seres stage- Variuos developmental stages of a community.
- **Types of ecological succession:** (4M)
- **Primary succession**– Gradual establishment of biotic communities on a lifeless ground
- (a) Hydrarch (or) Hydrosere: Establishment starts in a watery area like pond and lake.
- (b) Xerarch or Xerosere: Establishment starts in a dry area like, desert and rock.
- **Secondary succession**: Establishment of biotic communities in an area, where some type of biotic community is already present.
- **Process of Ecological Succession:** i) Nudation ii) Invasion–migration and establishment iii) competition iv) Reaction and v) Stabilization. (4 M)
- **Ecological Pyramids-**Graphic representation of tropic structure and function of an ecosystem



	(3 M)
5.	
	Explain the structure and function of the following. (i) Forest ecosystem (ii) Grassland ecosystem (iii) Desert ecosystem (iv) Aquatic ecosystem (13M) (A.U. May2011, May 2006) BTL2 **Answer: Page: 2.30 – 2.31, 2.33 – 2.34, 2.36 – 2.37, 2.38 – 2.40, 2.43 – 2.44-A. Ravikrishnan** **(i) Structure and Function of forest ecosystem:** • **Abiotic components** - Physical components found in the soil and atmosphere. Exs: Climatic factors (temperature, light, rainfall) and minerals. • **Biotic components-Producers**-Plants-Photosynthesis-Trees, shrubs and ground vegetation. • **Consumers**-Primary consumers (herbivores)-Ants, flies, insects, mice, deer, squirrels. • **Secondary consumers** (primary carnivores)- Snakes, birds, fox. • **Tertiary consumers**-Tigre, lion, etc. • **Decomposers**–Bacteria and fungi. (3M) **(ii) Structure and Function of Grassland Ecosystem**.- • **Abiotic**–C, H, O, N, P, S etc.–Supplied by rates, nitrates, phosphates and sulphates. • **Biotic**–Producers–Grasses, forbs and shrubs • **Consumers**–Cows, cows, buffaloes, deer, sheep • **Decomposers**–Fungi and bacteria. (3M) **(iii) Structure & Function of Desert Ecosystem-** • **Abiotic**–temperature, rainfall, sunlight, water, • **Biotic** – Producers – shrubs, bushes, grasses, • **Consumers**–Squirrels, mice, foxes; • **Decomposers** – fungi and bacteria. (3M) **(iv) Structure and Function of Aquatic Ecosystem-Pond**–Temporary-Fresh water body. • **Abiotic**– Temperature, light, water, organic and inorganic compounds. • **Biotic**–Producers–green photosynthetic organisms, • **Consumers**–Protozoa, small fish, ciliates, flagellates • **Decomposers**–Fungi, bacteria and flagellates. (2M) **Structure and Function of Aquatic Ecosystem-Lakes**–Natural shallow water bodies • **Abiotic**–Temperature, light, proteins and lipids, turbidity, oxygen and carbon dioxide. • **Biotic–Producers**–Phytoplanktons, algae, flagellates, • **Consumers**–Protozoans, insects, small fishes, large fish; • **Decomposers**–Bacteria, fungi and actinomycetes. (2M)
6.	
	Classify and explain the values of biodiversity. (13M) (A.U. Dec 2010, May 11, Jan 2018) BTL2 **Answer: Page: 3.5 – 3.9-A. Ravikrishnan**

	Classify values biodiversity – Consumptive use values; Productive use values; Social values; Ethical values; Optional values. (1M) **Consumptive use values**–Direct use values; products are harvested and consumed directly. Food, Drugs, Fuel. (2 M) **Productive use values**–Products derived from the animals and plants-commercial value. (2M) **Social values**–Bio-resources used to the society. Associated with the social life, religion and spiritual aspects of the people. (2M) **Ethical values**–"All life must be preserved". In India biodiversity have great value on religious and cultural basis. (2M) **Optional values**–Any species may be proved to be a valuable species after someday. (2M) **Aesthetic values-** Beautiful nature of plants and animals insist us to protect the biodiversity. "Eco-tourism" (2M)
7.	
	Explain the role of biodiversity at global, national and local levels. (13M) (A.U. May 07, Apr 10, May 11, June 2019) BTL2 **Answer: Page: 3.9 – 3.14-A. Ravikrishnan** **Role of Global biodiversity**- Total number of living species in the world are about 20 million. But, of which only about 1.5 million species are found and given scientific names. Tropical deforestation alone is reducing the biodiversity by 0.5% every year. **Terrestrial biodiversity or biomass** i) Largest ecological units present in different geographic areas named in different ways ii) Tropical rain forests –About 50 to 75% of global biodiversity lies in these tropical rain forest. iii) More than 25% of the world's prescription drugs are extracted from plants in tropical rain forest iv) Nearly 1,30,000 flowering plants are found available v) Temperate rain forests - Have much less biodiversity. 1,70,000 flowering plants, 30, 000 vertebrates, 2,50,000 other group of species are found. (3M) **Marine diversity** i) Much higher than terrestrial biodiversity ii) Estuaries coastal waters and oceans are biologically diverse but the diversity is very low iii) Out of 35 existing phyla of multicellular animals, 34 are marine iv) List of few living species (2M) **National level biodiversity**: i) India is second largest nation containing 5% of world's biodiversity and 2% of the earth surface. The second largest nation containing 50% of world's biodiversity and 2% of earth surface. ii) 10^{th} rank among the plant rich countries of the world. iii) 11^{th} rank among the endemic species of higher vertebrates. iv) 6^{th} rank among the centers of diversity and origin of agricultural crops. v) An agricultural country and its economic growth depend on the production of many crops. vi) India "mega - diversity" nation because it is rich in both fauna and flora.

	vii) Many species in India has Medicinal value and Commercial value (5M) **Biodiversity at local level** -1. Point richness 2. Alpha richness 3. Beta richness 4. Gamma richness. (3M)
8.	
	(i) Give the various hot spots of biodiversity.(ii) Explain the various threats to biodiversity along with the means to conserve them. (13M) (May 2008, MAY/JUNE 2013, Dec 2019) BTL4 **Answer: Page: 3.18 – 3.25-A. Ravikrishnan** (i) **Biodiversity hotspot-**The geographic areas which possess high endemic species. Eastern Himalayas, Western Ghats. (2M) **(ii)Threats to biodiversity** • **Habitat loss-**The loss of populations of interbreeding organisms. Threatened a wide range of animals and plants. Factors influencing habitat loss and any two remedies. (3M) • **Poaching-**Killing of animals (or) commercial hunting. Leads to loss of animal biodiversity. Factors influencing poaching loss and any two remedies to overcome. (3M) • **Man-Wild life conflict-** Arise when wildlife starts causing immense damage and danger to the man. Factor influencing man-wild life conflict and two conserve methods. (3M) • **Over exploitation of natural resources** i) Serious threat to the wildlife. ii) Disturbance in migratory routes of animals. iii) Cause of destruction of many species. (2M)
9.	
	Explain in-situ and ex-situ conservation along with their merits and limitations. (A.U. May 2008, Dec 2010, May 11, Dec 11) (13M) BTL2 **Answer: Page: 3.34 – 3.40-A. Ravikrishnan** **Conservation of Biodiversity:** management of biosphere so that it will yield the greatest sustainable benefit to present generation while maintaining its potential to meet the needs of future generation. (1M) **In-Situ Conservation (within habitat)** - Protection of wild flora and fauna within their habitat nature. (1 M) Biosphere reserves, National Parks, Sanctuaries, Reserve forests etc. (Each 1 M = 4M) **Advantages:** Cheap and convenient method. Species gets adjusted the natural disasters like drought, floods, forest fires. (1 M) **Limitations:** Large surface area of the earth required – shortage of staff and pollution may lead to improper maintenance of the habitat. (1 M) **Ex-Situ Conservation (outside habitat)** – Protection of flora and fauna outside their habitat nature. (1 M) Gene banks, seed banks, zoos, botanical gardens, culture collections. (2 M) **Advantages:** Special care and attention lead, Assured food, water, shelter and security, Longer

	life span. (1 M) **Limitations:** Expensive method- Loss of freedom of wild life – Animals cannot survive in such environments. (1 M)
10.	

Write a note on endangered and endemic species of India. (13M) (A.U. Dec 2009) BTL2

Answer: Page: 3.28 – 3.33-A. Ravikrishnan

Endangered Species – Species number has been reduced to a critical level. Unless it is protected and conserved, it is in immediate danger of extinction.

i) In India 450 plant species identified as endangered species.
ii) About 100 mammals and 150 birds are endangered species.
iii) India biodiversity threatened due to habitat destruction, degradation and over exploitation.
iv) No. of endangered species in India

Group of Threatened species	Number of Threatened species
Plants	250
Birds	70
Mammals	86
Reptiles	25
Amphibians	3
Fishes	3
Molluscs	2

(6M)

Factors affecting endangered species

- Pollution
- Over exploitation
- Climate change

Remedial measures

- International Treaties on Endangered Species (ITES) (1M)

Endemic Species-Species found only in a particular region

i) In India, Out of 47,000 species 7,000 plants are endemic.
ii) About 62% endemic flora found in Himalayas, Khasi Hills and Western Ghats.
iii) **Fauna-**Animals present in particular region or period. E.g. Sapriya Himalayan, Ovaria lurida, Nepenthes Khasiana, Pedicularis parroter, Pitcher plants and Orchids etc.
iv) Out of 81,000 animal species–Large number of species are described to be endemic
v) 62% amphibians, 50% Lizards are endemic to Western Ghats
vi) No. of endemic species in India
vii)

Group	No. of Species
Land	878
Freshwater	89
Insecta	16214
Amphibia	110
Reptilia	214
Aves	69

Nannakua	38

viii) **Flora**–Plants present in a particular region or period. Friendly bacteria which helps to protect the human body against invasion by pathogens. E.g. Monitor lizards, reticulated python, Indian Salamander, Viviparous toad

Group	No. of Species
Pteridophyta	200
Angiosperms	4950

(5M)

Factor affecting endemic species

- Habitat loss and fragmentation
- Pollution (1M)

11.

What are the major causes of Man- wild life conflict? Discuss the remedial steps that can curb the conflict. (13M) (A.U. Dec 2011, Apr 2015) BTL4

Answer: Page: 3.26–3.28-A. Ravikrishnan

Man-Wildlife Conflicts-Causes:

i) Shrinking of forest
ii) Human encroachment into forest areas
iii) Animals suffering from illness, weak and injured take humans
iv) Lack of alternate cultivation practices by forest department
v) Electric fencing causes injury to animals, which in return turn violent
vi) Poor cash compensation by govt. to farmers
vii) Food crops near forest areas attract wild animals. (10 M)

Remedies to curb the conflict

i) Adequate crop and cattle compensation schemes must be started.
ii) Solar powered fencing must be provided along with electric current proof trenches.
iii) Cropping pattern should be changed near the forest borders.
iv) Adequate food and water should be made available within the forest areas.
v) The development and constructional work near the forest area must be avoided. (3 M)

PART – C

1.

(i) Elaborate about the different biological zones of India. (5M) BTL6

(ii) Discuss a case study on (a) Man and wild life conflicts (b) Productive use of biodiversity. (10M) BTL6

Answer: Page: 3.4 – 3.5, 3.26–3.28, 3.8-3.9 A. Ravikrishnan

(i) Biogeographically Classification of India:

i) Division of India according to biogeographic characteristics. The study of the distribution of species, organisms, and ecosystems in geographic space and through geological time. The biogeographic zones of India are as follows:
ii) Himalayan zone; Desert zone; Semiarid zone; Western Ghats zone; Deccan plateau zone; Gangetic plain zone; North east zone; Coastal zone; Islands present near the shore line; Trans Himalayan zone. (5 M)

(ii) Case study on Man-Wildlife Conflicts:

i) Wildlife causing damage and danger to humans and properties – crops/houses
ii) In Samalpur (Orissa) 195 humans were killed in the last 5 years by elephants.
iii) Humans responded by killing 98 elephants and injuring 30 elephants.
iv) In Nepal, 17 peoples were killed in the Royal Chitwan National Park by a man-eating tiger.
v) Electrical fencing, explosives were some of the methods adopted by villages to kill wild animals.

Causes:

i) Shrinking of forest
ii) Human encroachment into forest areas
iii) Animals suffering from illness, weak and injured take humans
iv) Lack of alternate cultivation practices by forest department.
v) Electric fencing causes injury to animals, which in return turn violent
vi) Poor cash compensation by govt. to farmers
vii) Garbage near human settlements or food crops near forest areas. (7 M)

Productive use of biodiversity

Products derived from the animals and plants have obtained a commercial value.

Plant product	Industry
Wood	Paper and pulp industry, plywood industry Railway sleeper industry.
Cotton	Textile industry
Fruits, vegetables	Food industry
Leather	Leather industry
Ivory	Ivory - works
Pearl	Pearls industry

(3M)

2.

Inspect about the characteristic features of a pond, river and marine ecosystem and also quote a typical food chain based on that respective ecosystem. (15M) BTL4

Answer: Page: 2.27 – 2.29, 2.33 – 2.36-A. Ravikrishnan

Pond Ecosystem

i) Small bodies of freshwater with shallow and still water, marsh, and aquatic plants.
i) Temporary, only seasonal.
ii) Stagnant fresh water body.
iii) Get polluted easily due to limited amount of water
iv) The size and depth of ponds often varies greatly
v) Diverse array of aquatic life
vi) Top predators may include large fish, herons, or alligators. (3 M)

Food Chain–Producers- Green plants, phytoplanktons like hydrilla, vallisneria, pistia, sagittaria → **Primary consumers**- Zooplanktons like insects, dragon fly larvae, crustaceans, Larvae of insects, beetles, fishes, molluscs → **Secondary consumers**- Insects like water beetles, frogs, fishes → **Tertiary Consumers-**Big fishes, kingfisher, water birds → **Decomposers**–Fungi, bacteria.

(2M)

River Ecosystem:

	i) River viewed as a system operating in its natural environment includes biotic as well as abiotic. i) Fresh water and free flowing water systems. ii) Due to mixing of water, dissolved oxygen content is more. iii) River deposits large amount of nutrients iv) Unidirectional flow. v) State of continuous physical change. High degree of spatial and temporal heterogeneity at all scales. (3M) **Food Chain**–**Producers**-Phytoplankton, algae, water grasses, aquatic masses, amphibious plants →**Primary consumers**-Water insects, snails, fishes → **Secondary consumers**-Birds and mammals → **Decomposers**–Fungi, bacteria. (2M) **Ocean Ecosystem:** i) Largest of Earth's aquatic ecosystems. ii) Include oceans, salt marsh and intertidal ecology estuaries and lagoons, mangroves and coral reefs, the deep sea and the sea floor. iii) Since ship, submarines can sail in ocean, commercial activities may be carried out. iv) Rich in biodiversity. v) Moderates the temperature of the earth vi) Contrasted with freshwater ecosystems. vii) Very important for the overall health of both marine and terrestrial environments. (3M) **Food Chain**–**Producers**-Phytoplanktons, marine plants → **Consumers-Primary consumers**-Crustaceans, moiluscs, fish → **Secondary consumers**-Herring sahd, mackerel→**Tertiary Consumers**-Cod, Haddock → Decomposers–Fungi, bacteria and flagellates. (2M)
3.	
	What is forest ecosystem? List the types of forest ecosystem. Explain the features, characteristics, structure and function forest ecosystem. (15M) BTL1 **Answer: Page: 2.17–2.21-A. Ravikrishnan** **Definition -** Contains tall and dense trees grow that support many animals and birds. (2M) **Types of Forest ecosystem** i) Tropical rain forests. ii) Tropical deciduous forests. iii) Tropical scrub forests. iv) Temperate rain forests. v) Temperate deciduous forests. (2M) **Features of Forest ecosystems** i) **Tropical rain forests:** Found near the equator. High temperature. Broad leaf trees and lion, tiger and monkey are present. ii) **Tropical deciduous forests:** Found little away from the equator. Warm climate and rain only during monsoon. Have deciduous trees and deer, fox, rabbit and rat. iii) **Tropical scrub forests:** Dry climate for longer time. Have small deciduous trees and shrubs and deer, fox, etc., iv) **Temperate rain forests:** Found in temperate areas with adequate rainfall. Coniferous trees and squirrels, fox, cats, bear etc., v) **Temperate deciduous forests:** Found in areas with moderate temperatures. Broad leaf deciduous trees and deer, fox, bear, etc (4M)

Characteristics of forest ecosystem:

i) Warm temperature and adequate rainfall → Generation of number of ponds, lakes etc.,
ii) Maintains climate and rainfall.
iii) Supports many wild animals and protects biodiversity.
iv) The soil is rich in organic matter and nutrients, which support the growth of trees.
v) The conversion of organic matter into nutrients is very fast. (2M)

Structure and Function of forest ecosystem:

i) **Abiotic components** - Physical components found in the soil and atmosphere. E.g. Climatic factors and minerals.
ii) **Biotic components-Producers**-The plants absorb sunlight and produce food through photosynthesis–E.g. Trees, shrubs and ground vegetation.
iii) **Consumers**-Herbivores-E.g. Ants, flies, insects, mice, deer, squirrels. Secondary consumers -primary carnivores-E.g. Snakes, birds, fox. Tertiary consumers- Tiger, lion, etc.
iv) **Decomposers**–E.g. Bacteria and fungi. (5M)

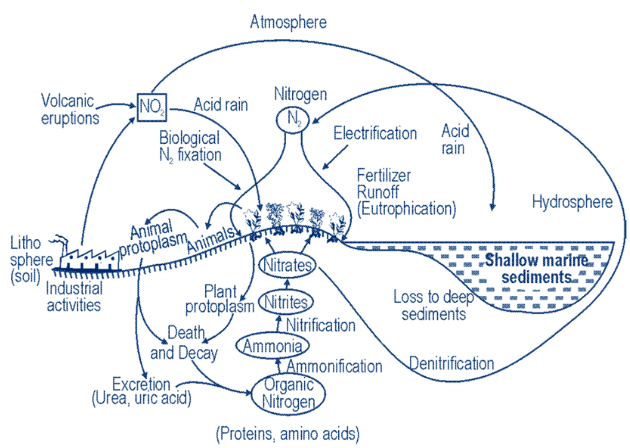
4.

(i) Survey the following topics with a neat diagram. (a) Nitrogen cycle b) Oxygen cycle c) Energy flow in the ecosystem. (12M) BTL4
(ii) Analyze in detail about hydrosere and xerosere (3M) BTL4

Answer: Page: 2.13 - 2.15 and 2.9 – 2.11 and 2.16-A. Ravikrishnan

(i)(a) Nitrogen cycle-Exchange of nitrogen between the lithosphere and atmosphere in cyclic manner.

Atmosphere nitrogen → Plants (protein, vitamin, amino acids) → Consumer → Decomposer
Nitrates→ammonia by anaerobic bacteria → nitrites by Nitrosomonas → nitrates by Nitrobacter -→ Rhizobium fixing N_2 in the roots. (3M)

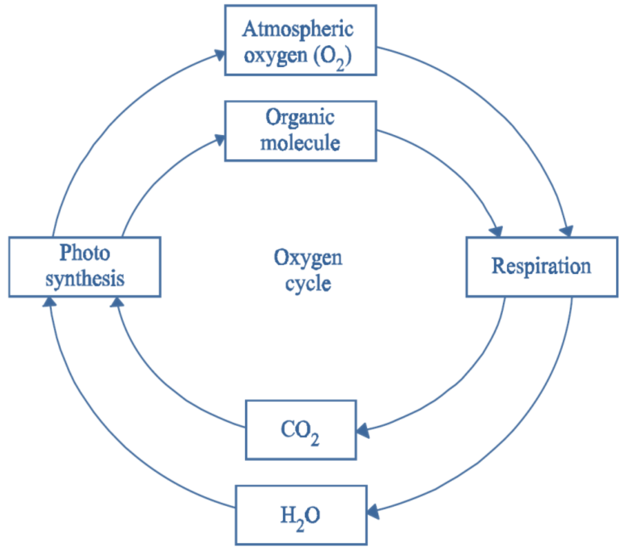


(2 M)

(i)(b) Oxygen cycle – Exchange of O_2 between the lithosphere and atmosphere and hydrosphere in a cyclic manner. Cyclic process of Photosynthesis and respiration. (4M)

$$6CO_2 + 6H_2O + Energy \rightarrow C_6H_{12}O_6 + 6O_2 \ (Photosynthesis)$$

$$6O_2 + C_6H_{12}O_6 \rightarrow 6O_2 + 6H_2O + Energy \ \ (Respiration)$$



(1 M)

(i)(c)Energy Flow In The Ecosystem

Sunlight → Plants (photosynthesis) → Primary Consumer → Secondary consumer → decomposer

- Loss of energy takes place through respiration, running, hunting etc
- Biotic components and abiotic components are linked together through energy flow and nutrient cycling. (2 M)

(ii) **Hydrosere**–Establishment starting in a watery area; **Xerarch**–Establishment starting in a dry area like, desert and rock. (3 M)

5. **Compare the physical and chemical characteristics of Marine water with terrestrial water. (15 M) (Dec 2018)** BTL4

Answer: Page: 2.37 - 2. and 2.9 – 2.11 and 2.16-A. Ravikrishnan

Marine Ecosystem:

i) Largest of Earth's aquatic ecosystems.
ii) Include oceans, salt marsh and intertidal ecology estuaries and lagoons, mangroves and coral reefs, the deep sea and the sea floor.
iii) Since ship, submarines can sail in ocean, commercial activities may be carried out.
iv) Rich in biodiversity.
v) Moderates the temperature of the earth
vi) Contrasted with freshwater ecosystems.
vii) Very important for the overall health of both marine and terrestrial environments.

Food Chain–**Producers**-Phytoplanktons, marine plants → **Consumers-Primary consumers**-Crustaceans, moiluscs, fish → **Secondary consumers**-Herring sahd, mackerel→**Tertiary Consumers**-Cod, Haddock → Decomposers–Fungi, bacteria and flagellates.

Terrestrial Ecosystem

Characteristics of Forest ecosystem:

vi) Warm temperature and adequate rainfall →Generation of number of ponds, lakes etc.,
vii) Maintains climate and rainfall.
viii) Supports many wild animals and protects biodiversity.
ix) The soil is rich in organic matter and nutrients, which support the growth of trees.
x) The conversion of organic matter into nutrients is very fast.

Structure and Function of forest ecosystem:

	v) **Abiotic components** - Physical components found in the soil and atmosphere. E.g. Climatic factors and minerals. vi) **Biotic components-Producers**-The plants absorb sunlight and produce food through photosynthesis–E.g. Trees, shrubs and ground vegetation. vii) **Consumers**-Herbivores-E.g. Ants, flies, insects, mice, deer, squirrels. Secondary consumers -primary carnivores-E.g. Snakes, birds, fox. Tertiary consumers- Tiger, lion, etc. **Decomposers**–E.g. Bacteria and fungi.

UNIT – II ENVIRONMENTAL POLLUTION

Definition – causes, effects and control measures of: (a) Air pollution (b) Water pollution (c) Soil pollution (d) Marine pollution (e) Noise pollution (f) Thermal pollution (g) Nuclear hazards – solid waste management: causes, effects and control measures of municipal solid wastes – role of an individual in prevention of pollution – pollution case studies – disaster management: floods, earthquake, cyclone and landslides. Field study of local polluted site – Urban / Rural / Industrial / Agricultural.

Q. No. **PART * A**

1. **Define the term pollution. List its types**. BTL1

Pollution-The unfavorable alteration of our surroundings

Types of Pollution-

- Air Pollution
- Water Pollution
- Soil Pollution
- Marine Pollution
- Noise Pollution
- Thermal Pollution and
- Nuclear hazards

2. **What is air pollution?** BTL1

The presence of one or more contaminants like dust, smoke, mist and odour in the atmosphere which are injurious to human beings, plants and animals.

3. **Define bio-degradable pollutant and non-biodegradable pollutant.** BTL1

Bio-degradable pollutant - Decompose rapidly by natural processes

Non-biodegradable pollutant - Do not decompose or decompose slowly in the environment

4. **State the composition of atmospheric air.** BTL1

Constituents	%
Nitrogen	78
Oxygen	21
Argon (Ar)	< 1
CO_2	0.037
Water vapour	Remaining
O_2, He, NH_3	Trace amount

5. **State the Indian ambient air quality standards.** BTL1

Category	Area	Concentration in µg/m3			
		SPM	SO_2	NO_X	CO
A	Industrial and mixed use	500	120	120	5,000
B	Residential and rural	200	80	80	2,000
C	Sensitive (hill stations, tourist resorts, monuments	100	30	30	1,000

6. **Outline the causes of air pollution?** BTL2

- Incomplete burning of fossil fuels, liberate CO, NO_2, Suspended Particulate Matter (SPM) etc.
- Coal burning in power plants, liberate SO_2

	• Ozone • Agriculture, decay of plants, liberate hydrocarbons.
7.	**Define photochemical smog. (NOV/DEC 2006)** BTL2 It is not related to smoke (or) fog. It is formed by the combination of NO, NO_2, CO_2, H_2O, CO, SO_2 and unburnt hydrocarbon particles. The important reaction is dissociation of NO_2 in sunlight. It is also named as los Angeles smog.
8.	**What are the effects of various air pollutants on human health?** BTL1

Name of the Pollutant	Name of the Diseases
NO_2	Lung irritation and damage
CO	Reacts with hemoglobin in red blood cells and reduces the ability of blood to bring oxygen to body cells and tissues, which causes headaches and anemia. At high levels it causes coma, irreversible brain cell damage and death.
SO_2	Breathing problems for healthy people.
SPM	Nose and throat irritation, lung damage, bronchitis, asthma, reproductive problems and cancer
Hydrocarbon	Carcinogenic

9.	**What are oxygen demanding wastes? (APR/MAY 2011)** BTL1 Oxygen demanding wastes is the one to reduce amount of oxygen water in water is known as oxygen demanding wastes. The oxygen demanding wastes are BOD and COD BOD is the amount of oxygen required for the biological decomposition of organic matter present in the water. COD is the amount of oxygen required for chemical oxidation of organic matter using some oxidizing agent like $K_2Cr_2O_7$ and $KMnO_4$
10.	**What Is PAN? Give Its Detrimental Effects.** BTL1 PAN • Peroxy Acetyl Nitrates - Secondary Pollutant Present In Photochemical Smog. • It is a lachrymatory substance. • It is thermally unstable and decomposes into peroxy ethanol radicals and nitrogen dioxide gas. • It is an oxidant and more stable than ozone Detrimental Effects • It is a powerful respiratory and eye irritants, toxic in nature. • Cause extensive damage to vegetation, causing skin cancer • Damages plants and art. • React explosively. • Plays a very large role in photochemical smog
11.	**How CFC's are accumulated in atmosphere. (MAY/JUNE 2006)** BTL1 CFC's are accumulated in atmosphere through • Propellant in Aerosol spray cans • Cleaning solvents • Refrigerants (Freon) in refrigerators, air conditioners • Foam plastic blowing agent • Blowing agent

12. **Define primary air pollutant and secondary air pollutant.** BTL1

Primary air pollutants - Those emitted directly in the atmosphere in harmful form. E.g. CO, NO, SO_2,

Secondary air pollutant – New pollutants formed by the reaction of some of the primary air pollutants with one another or with the basic components of air.

E.g. NO /$NO_2 \rightarrow HNO_3$ / NO_3

13. **State the composition of soil.** BTL1

Components	%
Mineral matter (inorganic)	45
Organic matter	5
Soil water	25
Soil air	25

14. **State the water quality standards.** BTL1

S. No.	Parameter	WHO standard in mgs/litre	ISI standard in mgs/litre.
1.	Colour, odour and taste	Colourless, odourless and tasteless	Colourless, odourless and tasteless
2.	p^H	6.9	6.9
3.	Total dissolved solids	1500	-
4.	Dissolved oxygen	-	3.0
5.	Chloride	250	600
6.	Sulphate	400	1000
7.	Nitrate	45	-
8.	Cyanide	0.2	0.01
9.	Fluoride	1.5	3.0
10.	Chromium	0.05	0.05
11.	Lead	0.05	0.1
12.	Arsenic	0.05	0.2

15. **List the self-cleaning processes of atmosphere.** BTL4

- Dispersion
- Gravitational settling
- Flocculation
- Absorption
- Rain washout and so on

16. **What are point and non-point sources of water pollution?** BTL1

Point sources are discharged pollutants at specific location through pipes, ditches or sewers into bodies of surface water.

Non-point sources: They cannot be traced at any single site of discharge. They are usually large land areas or air sheds that pollute water by runoff, subsurface flow or deposition from the atmosphere.

17. **Write any four major water pollutants. (MAY/JUNE 2006)** BTL1

- Infectious agents
- Oxygen demanding wastes
- Inorganic chemicals

	• Organic chemicals • Plant nutrients • Sediments • Radioactive materials • Heat (any four)
18.	**What is marine pollution? Name the sources and effects of marine pollution. (MAY/JUNE 2005, NOV/DEC 2014)** BTL1 The discharge of waste substances into the sea resulting in harm to living resources, hazards to human health, hindrance to fishery and impairment of quality for use of sea water. • Dumping the wastes - Marine birds ingest plastic which causes gastrointestinal disorders • Oil - Damage to marine fauna and flora, retard the rate of O_2 uptake by water.
19.	**Define noise pollution. When a sound does cause noise pollution? (NOV/DEC 2013, APR/MAY 2015)** BTL1 • Noise pollution is defined as the unwanted, unpleasant or disagreeable sound that causes discomfort for all living beings. • The sound intensity is measured in decibel (dB), which is tenth part of the longest unit Bel. One dB is equal to the faintest sound, a human ear can hear. If the intensity of the sound exceeds 80 dB, noise pollution occurs. Noise above 140 dB becomes painful.
20.	**Give any four methods to control noise pollution. (MAY/JUNE 2007)** BTL1 • Source Control • Transmission Path Intervention • Receptor control • Oiling
21.	**Define thermal pollution. (NOV/DEC 2005, NOV/DEC 2008)** BTL1 The addition of excess of undesirable heat to water that makes it harmful to man, animal or aquatic life or otherwise causes significant departures from the normal activities of aquatic communities in water.
22.	**What are the causes of thermal pollutions?** BTL 1 • Nuclear power plants • Coal-fired power plants • Industrial effluents • Domestic sewage • Hydro-electric power
23.	**Define hazardous wastes. Why nuclear hazards are so dangerous? (NOV/DEC 2006)** BTL1 • Wastes like toxic chemicals, radioactive or biological substances which contribute to an increase in mortality or in serious irreversible illness to human health and environment are called hazardous wastes. • Radioactive radiation, liberated by nuclear hazards, affects the cells in the body and the function of glands and organs. People suffer from blood cancer and bone cancer if exposed to doses around 100 to 1000 roentgens. Unlike the other pollution, radioactive pollution can cause genetic disorders even in the subsequent generations.
24.	**What are the various sources of radioactive pollution? (NOV/DEC 2008, APR/MAY 2015)** BTL1 • Natural sources.

	The very important natural source is space, which emit cosmic rays. Soil, rocks, air, water, food, radioactive radon-222 etc. also contain one or more radioactive substances. • Man-made sources Man-made sources are nuclear power plants, X-rays, nuclear accidents, nuclear bombs, diagnostic kits, etc., where radioactive substances are used.
25.	**List any four causes of floods. (NOV/DEC 2010)** BTL4 • Heavy rain, rainfall during cyclone causes flood. • Sudden snow melt also raises the quantity of water in streams and causes flood. • Clearing of forests for agriculture has also increased severity of floods. • Reduction in the carrying capacity of the channel, due to accumulation of Sediments cause floods
26.	**What are the types of solid wastes? (NOV/DEC 2006, MAY/JUNE 2007)** BTL2 a. Municipal wastes ; b. Industrial wastes ; c. Hazardous wastes
27.	**Mention the sources of solid wastes. (NOV/DEC 2009)** BTL1 • Domestic wastes – cloth, waste papers • Commercial wastes – cans, bottle, polythene bags • Construction wastes – Wood, Concrete • Biomedical wastes – Infectious wastes • Industrial wastes – Nuclear and thermal power plants • Hazardous wastes – Toxic wastes, chronic toxicity
28.	**Differentiate between recycling and reuse. (NOV/DEC 2007, APR/MAY 2011)** BTL4 • Reuse The refillable containers, which discarded after use can be reused. Rubber rings can be made from the discarded cycle tubes which reduces the waste generation during manufacturing of rubber bands. • Recycling Recycling is the reprocessing of the discarded materials into new useful products Example • Old aluminum cans and glass bottles are melted and recast into new cans and bottles • Preparation of cellulose insulation from paper.
29.	**What are the roles of women in environmental pollution? (NOV/DEC 2008)** BTL1 In rural areas women plant trees and grass, grow vegetables with the drip-irrigation method on order to save water. b. In urban areas they go shopping using cloth bags to reduce white pollution.
30.	**What are the effects of thermal pollution? (APR/MAY 2011)** BTL1 • Reduction in dissolved oxygen • Increase in toxicity • Interference with biological activity • Interference with reproduction • Direct mortality • Food storage for fish
31.	**What do you meant by soil pollution? Or Define soil pollution. (NOV/DEC 2010) Write the causes of soil pollution.** BTL1 The pollution affects and alter the chemical and biological properties of soil. As a result, hazardous

	chemical can enter into human food chain from the soil or water disturbs the biochemical process and finally lead to serious effects on living organism.
32.	**What are causes of noise pollution? (NOV/DEC 2010)** BTL1 • By machine like mechanical saws and pneumatic drill. • From transport, rail, air craft, road vehicles like scooters, cars, motorcycles, buses. • Common noise makers are musical instruments, TV, VCR, radios, transistors, • Telephone and loudspeakers.
33.	**What is a Dobson unit? (MAY/JUNE 2007)** BTL1 The amount of atmospheric ozone is measured by "Dobson spectrometer" and is expressed in Dobson units (DU). 1 DU is equivalent to a 0.01 mm thickness of pure ozone at the density it possesses if it is brought to the ground level (1atm) pressure • In temperate latitude its concentration is 350 DU • In tropics its concentration is 250 DU • In sub polar region its concentration is 450 DU
34.	**What are the harmful effects of landslides?** BTL1 • Landslides block the roads and diverts the passage • Erosion of soil increases. • Sudden landslides damage the houses, crop yield, live stock etc.
35.	**What do you know about particulate? (MAY/JUNE 2018)** BTL1 Particulate refers to all atmospheric substances that are not gases. They can be suspended droplets or solid particles or mixtures of the two. Particulates can be composed of materials ranging in size from 100mm to 0.1mm and less. The chemical composition of particulate pollutants is very much dependent upon the origin of the particulate.
36.	**What are landslides? (MAY/JUNE 2018)** BTL1 The movement of earthy materials like coherent rock, mud, soil and debris from higher region to lower region due to gravitational pull is called landslides.
37.	**Define the term Tsunami.** BTL2 A tsunami is a large wave that is generated in a water body when the sea floor is deformed by seismic activity. This activity displaces the overlying water in the ocean.
	PART * B
1	**Discuss the causes, effects and control of marine pollution. (7 M) (NOV/DEC 2009, APR/MAY 2010, NOV/DEC 2011)** BTL6 **Answer : Page: 4.32 - 4.34- A. Ravikrishnan** • Definition- The discharge of waste substances into the sea resulting in harm to living organisms, hazards to human health, hindrance to fishery and impairment of quality for use of sea water. (1 M) • Sources (Causes) of marine pollution Dumping the wastes-large amount of sewage, garbage, agricultural discharge, pesticides and huge amount of plastics. (1 M) Oil pollution of marine water-Imposed by petroleum and its products. (1 M) • Effects of marine pollution on human health and environment – Oil spilling in sea inhibit the photosynthesis-damage to marine fauna and flora including algae, fish, birds, invertebrates-hydrocarbons and benzpyrene accumulate in food chain and consumption of fish by man cause cancer. (2 M) • Control measures – Plans for conserving marine biodiversity-education about marine

	ecosystems-industrial units on the coastal lines equipped with pollution control instruments-urban growth should be regulated-fisherman needs should be accommodated. (2 M)
2	**What is an earthquake? Write about its causes, effects and measures to face the earthquake. (8 M) (APR/MAY 2008, NOV/DEC 2008, NOV/DEC 13, NOV/DEC 2014)** BTL4 **Answer : Refer : 4.78 – 4.80 - A. Ravikrishnan** • Definition: An earthquake is a sudden vibration caused on the earth's surface due to the sudden release of tremendous amount of energy stored in the rocks under the earth's crust. (2 M) • Causes- disequilibrium in any part of the earth crust-volcanic eruption, hydrostatic pressure and manmade activities-underground nuclear testing-decrease of groundwater level. (2M) • Effects- hilly and mountains cause landslides-collapses houses due to poor construction, peoples die increases depending on the severity-seismic waves caused by earth quakes under the sea. (2 M) • Preventive measures-constructing earthquake resistant buildings, wooden houses are preferred – information about magnitude of intensity should give by seismic hazard map by Seismologist. (2 M)
3	**Describe the sources, effects and various measures to control of noise pollution. (7 M) (NOV/DEC 2009, MAY/JUNE 11, NOV/DEC 2014)** BTL4 **Answer : Page: 4.37 to 4.40 - A. Ravikrishnan** • **Definition** – The unwanted , unpleasant or disagreeable sound that causes discomfort for all the living beings (1 M) • **Types and sources** Industrial noise-by machines, particularly mechanical saws and pneumatic drill is unbearable and is a nuisance to public. (1 M) Transport noise-road traffic noise, rail traffic noise and craft noise. (1M) Neighborhood noise-household gadgets and community like musical instruments, transistors, telephones, TV, VCR, radios, etc. (1M) • **Effects** (2M) Interferes communication Hearing damage (90 dB) Physiological and Psychological disorders • **Control and preventive measures** (1M) Reduction in source of noise Noise making machines should be kept in containers with sound absorbing media Proper oiling will reduce noise from machinery Using silencers – fibrous material Planting trees Legislation can prevent excess sound production, unnecessary horn blowing etc.
4	**What are types, sources and the effects of improper municipal solid waste management? State the measures recommended for proper management for the solid wastes. (7M + 6M)**

(MAY/JUNE 2005, APR/MAY 2010, NOV/DEC 2010, MAY/JUNE 2011, NOV/DEC 2011, NOV/DEC 2013, APR/MAY 2015) BTL1

Answer : Page: 4.61 to 4.70 - A. Ravikrishnan

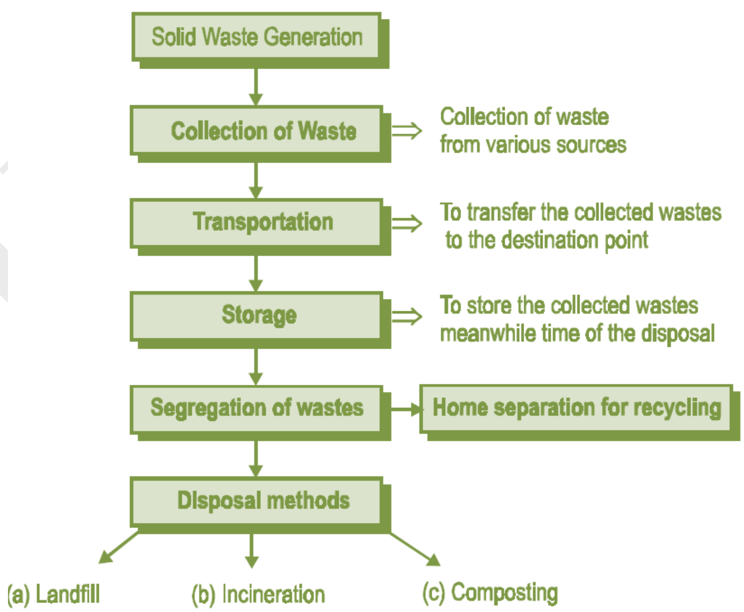
- Effects of solid wastes (2 M)
- Types
  - Urban or municipal wastes
  - Industrial wastes
  - Hazardous wastes (1 M)
- Sources

  Urban or municipal wastes
  - Domestic wastes
  - Commercial wastes
  - Construction wastes
  - Biomedical wastes (1 M)

  Industrial wastes
  - Nuclear power plants
  - Chemical industries
  - Other industries (1 M)

  Hazardous wastes
  - Toxic wastes
  - Reactive wastes
  - Corrosive wastes
  - Radioactive wastes
  - Infectious wastes
  - Heavy metals (2 M)
- Process of solid waste management

  Flow chart



(2 M)

Reduce the usage of raw materials

	Reuse of waste materials Recycling of material (1 M) • Discarding wastes Landfill – Advantages - Disadvantages (1 M) Incineration - Advantages - Disadvantages (1 M) Composting - Advantages - Disadvantages (1 M)
5	**Mention any five air pollutants with their source, effects and control measures. (7 M) (NOV/DEC 2005, APR/MAY 2006, NOV/DEC2005, MAY/JUNE 2013)** BTL1 **Answer : Page: 4.4 to 4.11 - A. Ravikrishnan** • Any five air pollutants (1 M) • Sources, health effects, environmental effects and control measures Carbon monoxide (CO) (1 M) Nitrogen dioxide (NO_2) (1 M) Sulphur dioxide (SO_2) (1 M) Suspended Particulate Matter (SPM) (1 M) Ozone (1 M) Hydrocarbons (Aromatic and aliphatic) (1 M) Any five (5 M) • Control measures (1 M)
6	**How can you, as an individual, prevent environmental pollution? Why such an effort at an individual level is important. (6 M) (NOV/DEC 2009, NOV/DEC 2010,MAY/JUNE 2014, NOV/DEC 2014, APR/MAY 2015)** BTL4 **Answer : Page: 4.61 to 4.62 - A. Ravikrishnan** **Role and responsibility of individual participation:** Use stairs instead of elevators Use public transportation walk or ride a bicycle Plant trees around building Turn off lights, television sets and computer when not in use. Pay immediate attention to leaks in pipes. Install waste saving equipments. Recycle glass metal and paper. Compost garden waste Segregate waste and recycle Buy locally made long losing material Buy environmentally degradable products. Take some bag from home to market to purchase.
7	**Explain the causes, effects and control measure of water pollution. (13 M) (MAY/JUNE 2013) (NOV/DEC 2013)** BTL42 **Answer : Page: 4.12 to 4.24 A. Ravikrishnan** • **Definition** – The alteration and physical, chemical and biological characteristics of water which may cause harmful effects on humans and aquatic life (1 M) • **Causes:** (4M) Infectious agents Oxygen demanding wastes Inorganic chemicals Organic chemicals

	Plant nutrients Sediments Radioactive materials Heat Point and non-point sources **Effects of water pollution** (4M) 1. Objectionable colour and odour is unacceptable and unsuitable for drinking and other purposes. 2. highly turbid and very hard water is unpleasant to drink, food processing 3. acid and alkaline water cause serious health problem 4. water borne infectious enteric disease like typhoid, cholera, dysentery, are the predominant health hazard arising from drinking contaminated water 5. radioactive pollution enter human body through food and get accumulated in thyroid gland, liver, bones and muscles 6. biodegradable waster deplete D O in the receiving stream, affect the flora cause creates anaerobic conditions 7. non biodegradable waste and pesticides travel the food chain and ultimately reach human where they accumulate in fatty tissues 8. thermal discharge in stream depletes D O 9. phosphate, nitrate, promote the growth of algae and encourage eutrophication 10. Industrial effluents result in addition of poisonous chemicals such as arsenic, mercury, lead may reach human body through contaminated food. **Control measures of water pollution** (4M) a) lay down standard for a. drinking water b. disposal of waste water into water course/sewer/land monitoring b) Waste water treatment • preliminary treatment • primary treatment • secondary treatment • advanced treatment
8	**Explain the sources, effects and various measures to control of thermal pollution. (13 M) (MAY/JUNE 2013, NOV/DEC 2013)** BTL4 **Answer : Page: 4.40 to 4.46 - A. Ravikrishnan** • Definition The addition of excess of undesirable heat to water that makes it harmful to man, animal or aquatic life of otherwise causes significant departures from the normal activities of aquatic communities in water (1 M) • Sources of thermal pollution Nuclear power plants Coal-fired power plants Industrial effluents

	Domestic sewage Hydro-electric power (5 M) • Effects of thermal pollution on human health Reduction in dissolved oxygen Increase in Toxicity Interference with biological activities Interference with reproduction Direct mortality Food storage for fish (3 M) • Control measures Cooling towers Cooling ponds Spray ponds Artificial lakes (4 M)
9.	**Give a note on** **(a) Floods** **(b) Cyclone** **(c) Landslides** **(13M)** BTL2 **Answer : Refer : 4.72 – 4.77 - A. Ravikrishnan** • Definition of flood: Whenever the magnitude of water flow exceeds the carrying capacity of the channel within its banks, the excess of water over flows on the surroundings causes floods (1 M) • Causes and effects (2 M) • Preventive measures of floods (1 M) • Definition: Cyclone is a meteorological phenomenon, intense depressions forming over the open oceans and moving towards the land. On reaching the shores, it move into the interior of the land or along the shore lines. (1 M) • Causes and effects (2 M) • Preventive measures of cyclone (1 M) • Definition: The movement of earthy materials like coherent rock, mud, soil and debris from higher region to lower region due to gravitational pull is called landslides. (1 M) • Causes and effects (2 M) Preventive measures of landslides (2 M)
10.	**Discuss the significance of parameters of drinking water quality standards. (7 M) (Dec. 2008)** BTL2 **Answer : Page: 4.22 to 4.23 - A. Ravikrishnan** • Physical parameters Colour Tastes and Odours Turbidity and Sediments (2 M) • Chemical parameters P^H Acidity Alkalinity Flouride

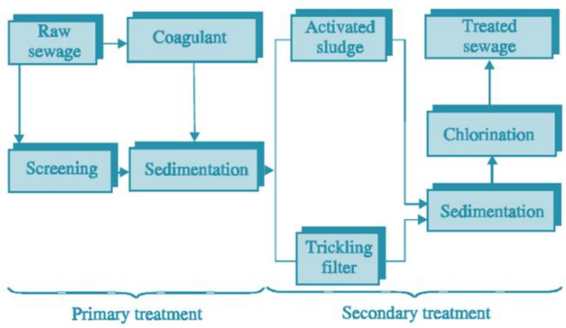
Nitrogen
Chlorides
Sulphates
Nitrates
Arsenic (6 M)

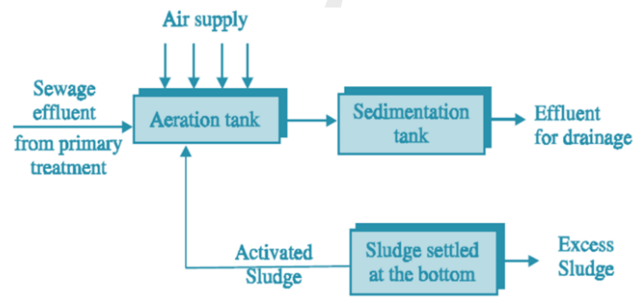
11.

With a flow diagram explain the waste water treatment. (7 M) (Dec. 2007) BTL2

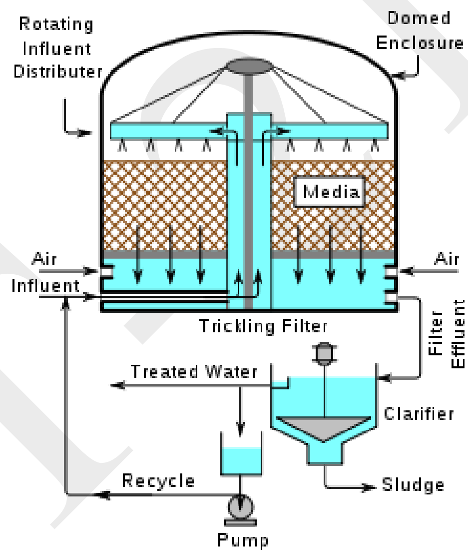
Answer : Page: 4.20 to 4.22 - A. Ravikrishnan

Flow charts and Diagrams





Activated Sludge Process



(1 + 1M)

Step-I Preliminary treatment (1 M)
Step-II Primary Treatment or Settling Process (1 M)
Step-III Secondary or Biological Treatment
Trickling Filter Process (1 M)
Activated Sludge Process (1 M)
Step-IV Tertiary Treatment (1 M)
Step-V Disposal of Sludge (1 M)

12.

Write a note on nuclear hazards (Nuclear pollution). (or) Explain the sources, effects and control measures of radioactive pollution. (7 M) (Dec. 2006) BTL2

Answer : Page: 4.48 to 4.50 - A. Ravikrishnan

Definition – The presence of radioactive elements in the environment (1M)

Causes:- (2M)

	a)Natural Sources: Solar rays Radio nuclides in earth‟s crust Environmental radiation b)Manmade Sourse: Medical X-rays Radio isotopes Nuclear test Nuclear installations Nuclear reactor **Effects:-** (2M) Causes skin burns, loss of teeth, vomiting anemia Blood cancer Brain damage **Control measures:-** (2M) Radiation exposure protection Radiation contamination protection Controlled area Disposal of radioactive waste
13.	**Explain the sources, effects and control measures of soil pollution. (8 M)** BTL2 **Answer : Page: 4.54 - A. Ravikrishnan** Definition- The contamination of soil which may cause harmful to environment (1 M) Sources and effects Industrial wastes (1 M) Urban wastes (1 M) Agricultural practices (1 M) Radioactive pollutants (1 M) Biological agents (1 M) Control Measures Control of soil erosion Proper dumping of unwanted materials Production of natural fertilizers Proper hygienic conditions Public awareness Recycling and reuse of wastes Ban on toxic chemicals (2M)
	PART – C
1	**Discuss about the following case study (a) Bhopal gas tragedy (b) Gulf War (c) Mercury wastes (15 M)** BTL6 **Answer : Page: 4.65,4.68 to 4.69 - A. Ravikrishnan** • **Causes and effects of Bhopal gas tragedy:** (5M) Pesticide factory-Union Carbide- corporation leak large volume of methyl iso cyanate – atmosphere Bhopal- India-midnight on December 3,1984-city- change- gas chamber-within a week 10,000 people died – 1000 people turned blind-lakhs of people still continue to

	suffer various diseases • **Causes and effects of Gullf War**: (5 M) Gulf war was fought between Iraq and US-Period of 6 weeks in 1991-American fighters dropped a lakh of bombs-force the Iraq army to withdraw from Kuwait- retreat of Iraq-burning of 700 oil wells-near sea shore –oil from well spills out into the sea-the floating oil oversea water nearly 80 km long-burning of oil wells nearly 10 months-released huge amounts of pollutants likeCO_2 and SO_2 into the atmosphere-1 million birds killed. • **Causes and effects of mercury wastes**: (5 M) Minamata- Small hostel village in Japan –Chicago-chemical company produces Venyl polymer plastics-industry release its effluent into Minamata sea-Effluents by fishes – affect human being through food chain-damage central nervous system-loss of vision and hearing-loss of muscular coordination and severe headache- nervous disorders.
2	**Discuss about the following case study (a) Palar river pollution (b) Textile and dye industries (c) Chernobyl nuclear disaster. (15 M)** BTL4 **Answer : Page: 4.66, 4.69 - A. Ravikrishnan** **Explanation of Palar river pollution** (5 M) Palar river originates in Nandidurgam of Karnataka state and flows for about 350 km through Karnataka, Andra Pradesh and Tamil Nadu.Palar supply drinking water for several municipalities, towns and villages in Vellore district, Tamil Nadu**.** The effluent from the above industries affect the surface and underground water and make the water unfit for domestic work. The effluent also increase the pH of the soil and affect the cultivation. The rivers like Bhavani, Noyyal and Cauvery get polluted due to mixing of effluent from the above industries. Tamil Nadu Pollution Control Board (TNPCB) has directed all textile printers and dyers of Thirupur to not allow the effluent to mix in the river systems. **Explanation of Textile and dye industries** (5 M) There are nearly 500 dying units and 195 bleaching units operating in and around Tirupur. They consume large quantity of water for processing and later discharge waste water. The effluent from the above industries affect the surface and underground water and make the water unfit for domestic work. The effluent also increase the pH of the soil and affect the cultivation. The rivers like Bhavani, Noyyal and Cauvery get polluted due to mixing of effluent from the above industries. Tamil Nadu Pollution Control Board (TNPCB) has directed all textile printers and dyers of Thirupur to not allow the effluent to mix in the river systems. **Explanation of Chernobyl nuclear disaster** (5 M) Occur at Chernobyl in USSR 28 th April,1986-the reactor exploded- result of uncontrolled nuclear reactions-radioactive fuel spread out in to the surrounding areas –killed at least 20,000 people-damage to soil, water and vegetation around 60 km.
3.	**Compare the physical and chemical characteristics of Marine water with terrestrial water. (15 M) (May 2018)** BTL4 **Answer : Page: 4.23 to 4.25 and 2.44 to2.46 - A. Ravikrishnan** **Physical and Chemical Characteristics of terrestrial water: (8M)** **The common specifications recommended by the U.S Public Health for Drinking Water are**

given below.

1.

S. No.	Parameter	WHO standard in mgs/litre	ISI standard in mgs/litre.
1.	Colour, odour and taste	Colourless, odourless and tasteless	Colourless, odourless and tasteless
2.	p^H	6.9	6.9
3.	Total dissolved solids	1500	-
4.	Dissolved oxygen	-	3.0
5.	Chloride	250	600
6.	Sulphate	400	1000
7.	Nitrate	45	-
8.	Cyanide	0.2	0.01
9.	Fluoride	1.5	3.0
10.	Chromium	0.05	0.05

Water should be clear and odourless.
2. It should be cool.
3. It should be pleasant to taste.
4. Turbidity of the water should not exceed 10 ppm.
5. pH of the water should be in the range of 7.0 - 8.5.
6. Chloride and sulphate contents should be less than 250 ppm.
7. Total hardness of the water should be less than 500 ppm.
8. Total dissolved solids should be less than 500 ppm.
9. Fluoride content of the water should be less than 1.5 ppm.
10. The water must be free from disease-producing bacteria.
11. Water should be free from objectionable dissolved gases like H_2S.
12. Water should be free from objectionable minerals such as lead, chromium, manganese and arsenic salts.

11.	Lead	0.05	0.1
12.	Arsenic	0.05	0.2

UNIT III – NATURAL RESOURCES	
Forest resources: Use and over-exploitation, deforestation, case studies- timber extraction, mining, dams and their effects on forests and tribal people – Water resources: Use and overutilization of surface and ground water, dams-benefits and problems – Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies – Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies – Energy resources: Growing energy needs, renewable and non renewable energy sources, use of alternate energy sources. Energy Conversion processes – Biogas – production and uses, anaerobic digestion; case studies – Land resources: Land as a resource, land degradation, man induced landslides, soil erosion and desertification – role of an individual in conservation of natural resources – Equitable use of resources for sustainable lifestyles. Introduction to Environmental Biochemistry: Proteins –Biochemical 39 degradation of pollutants, Bioconversion of pollutants. Field study of local area to document environmental assets – river / forest / grassland / hill / mountain.	
Q.No.	**PART * A**
1.	**How are forest classified?** BTL2 1. Evergreen forests; 2. Deciduous forests; 3. Coniferous forests
2	**What are the preventive measures of deforestation?** BTL1 • Steps should be taken by the government to discourage the migration of people into the islands from mainland. • To counter the depletion of forest areas, tree plantation programs have been started. • Education and awareness programmes must be conducted. • Strict implementation of law of Forest Conservation Act • Forest fire must be controlled by modern techniques • Use of wood for fuel should be discouraged
3	**Define sustainable forestry (Chen AU Dec 2005)** BTL1 Sustainable forestry is the optimum use of forest resources, which meet the needs of the present without compromising the ability of future generations to meet their own needs.
4.	**Write the functions of forests. (Chen A.U. Jun 2006)** BTL2 • Forests perform very important functions both to humans and nature. • They are habitats to millions of plants, animals and wildlife. • They recycle rainwater and remove pollutants from air. They control water quality and quantity • They moderate temperature and weather and help to maintain humidity. • They influence soil Conditions and prevent soil erosion and perform watershed functions. • They promote tourism and contribute aesthetic beauty
5	**Define deforestation. What are the causes of deforestation? (Chen A.U. Jun 2006, Dec 2010)** BTL1 **Deforestation:** The process of destruction of forest (or) process of removal of or elimination of forest resources due to many natural or man-made activities. The process of removal

Causes of deforestation: 1. Developmental projects. 2. Mining operations. 3. Raw-materials for industries. 4. Fuel requirements. 5. Shifting cultivation. 6. Forest fires

6. **Differentiate between deforestation and forest degradation. (Chen A.U. Dec 2007, Dec2010)** BTL4

Forest Degradation	**Deforestation**
It is the process of deterioration forest materials.	It is the process of destruction of forest materials.
Slow process	Rapid process.
Can be removed.	Cannot be recovered.

7. **What are the consequences of timber extraction?** BTL1

- Large scale timber extraction causes deforestation.
- Timber extraction leads to soil erosion, loss of fertility, landslides and loss of biodiversity.
- Timber extraction also leads to loss of tribal culture and extinction of tribal people.
- Timber extraction reduces thickness of the forest

8. **List the adverse effects of mining. (TNV A.U. Dec 2009, 2013)** BTL1

- During mining operations, the vibrations are developed, which leads to earthquake.
- When materials are disturbed in significant quantities during mining process, large
- quantities of sediments are transported by water erosion
- Noise pollution is another major problem from mining operations.
- Mining reduces the shape and size of the forest areas.
- Destruction of natural habitat at the mine and waste disposal sites.

9. **State the problems caused by the construction of Dam. (Chen AU Jan 2006)** BTL3

- Displacement of tribal people.
- Loss of non-forest land.
- Loss of forests, flora and fauna.
- Landslips, sedimentation and siltation occur.
- Stagnation and water logging around reservoirs retards plant growth.
- Breeding of vectors and spread of vector-borne diseases.
- Reservoir induced seismicity (RIC) causes earthquakes.
- Navigation and aquaculture activities can be developed in the dam area.

10. **What are the effects of dams on tribal?** BTL1

- The greatest social cost of big dam is the widespread displacement of tribal people, such a biodiversity cannot be tolerated.
- Displacement and cultural change affects the tribal people both mentally and physically. They do not accommodate the modem food habits and life styles
- Tribal people are ill-treated by the modem society.
- Many of the displaced people were not recognized and resettled or compensated.
- Tribal people and their culture cannot be questioned and destroyed.
- Generally, the body conditions of tribal people (lived in forest) will not suit with the new areas and hence they will be affected by many diseases.

11. **Compare merits and problems of dams**. (**Chen A.U. Jun 2007)** BTL4

Merits of dams	**Problems of dams**
Dams are built to control flood and store flood water.	Displacement of tribal people.

Sometimes dams are used for diverting part or all of the water from river into	Loss of non-forest land.
Dams are used mainly for drinking and agricultural purposes.	Loss of forests, flora and Fauna.
Dams are built for generating electricity.	Water logging and salinity due to over irrigation.
Dams are used for recreational purposes.	Reduced water flow and silt deposition in rivers.
Navigation and fishery can be developed in the dam areas.	Salt water intrusion at river mouth.

12. **Explain flood management**. BTL2

- Floods can be controlled by constructing dams or reservoirs.
- Channel management and embankments also control the floods.
- Encroachment of flood ways should be banned.
- Flood hazard may also be reduced by forecasting or flood warning.

13. **Write short note on mineral resources of India**. **(Coim A.U. Dec 2009)** BTL3

India has the following mineral resources

S. No.	**Mineral**	**Place**
1.	Iron	Bihar, Orissa, Tamil Nadu, Goa
2.	Coal	A.P, Bihar, MP, West Bengal
3.	Manganese	MP, Orissa, A.P, Rajasthan
4.	Copper	Bihar, A.P, MP, Orissa
5.	Gold	Karnataka, A.P
6.	Aluminum	MP, TN, Bihar, Orissa
7.	Tin	Bihar, Orissa and Rajasthan
8.	Chromium	Bihar, Orissa, MP, TN

14. **State the environmental effects of (mining) extracting and using mineral resources. (Chen AU Jun 2005)** BTL1

- Devegetation and defacing of landscape
- Ground water contamination
- Surface water pollution
- Air pollution
- Subsidence of land
- During mining operations, the vibrations are developed, which leads to earthquake.
- When materials are disturbed in significant quantities during mining process, large
- quantities of sediments are transported by water erosion
- Noise pollution is another major problem from mining operations.
- Mining reduces the shape and size of the forest areas.
- Destruction of natural habitat at the mine and waste disposal sites.

15 **What do you mean by environmental impact? (Chen A.U. Dec 2006) (or) Define environmental impact statement. (Coim. A.U. Dec 2009)** BTL1

Environmental impact is nothing but the effect on the natural environment caused by various human actions. It includes two types

(j) Indirect effects. Example: Pollution.

	(ii) Direct effects. Example: Cutting down trees
16	**Define overgrazing**. **Write the adverse effects caused by overgrazi**ng. (**TNV A.U. Dec 2008, A.U. May 2008 ,Dec 2013, Chen AU Dec 2006)** BTL1, BTL3 **Overgrazing:** Process of “eating away the forest vegetation without giving it a chance to regenerate”. **Effects of overgrazing:** (i) Land degradation (ii) Soil erosion (iii) Loss of useful species
17	**What is water logging? List the effects of water logging.** (**Coim A.U. Dec 2009, Chen AU Dec 2006, Apr 11)** BTL1 Water logging is the land where water stand for most of the year or time. **Problems in water logging**: During water-logged conditions, pore-voids in the soil get filled with water and the soil-air gets depleted. In such a condition the roots of the plants do not get adequate air for respiration. So, mechanical strength of the soil decreases and crop yield falls.
18.	**Enumerate the desired qualities of an ideal pesticide**. (**A.U. Dec 2007)** BTL3 • An ideal pesticide must kill only the target species. • It must be a biodegradable. • It should not produce new pests. • It should not produce any toxic pesticide vapour. Excessive synthetic pesticide should not be used. • Chlorinated pesticides and organophosphate pesticides are hazardous, so they should be used.
19	**Define desertification, land degradation and land slide.** BTL1 **Desertification:** A progressive destruction or degradation of arid or semiarid lands to desert **Land degradation or Soil degradation:** The process of deterioration of soil or loss of fertility of the soil **Land slide:** Landslides are the downward and outward movement of a slope composed of earth materials such as rock, soil, artificial fills.
20	**What are the advantages in conjunctive use of water? (Chen A.U. Dec 2006)** BTL3 • Control of water logging. • Use of saline water, especially for cooling purposed. • Control of salt intrusion in coastal aquifers. • Controlled withdrawal of water from ground water aquifer
21	**What are renewable and non-renewable energy resources? (Chen. A.U. Dec 2009, TCY A.U. Dec 2008, Dec 2009,Apr 2015)** BTL1 Renewable energy resources are natural resources which can be regenerated continuously by the ecological process within a reasonable time period and are inexhaustible. They can be used again and again in an endless manner. Examples: solar energy, wind energy, tidal energy, ocean thermal energy Non-Renewable energy resources are natural resources which cannot be regenerated. E.g. coal, petroleum, minerals, oils, ground water
22	**Differentiate renewable and non-renewable sources of energy. (TNV A.U. Dec 2008, 11**) BTL4

Renewable energy	**Non-renewable energy**
It is regenerated continuously	Cannot be regenerated.
In exhaustible	Exhaustible

	It can be used again and again	Cannot be used again
	It is pollution free	It pollutes the atmosphere
	Available in unlimited amount in nature	Available in limited amount
	It is developed in a short period	It is developed in a long period It is developed in a long period

23	**What are the conventional sources of energy for the mankind? (Chen AU Jan 2006)** BTL1 Non-renewable energy resources are natural resources, which cannot be regenerated once they are exhausted. They cannot be used again.
24	**What is geothermal energy? (Coim A.U. Dec 2009)** BTL1 The energy harnessed form the high temperature present inside the earth is called geothermal energy
25	**What is meant by soil erosion? List its types. (Chen A.U. Jun 2007)** BTL1 Soil erosion is the process of removal of superficial layer of the soil from one place to another. Soil erosion also removes the soil components and surface litter. 1. Normal erosion 2. Accelerated erosion
26	**Explain soil leaching**. **(Chen A.U. Dec 2006)** BTL2 1. It removes valuable nutrients from the soil. 2. It may catty buried wastes into ground water and contaminates it.
27	**Mention the factors causing soil erosion**. (**TCY A.U. Dec2008**) BTL4 1. Water 2. Wind 3. Biotic agents 4. Landslides 5. Construction
28.	**What are the present food problems of the world? (Chen A.U. Dec 2010)** BTL4 We know that 79% of the area is covered with water and rest is land, of which most of the areas are forest, desert, mountain, barren area only less percentage of land is cultivated. So the food supplied from the rest of the land is not enough to feed all the people. The problem of population explosion has made it worse. The world population increases and cultivable land area decreases therefore the world food problem arises. Urbanization is another problem in developing countries which deteriorates the agricultural lands.
29.	**What are the effects of over utilization of groundwater? (Chen A.U. Dec 2010)** BTL1 1. Decrease ground water 2. Ground subsidence 3. Lowering of water table 4. Intrusion of salt water 5. Earthquake and landslides 6. Drying up of wells 7. Pollution of water
30.	**Define the term Nuclear energy. (A.U DEC2014, A.U.Apr.2018)** BTL1 Energy released during a nuclear reaction is called nuclear energy. Nuclear reactors produce the nuclear energy either by nuclear fission (or) nuclear fusion. The nuclear power (or) nuclear energy is clean and safe
31.	**Define sustainable life style and bio gas.** BTL1 **Sustainable life style:** Sustainable development is the development of healthy environment without damaging the natural resources. In other words, all the natural resources must be used in such a way that it must be available for the future generation also. **Bio gas:** Mixture of various gases formed by anaerobic degradation of biological matter in the absence of oxygen
	PART * B
1	**Discuss the causes, ill effects and preventive measures of deforestation. (13M) (A.U. Dec 2005, Dec 2014, Apr 2015, A.U. Jan 2006, Dec 09, Apr 2015, A.U. Dec 2006, June 2007, A.U. May 2008)** BTL2

Answer :Page : 5.7 – 5.9 - A. Ravikrishnan

Causes (Sources) of Deforestation

Developmental Projects:

Development projects cause deforestation in two ways.
(i) Through submergence of forest area underwater.
(ii) Destruction of forest area.
Examples. Big dams, hydroelectric projects, construction (1 M)

Mining operations

Mining have a serious impact on forest areas. Mining operation reduces the forest area. Examples Mica, coal, manganese, limestone, etc. (1 M)

Raw materials for industries

Wood is the important raw material for so many purposes.
Example - For making boxes, furniture, match-boxes, pulp, etc., (1 M)

Fuel requirements

In India both rural and tribal population depend on the forest for meeting their daily need of fuel wood, which leads to the pressure on forest, ultimately to deforestation. (1 M)

Shifting cultivation: Replacement of forest ecosystem for monospecific tree plantation can lead to disappearance of number of plant and animal species.
Examples: India is the richest nation with more than 15,000 species of plants, many of which is endangered due to deforestation (1M)

Forest fires: Forest fire is one of the major causes for deforestation. Due to human interruption and rise in ambient temperature, forest fire is happened often nowadays. Thus, due to forest fire thousands of forest area gets destructed. (1 M)

Ill effects of deforestation on the environment

Global warming: Cutting and burning of forest trees increases the CO_2 content in the atmosphere, which in turn changes the global climatic pattern, rising sea levels and depletion of the protective ozone layer.

Loss of genetic diversity: Destruction of our forest destroys the greatest storehouse of genetic diversity on earth, which provides new food and medicines for the entire world

Soil erosion: Deforestation also causes soil erosion, landslides, floods and drought. Natural vegetation acts as a natural barrier to reduce the wind velocity, this in turn reduces soil erosion. 6000 million tons of soil gets eroded every year in India

Loss of biodiversity: Most of the species are very sensitive to any disturbance and changes. When the plants no longer exist, animals that depend on them for food and habitat become extinct.

Loss of food grains: As a result of soil erosion, the countries lose the food grains

Unemployment problems: The people living around forest areas lose their livelihood

Flood and Landslides: Frequent floods, landslides in hilly areas and wind speed are heavy. (Any five Each 1 M = 5 M)

Preventive measures (or) avoid of deforestation (or) methods of conservation of forest

- New plants of more or less the same variety should be planted to replace the trees cut down for timber.
- Use of wood for fuel should be discouraged.
- Forest pests can be controlled by spraying pesticides by using aeroplanes.
- Forest fire must be controlled by modem techniques.
- Over grazing by cattle must be controlled.
- Steps should be taken by the government to discourage the migration of people into the

	islands from mainland. • Education and awareness programmes must be conducted. • Strict implementation of law of Forest Conservation Act (2 M)
2	**What are the measures recommended for conservation of natural resources? (7 M) (A.U. June 2005, Jan 2006, A.U. Apr 2010, Dec 2013)** BTL2 **Answer : Page : 5.76 – 5.80 - A. Ravikrishnan** **Measures recommended for (Role of Individual)conservation of natural resource** **Conservation of Energy** • Switch off lights, fans and other appliances when not in use. • Use solar heater for cooking your food on sunny . days, which will cut down your LPG expenses. • Dry the clothes in sunlight instead of driers. • Grow trees near the houses and get a cool breeze and shade. This will cut off your electricity charges on AC and coolers. • Use always pressure cooker. • Ride bicycle or just walk instead of using car and scoot (2 M) **Conservation of water** • Use minimum water for all domestic purposes. • Check for water leaks in pipes and toilets and repair them promptly. • Reuse the soapy water, after washing clothes, for washing off the courtyards, drive ways, etc., • Use drip irrigation to improve irrigation efficiency and reduce evaporation. • The wasted water, coming out from kitchen, bath tub, can be used for watering the plants. • Build rainwater harvesting system in your house (2 M) **Conservation of soil** • Grow different types of plants, herbs, trees and grass in your garden and open areas, which bind the soil and prevent its erosion. • While constructing the house don't uproot the trees as far as possible. • Don't irrigate the plants using a strong flow of water, as it will wash off the top soil. • Soil erosion can be prevented by the use of sprinkling irrigation. • Use green manure in the garden, which will protect the soil. • Use mixed cropping, so that some specific soil nutrients will not get depleted (1 M) **Conservation of Food Resources** • Eat only minimum amount of food. A void over eating. • Don’t wastes the food instead gives it to someone before getting spoiled. • Cook only required amount of the food. • Don't cook food unnecessarily. • Don't store large amounts of food grains and protect them from damaging insects (1 M) **Conservation of Forest** • Use non-timber products. • Plant more trees and protect them. • Grassing, fishing must be controlled. • Minimise the use of papers and fuel wood. • Avoid of executing developmental work like dam, road, construction in forest areas (1 M)

3	**What are the effects, causes of soil erosion and the methods of preventing it? (7 M) (A.U. Dec 2005,11)** BTL3 **Answer : Page : 5.70 – 5.73 - A. Ravikrishnan** **Soil erosion-** Damage or removal of top soil renders the soil infertile. Erosion may occur in many ways **Effects of soil erosion** (1M) **Causes of (factors causing) soil erosion** Water ; wind; biotic agents; landslides; construction (1 M) **Control of soil erosion (Soil conservation practices)** • Conservation of till farming or no-till-farming (1 M) • Contour farming (1 M) • Terracing (1 M) • Alley cropping or agro forestry (1 M) • Wind breaks or shelter belts (1 M) Decreasing soil pollution is also a method which helps in soil conservation
5	**Discuss briefly on the consequences of overdrawing of ground water. (13 M) (A.U. Dec 2006)** BTL2 **Answer : Page : 5.19 – 5.21 - A. Ravikrishnan** **Decrease of Ground Water :** Due to increased usage of ground water, the ground water level decreases. Reason (a) The erratic and inadequate rainfall results in reduction in storage of water in reservoirs. (b) The building construction activities are sealing the permeable soil zone, reducing the area for percolation of rain water and increase in surface runoff (2 M) **Ground subsidence** When the ground water withdrawal is more than the recharge rate, the sediments in the aquifer get compacted which results in sinking of over lying land surface. This process is known as ground subsidence. (2M) **Lowering of water table** Over utilization of ground water in arid and semi-arid regions for agriculture disturbs the state of equilibrium of the reservoir (disturb the hydrological cycle) in the region. This causes following problems. (1 M) **Intrusion of salt water** In coastal areas, over exploitation of ground water would lead to rapid intrusion of salt water from sea. (2M) **Earthquake and landslides** Over-utilization of ground leads to decrease in water level, which cause earth quake, landslides and famine (2M) **Drying up of wells** As a result of over utilization of ground water, the level of ground water getting depleted at much faster rates than they can be regenerated. This leads to drying up of dug as well as bore wells. (2M) **Pollution of water** When ground water level near the agricultural land decreases, water, containing the nitrogen as nitrate fertilizer, percolates rapidly into the ground and pollute the ground water (2M)
6	**Write a brief note on changes caused by agricultural and overgrazing. (7 M) (A.U May 2007,**

	Dec 2014) BTL2 **Answer : Page : 5.36 – 5.38 - A. Ravikrishnan** **Overgrazing:** Process of, "eating away the forest vegetation without giving it a chance to regenerate" **Agriculture**: An art, science and industry of managing the growth of plants and animals for human use. (1 M) **Effects (or) impacts of overgrazing** **Land degradation** ✓ Overgrazing removes the cover of vegetation over the soil and the exposed soil gets compacted. ✓ So the roots of plant cannot go much deep into the soil and the adequate soil moisture is not available. ✓ Thus, overgrazing leads to organically poor, dry, compacted soil, this cannot be used for further cultivation. (1 M) **Soil erosion** ✓ Due to overgrazing by livestock, the cover of vegetation gets removed from the soil. ✓ The roots of the grass are very good binders of the soil. ✓ The soil becomes loose by the action of wind and rainfall. (1 M) **Loss of useful species** ✓ Overgrazing also affects the composition of plant population and other regeneration capacity. ✓ When livestock grazes the grasses heavily, the root stocks, which carry the food reserve gets destroyed. (1 M) **Traditional agriculture:** ✓ It involves small plot, simple tools, surface water, organic fertilizers and a mix of crops. ✓ They produce enough and a mix of crops. They produce enough food for their families and to sell it for their income **Effects (or) impacts of Traditional agriculture** **Deforestation:** ✓ Cutting and burning of trees in forests to clear the land for cultivation results in loss of forest cover. **Soil erosion:** ✓ Clearing of forest cover exposes the soil to wind and rainfall, resulting in loss of top fertile soil layer. **Loss of nutrients:** ✓ During cutting and burning of trees, organic matter in the soil gets destroyed and most of the nutrients are taken up by the crops within a short period (each 1M)
7	**Explain how the alternate energy sources play an important role in environmental impact. (8 M) (A.U. May 2007)** BTL4 **Answer : Page : 5.63 – 5.64 - A. Ravikrishnan** **Need of Alternate (Renewable) Energy Sources (or) Role of Alternate (Renewable) Energy sources in environmental impact** 1. The importance of solar energy can be emphasized particularly in view of the fact that fossil fuels and other conventional sources are not free from environmental implications. 2. Energy sources which have least pollution, safety and security snags and are universally available have the best enhance of large scale utilization in future.

	3. Hydro-electric power generation is expected to upset the ecological balance existing on earth. 4. Besides space heating, hydroelectric power plants critically pollute the aquatic and terrestrial biota 5. Radioactive pollutants released from nuclear power plants are chronically hazardous. The commissioning of boiling water power reactors (BWRS) have resulted in the critical accumulation of large number of long lived radionuclides in water. 6. The dangerous radio waste cannot be buried in land without the risk of polluting soil and underground water. Nor the waste can be dumped into the rivers without poisoning aquatic life and human beings as well. 7. The burning of coal, oil, wood, dung cakes and petroleum products have well debated environmental problems. The smoke so produced causes respiratory and digestive problems leading to lungs, stomach and eye diseases. 8. The disposal of fly ash requires large ash ponds and may pose a severe problem considering the limited availability of land. So, the non conventional sources of energy needed (8 M)
8	**Discuss the effects of timber extraction, effects of dams on forests and tribal people. (7 M) (A.U. May 2008, Dec 2013)** BTL2 **Answer : Page : 5.11, 5.13 – 5.15 - A. Ravikrishnan** **Consequences (or) effects of timber extraction** 1. Large scale timber extraction causes deforestation. 2. Timber extraction leads to soil erosion, loss of fertility, landslides and loss of biodiversity. 3. Timber extraction also leads to loss of tribal culture and extinction of tribal people. 4. Timber extraction reduces thickness of forest (1M) **Effects of dam on Forest** 1. Thousands of hectares of forest have been cleared for executing river valley projects. 2. In addition to the dam construction, the forest is also cleared for residential accommodation, office buildings, storing materials, laying roads, etc., 3. Hydroelectric projects also have led to widespread loss of forest in recent years. 4. Construction of darns under these projects led to killing of wild animals and destroying aquatic life. 5. Hydroelectric projects provide opportunities for the spread of water borne diseases. **6.** The big river valley projects also cause water logging which leads to salinity and in tum reduces the fertility of the land. (3M) **Effects of dam on tribal people** 1. The greatest social cost of big dam is the widespread displacement of tribal people, such a biodiversity cannot be tolerated. 2. Displacement and cultural change affects the tribal people both mentally and physically. They do not accommodate the modem food habits and life styles. 3. Tribal people are ill-treated by the modem society. 4. Many of the displaced people were not recognized and resettled or compensated. 5. Tribal people and their culture cannot be questioned and destroyed. **6.** Generally, the body conditions of tribal people (lived in forest) will not suit with the new areas and hence they will be affected by many diseases (3 M)
9	**(i) Discuss the problems of fertilizer and pesticide on modern agriculture. (7 M) (A.U. May 2008, Dec 2010)** BTL2

(ii) List the desired qualities of pesticide. (2M) BTL4

(i) Answer : Page : 5.38 – 5.40 - A. Ravikrishnan

Problems in using fertilizer

(a) Micronutrient imbalance

- ✓ Most of the chemical fertilizers, used in modem agriculture, contain nitrogen, phosphorus and potassium (N, P, K), which are macronutrients.
- ✓ When excess of fertilizers are used in the fields, it causes micronutrient imbalance.
- ✓ Examples: Excessive use of fertilizer in Punjab and Haryana has caused deficiency of the micronutrient zinc in the soil, which affects the productivity of the soil. (1M)

(b) Blue Baby syndrome (Nitrate pollution)

- ✓ When Nitrogenous fertilizers are applied in the fields, they leach deep into the soil and contaminate the ground water.
- ✓ The nitrate concentration in the water gets increased.
- ✓ When the nitrate concentration exceeds 25 mg / lit, they cause serious health problem called "Blue Baby syndrome".
- ✓ This disease affects infants and leads even to death. (1M)

(c) Eutrophication.

- ✓ A large proportion of N and P fertilizers, used In crop field is washed off by the runoff water and reaches the water bodies causing over nourishment of the lake. This process is known as Eutrophication.
- ✓ Due to eutrophication lake gets attacked by algal bloom.
- ✓ These algal species use up the nutrients rapidly and grow very fast.
- ✓ Since the time of algal species is less they die quickly and pollute the water, which in turn affect the aquatic life. (1M)

Problems in using pesticides

In order to improve the crop yield, lot of pesticides are used in the agriculture.

(i) First generation pesticides - Sulphur, arsenic, lead or mercury are used to kill the pests.

(ii) Second generation pesticides - DDT (Dichloro Diphenyl Trichloromethane) kill the pests.

Although these pesticides protect our crops from huge losses due to pests, they produce number of side-effects.

i. Death of non-target organisms

- ✓ Some pest species usually survive even after the pesticide spray, which generates highly resistant generations.
- ✓ They are immune to all type of pesticides and are called super pests. (1 M)

i. Producing new pests

- ✓ Some pest species usually survive even after the pesticide spray, which generates highly resistant generations.
- ✓ They are immune to all type of pesticides (1 M)

(c)Bio-magnification

- ✓ Many of the pesticides are non-biodegradable and keep on concentrating in the food chain.
- ✓ This process is called bio-magnification.

	✓ These pesticides in a bio-magnified form are harmful to the human beings. (1 M) (d)**Risk of cancer** ✓ Pesticides enhance the risks of cancer in two ways. ✓ It directly acts as carcinogens. ✓ It indirectly Suppress the immune system. (1 M) **(ii) Answer : Page : 5.40 - A. Ravikrishnan** **<u>Desired qualities of an ideal pesticide</u>** ✓ An ideal pesticide must kill only the target species. ✓ It must be a biodegradable. ✓ It should not produce new pests. ✓ It should not produce any toxic pesticide vapour. ✓ Excessive synthetic pesticide should not be used. ✓ Chlorinated pesticides and organophosphate pesticides are hazardous, so they should not be used (2 M)
10	**Explain the environmental impacts of mineral extraction (mining) and uses (7 M) (A.U. Dec 2009, Apr 2015)** BTL2 **Answer : Page : 5.29 – 5.31 and 5.24 – 5.26 - A. Ravikrishnan** **Mining:** Mining is the process of extraction of metals from a mineral deposit. **Types of mining** (a) **Surface mining:** Surface mining is the process of extraction of raw materials from the near surface deposits (b) **Underground mining**: The process of extraction of raw materials below the earth's surface. It includes, (c) **Open-pit mining**: Open-pit mining machines dig holes and remove the ores. Example: Iron, copper, limestone, and marble etc **Environmental damage, caused by mining activities** **Devegetation and defacing of landscape:** Topsoil as well as the vegetation are removed from the mining area. Large scale deforestation or devegetation leads to several ecological losses and also landscape gets badly affected**.** (1 M) **Groundwater contamination**: Mining disturbs and also pollutes the ground water. Usually sulphur, present as an impurity in many ores, gets converted into sulphuric acid due to microbial action, which makes the water acidic. Some heavy metals also get leached into groundwater (1 M) **Surface water pollution:** Drainage of acid mines often contaminates the nearby streams and lakes. The acidic water is harmful to many aquatic lives. Radioactive substances like uranium also contaminate the surface water and kill many aquatic animals. (1 M) **Air pollution:** Smelting and roasting are done to purify the metals, which emits enormous amounts of air pollutants damaging the nearby vegetation. The suspended particulate matter (SPM), SOx arsenic particles, cadmium, lead, etc., contaminate the atmosphere and public suffer from several health problems. (1 M) **Subsidence of land:** It is mainly associated with underground mining. Subsidence of mining area results in cracks in houses, tilting of buildings, bending of rail. (1 M) **Effects of over exploitation of Mineral resources** 1. Rapid depletion of mineral deposits. 2. Over exploitation of mineral resources leads to wastage and dissemination of mineral deposits.

	3. Over exploitation of mineral resources causes environmental pollution. 4. Over exploitation needs heavy energy requirement (1 M) **Uses of mining** The extraction of metals and other materials from a mineral deposit by mining has verity of uses. 1. Development of industrial plants and machinery. Examples - Iron, aluminium, copper, etc., 2. Construction, housing, settlements. Example - Iron, aluminium, nickel, etc., 3. Jewellery – Example - Gold, silver, platinum and diamond 4. Generation of energy. Example – Coal, Lignite, Uranium etc 5. Designing of defence equipments, weapons, ornaments **6.** Agriculture purposes, as fertilizers, seed dressings and fungicides. Example Zineb – containing zinc and Maneb - containing manganese. (1 M)
11	**Explain the various food resources. (7 M) (A.U. Apr 2010, Apr 2015, Dec 2010)** BTL2 **Answer : Page : 5.33 – 5.36 - A. Ravikrishnan** **Food Resources** Food is an essential requirement for the human survival. Each person has a minimum food requirement. The main components of food are carbohydrates, fats, proteins, minerals and vitamin (1 M) **Types of Food Supply** Historically humans have dependent on three systems for their food supply. **1. Croplands:** It mostly produces grains and provide about 76% of the world's food. (1 M) Examples: Rice, wheat, maize, barley, sugarcane, potato, etc **2. Rangelands:** It produces food mainly from the grazing livestock and provide about 17% of the world's food. Examples: Meat, milk, fruits, etc., (1 M) **3. Oceans:** Oceanic fisheries supply about 7% of the world's food. Examples: Fish, prawn, crab, etc. (1 M) **Major Food Sources** Earth is provided with more than thousands of edible plants and animals. However only 15 plants and 8 terrestrial animal species supply 90% of our global intake of calories. Examples: Rice, wheat, maize, potato, barley, sugarcane, pulses, fruits, vegetables, milk, meat, fish and sea food. Rice, wheat and maize are the major grains, provide more than 50% of the calories people consume. (2 M) **World food problem** (1 M)
13	**Explain the various conventional (nonrenewable) energy resources. (7 M) (A.U. Dec 2010)** BTL2 **Answer : Page : 5.56 – 5.60 - A. Ravikrishnan** Coal – (1 M), Petroleum – (2 M) LPG - (1 M) Natural gas - (1 M) Nuclear energy - (2 M)
12	**Discuss in detail the over-exploitation of forests. (7 M) (A.U. Dec 2010)** BTL2 **Answer : Page : 5.6 – 5.7 - A. Ravikrishnan** **Over Exploitation of Forest** • Due to overpopulation the materials supplied by the forest like food, medicine, shelter,

	wood and fuel is not sufficient to meet the people's demand. • Hence exploitation of forest materials is going on increasing day by day. • With growing civilization, the demand for raw materials like timber, pulp, minerals, fuel wood, etc., increases resulting in large scale logging, mining, road building and cleaning of forests (3 M) **Reason for over exploitation in India** It has been estimated that in India the minimum area of forests required to maintain good ecological balance is about 33% of total area. But, at present it is only about 22%. So over exploitation of forest materials occur. (2 M) **Causes of over exploitation** (a) Increasing agricultural production. (b) Increasing industrial activities. (c) Increase in demand of wood resources (2 M)
13	**Discuss any four factors responsible for land degradation. (8 M) (A.U. Dec 2010,May 11,Dec 2013, A.U. Dec 2014)** (BTL2 **Answer : Page : 5.69 – 5.70 - A. Ravikrishnan** **Causes of (or factors influencing) land degradation** 1. **Population:** As population increases, more land is needed for producing food, fibre and fuel wood. Hence there is more and more pressure on the limited land resources, which are getting degraded due to over exploitation. (2 M) 2. **Urbanization:** The increased urbanization due to population growth reduce the extent of agricultural land. To compensate the loss of agricultural land, new lands comprising natural ecosystems such as forests are cleared. Thus urbanization leads to deforestation, which intum affects millions of plant and animal species. (2 M) 3. **Fertilizers and pesticides:** Increased applications of fertilizers and pesticides are needed to increase farm output in the new lands, which again leads to pollution of land and water and soil degradation. (1 M) 4. **Damage of top soil:** Increase in food production generally leads to damage of top soil through nutrient depletion. (1 M) 5. Water-logging, soil erosion, salination and contamination of the soil with industrial wastes all cause land degradation. (2 M)
15	**What are the ecological services rendered by forests? Discuss. (7 M) (A.U. Dec 2010)** BTL2 and BTL1 **Answer : Page : 5.2 – 5.5 - A. Ravikrishnan** List the ecological uses of forest (1 M) **Ecological Uses or services rendered by forest** **Production of oxygen:** During photosynthesis trees produce oxygen which is essential for life on earth. (1 M) **Reducing global warming:** The main greenhouse gas carbon dioxide (CO_2) is absorbed by the trees (forests). Trees absorb the main greenhouse gas CO_2 which is a raw material for photosynthesis. Thus the problem of global warming, caused by greenhouse gas CO_2, is reduced. (1 M) **Soil conservation:** Roots of trees (forests) bind the soil tightly and prevent soil erosion. They also act as wind breaks. (1 M) **Regulation of hydrological cycle:** Watersheds in forest act like giant sponges, which absorb rainfall, slow down the runoff and slowly release the water for recharge of springs. (1 M)

	Pollution moderators: Forests can absorb many toxic gases and noises and help in preventing air and noise pollution. (1 M) **Wildlife habitat:** Forests are the homes of millions of wild animals and plants. (1 M)
16.	**What is land degradation? Explain the causes and effects land (soil) degradation. (7 M) (AU A.U. Dec 2010,May 11,Dec 2013, A.U. Dec 2014)** BTL2 **Answer : Page : 5.69 – 5.70 - A. Ravikrishnan** **Land degradation:** The process of deterioration of soil or loss of fertility of the soil (1 M) **<u>Causes of land degradation (or) factors responsible for land degradation</u>** **1. Population:** ✓ As population increases, more land is needed for producing food, fibre and fuel wood. ✓ Hence there is more and more pressure on the limited land resources, which are getting degraded due to over exploitation. (1M) **2. Urbanization:** ✓ The increased urbanization due to population growth reduce the extent of agricultural land. To compensate the loss of agricultural land, new lands comprising natural ecosystems such as forests are cleared. ✓ Thus urbanization leads to deforestation, which in turn affects millions of plant and animal species. (1M) 3. **Fertilizers and pesticides:** ✓ Increased applications of fertilizers and pesticides are needed to increase farm output in the new lands, which again leads to pollution of land and water and soil degradation. (1M) **4. Damage of top soil:** ✓ Increase in food production generally leads to damage of top soil through nutrient depletion. (1M) 5. Water-logging, soil erosion, salination and contamination of the soil with industrial wastes all cause land degradation (1M) **<u>Harmful effects of land (soil) degradation</u>** ✓ The soil texture and structure are deteriorated. ✓ Loss of soil fertility, due to loss of invaluable nutrients. ✓ Increase in water logging, salinity, alkalinity and acidity problems. ✓ Loss of economic social and biodiversity. (1 M)
17.	**What is desertification? Describe the causes and effects of desertification. (7 M) (AU May 2015, Dec. 2016)** BTL2 **Answer : Page : 5.74 – 5.75 - A. Ravikrishnan** **Desertification:** A progressive destruction or degradation of arid or semiarid lands to desert (1M) **<u>Causes of desertification (or) reason for desertification</u>** **1. <u>Deforestation:</u>** ✓ The process of denuding and degrading a forest land initiates a desert. ✓ If there is no vegetation to hold back the rain water, soil cannot soak and groundwater level do not increases. ✓ This also increases, soil erosion, loss of fertility. **2. <u>Over grazing:</u>** ✓ The increase in cattle population heavily graze the grass land or forests and as a

result denude the land area.

- ✓ The denuded land becomes dry, loose and more prone to soil erosion and leads to desert.

3. **Water Management:**
   - ✓ Over utilization of groundwater, particularly in coastal regions, resulting in saline water intrusion into aquifers, which is unfit for irrigation.
4. **Mining and quarrying :**
   - ✓ These activities are also responsible for loss of vegetal cover and denudation of extensive land area leading to desertification.
5. **Climate change:**
   - ✓ Formation of deserts may also take place due to climate change, ie., failure of monsoon, frequent droughts.
6. **Pollution:**
   - ✓ Excessive use of fertilizers and pesticides and disposal of toxic water into the land also leads to desertification (Each 1 M; any 5 = 5 M)

Harmful effects of desertification

- ✓ Around 80% of the productive land in the arid and semi-arid regions are converted into desert.
- ✓ Around 600 million people are threatened by desertification. (1 M)

18.

Describe the following effects and their remedies on modern agriculture. (a) Water logging (b) Salinity. (7 M) BTL2

(a) Answer : Page : 5.40 - A. Ravikrishnan

Water logging: The land where water stand for most of the year.

Causes of water logging

- ✓ Excessive water supply to the croplands.
- ✓ Heavy rain.
- ✓ Poor drainage. (1 M)

Problems (or) Effects in water logging

- ✓ During water-logged conditions, pore-voids in the soil get filled with' water and the soil-air gets depleted.
- ✓ In such a condition the roots of the plants do not get adequate air for respiration. So, mechanical strength of the soil decreases and crop yield falls. (1 M)

Remedy for water logging

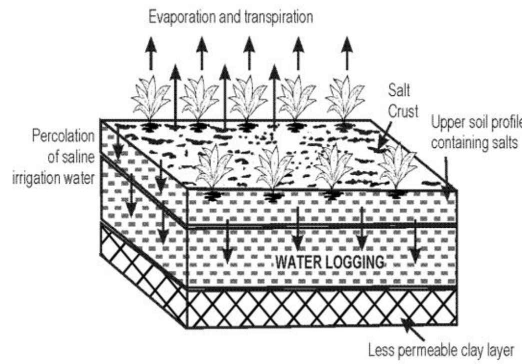
- ✓ Preventing excessive irrigation, sub surface draining technology and bio-drainage by trees like Eucalyptus tree are some method of preventing water logging. (1 M)

(b) Answer : Refer page : 5.41 - A. Ravikrishnan

Salinity: The water, not absorbed by the soil, undergo evaporation leaving behind a thin layer of dissolved salts in the topsoil. This process of accumulation of salts is called the salinity. (1 M)

Problems in Salinity

- ✓ Most of the water, used for irrigation comes only from canal or ground, which unlike rainwater contains dissolved salts. Under dry climates, the water gets evaporated leaving behind the salt in the upper portion of the soil.
- ✓ Due to salinity, the soil becomes alkaline and crop yield decreases. (1 M)



(1M)

<u>Remedy for salinity</u>

- ✓ The salt deposit is removed by flushing them out by applying more good quality water to such soils.
- ✓ Using sub-surface drainage system the salt water is flushed out slowly (1 M)

PART – C QUESTIONS

1

Discuss the world food problems in detail and how does it affects other resources. (15 M) (A.U. May2011) BTL4

Answer : Page : 5.34 – 5.42 - A. Ravikrishnan

World Food problems

1. We know that 79% of the total area of the earth is covered with water. Only 21% of the earth surface is land, of which most of the areas are forest, desert, mountains, barren areas, only less percentage of the land is cultivated. So the food supplied from the rest of the land is not enough to feed all the people. The problem of population explosion has made it worse. The world population increases and cultivable land area decreases. Therefore world food problem arises.
2. Environmental degradation like soil erosion, water logging, water pollution, salinity, affect agricultural lands.
3. Urbanisation is another problem in developing countries, which deteriorates the agricultural lands.
4. Since the food grains like rice, wheat, com and the vegetable like potato are the major food for the people all over the world, the food problem raises.
5. A key problem is the human activity, which degrade most of the earth's net primary productivity which supports all life (5 M)

Effects (or) impacts of overgrazing

1. Land degradation 2. Soil erosion 3. Loss of useful species (3 M)

Effects (or) impacts of agriculture

Effects (or) impacts of Traditional agriculture

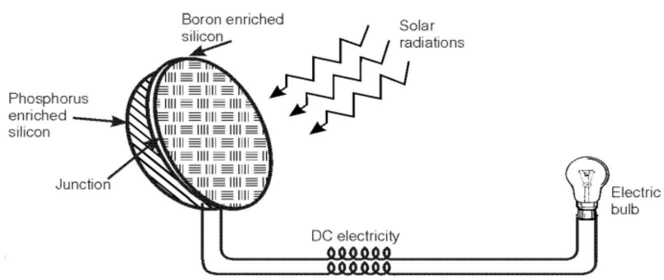
a. Deforestation: Cutting and burning of trees in forests to clear the land for cultivation results in loss of forest cover.

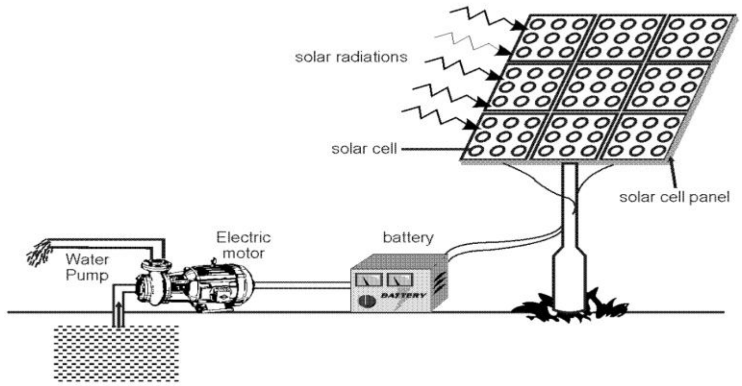
b. Soil erosion: Clearing of forest cover exposes the soil to wind and rainfall, resulting in loss of top fertile soil layer.

c. Loss of nutrients: During cutting and burning of trees, organic matter in the soil gets destroyed and most of the nutrients are taken up by the crops within a short period (2 M)

Effects (or) impacts of modern agriculture (or) adverse effects of agricultural practices (or) Environmental effects of agriculture

(a) Micronutrient imbalance

	(b) Blue Baby syndrome (Nitrate pollution) (c) Eutrophication. d) Water logging e) Salinity (5 M)
2	**What are the natural resources availability in India and discuss any two of them. (15 M) (A.U. May2011)** BTL4 List the natural resources available in India (5M) Any two natural resources available in India (Each 5M)
3.	(i) **Relate the role-play of Environmental Issues in the modern world. (5 M) (ii) Generalize the different methods to propagate environmental awareness. (10 M)** BTL6 **Answer: Page: 5.76 - A. Ravikrishnan** The role-play of environmental issues (5M) Different methods to propagate environmental awareness (10M)
4.	**Discuss the different types of renewable energy resources.(15 M) (A.U. June 2006)** BTL2 **Answer : Page : 5.43 – 5.58 - A. Ravikrishnan** **Renewable energy resources (or) Non-Conventional energy resources** Natural resources which can be regenerated continuously and are inexhaustible. They can be used again and again in an endless manner. Examples: Solar energy, wind energy, tidal energy, etc. (1M) **Renewable energy resources (or) Non-Conventional energy resources** 1. **Solar energy -** The energy that we get directly from the sun is called solar energy. The nuclear fusion reactions occurring inside the sun release enormous amount of energy in the form of heat and light. • **Solar cells** **1. Solar cells (or) photovoltaic cells (or) PV cells**  Solar cell (PV cell) When solar energy falls on the P-type semiconductor, the electrons in the conduction band transferred to conduction band so that a potential difference is developed across the PN junction. Therefore a current is flowing across the junction. (2M) • **Solar battery** When solar cells are connected in series, a solar battery is formed. Using solar battery we can run electrical machines such as pump, fan, etc.



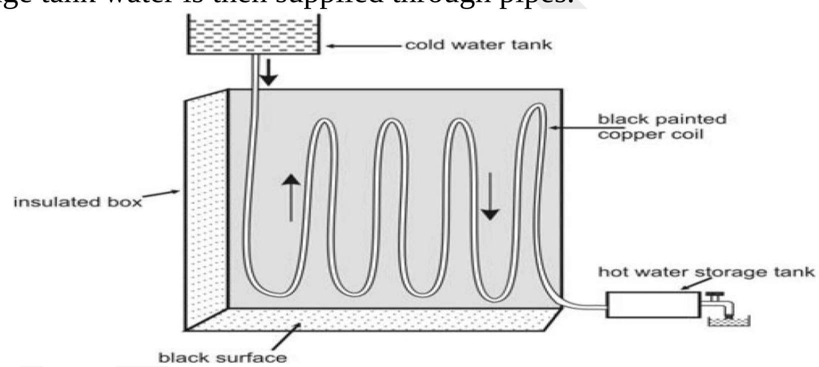
(2 M)

- **Solar Heat Collectors**

Solar heat collectors consist of natural materials like stones, bricks (or) materials like glass, which can absorb heat during the day time and release it slowly at night. (1M)

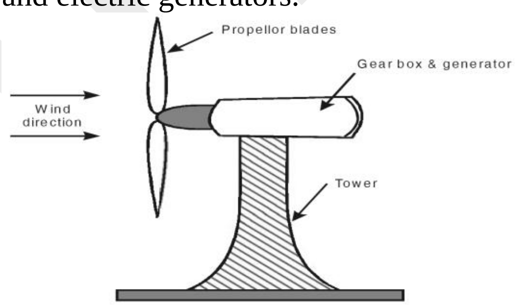
- **Solar water heater**

It consists of an insulated box inside of which is painted with black paint. It is also provided with a glass lid to receive and store solar heat. Inside the box it has black painted copper coil, through which cold water is allowed to flow in, wl1ich gets heated up and flows out into a storage tank. From the storage tank water is then supplied through pipes.



(2M)

2. **Wind energy :** Energy recovered from the force of wind (moving air) is wind energy
    - **Wind mill:** When fast moving air strikes the wind mill blades, it starts to rotate. This rotational motion of the blades derives a number of machines like water pumps, flour mills and electric generators.

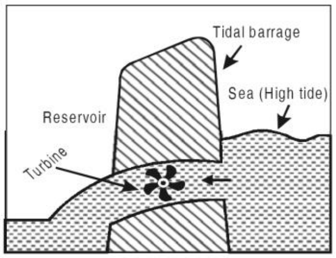
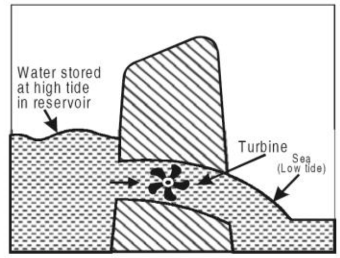
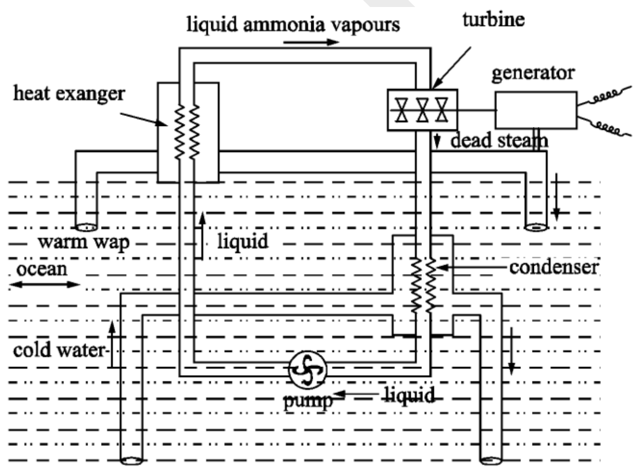


- **Wind Farms.**

When a large number of wind mills are installed and joined together in a definite pattern ir forms a wind farm. The wind farms, produce a large amount of electricity (2M)

3. **Ocean energy**

Ocean can also be used for generating energy of the following ways.

	• **Tidal energy (or) Tidal power** ✓ Ocean tides, produced by gravitational forces of sun and moon, contain enormous amount of energy. ✓ The 'high tide' and 'low tide' refer to the rise and fall of water in the oceans. ✓ The tidal energy can be harnessed by constructing a tidal barrage. ✓ During high tide, the sea-water is allowed to flow into the reservoir of the barrage and rotates the turbine, which in turn produces electricity by rotating the generators. ✓ During low tide, when the sea level is low, the sea water stored in the barrage reservoir is allowed to flow into the sea and again rotates the turbine. (2M) **4. Ocean thermal energy (OTE)** Energy available due to the difference in temperature of water known as ocean thermal energy. Warm surface water boils the liquid ammonia, thus high pressure steam is produced. This steam rotates the turbine which in turn produces electricity by a generator. Dead steam passing through condenser condensed by the cold water at deep ocean. This liquid again pumped upwards using a pump. This process is repeated to produce the electricity using OTE. (3 M)
5.	**Discuss the different types of nonrenewable energy resources.(15 M) (A.U. June 2006)** BTL2 **Answer : Page : 5.43 – 5.58 - A. Ravikrishnan** **Non-renewable (Conventional) energy resources:** Energy resources are natural resources, which cannot be regenerated once they are exhausted. They cannot be used again. Examples: Coal, petroleum, natural gas and nuclear fuels. (1M) **Non-renewable energy resources (or) Conventional energy resources** **1. Coal**

Coal is a fossil fuel formed as several stages as buried remains of land plants that lived 300-400 million years ago.

Various stages of coal formation

Wood → **Peat** → **Lignite** → **Bituminous coal** → **Anthracite** (1M)

The carbon content of Anthracite is 90% and its calorific value is 8700 k.cal. The carbon content of bituminous, lignite and peat are 80, 70 and 60% respectively.

Disadvantages of coal

- ✓ When coal is burnt it produces CO_2, causes global warming.
- ✓ Since it contains S, N, O, produces toxic gases during burning (1M)

2. Petroleum

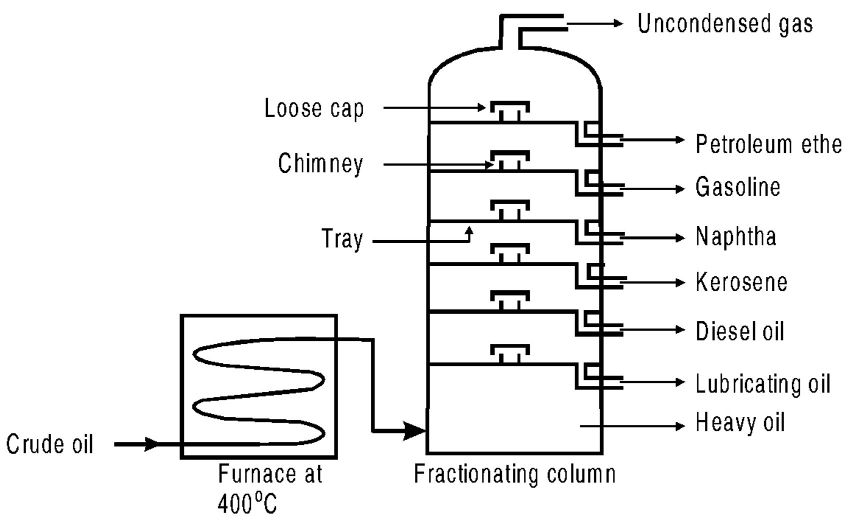
Petroleum or crude oil is a thick liquid contains more than hundreds of hydrocarbons with small amount of S, N, O as impurities.

<u>Occurrence of petroleum</u>

Petroleum or Coal is formed by decomposition of dead animals and plants that were buried under lake and ocean at high temperature and pressure for millions of years. (1M)

<u>Fractional distillation of petroleum</u>

From petroleum various hydrocarbons are separated by purifying and fractionating using fractionating coloumn. (Fig.)



(2 M)

3. LPG

- ✓ Petroleum gas, obtained during cracking and fractional distillation, can be easily converted into liquid under high pressure as LPG.
- ✓ LPG is colourless and odourless gas.
- ✓ But during bottling some mercaptans is added, which produces bad odour, thereby any leakage of LPG from the cylinder can be detected instantaneously. (1M)

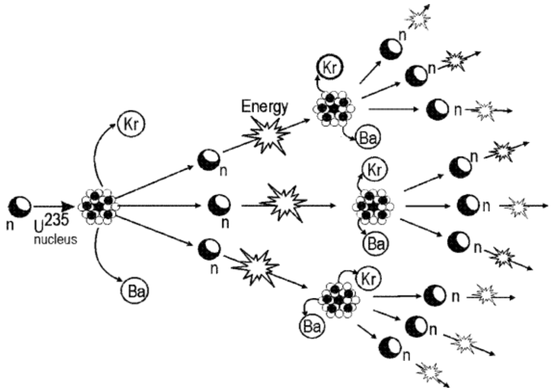
4. Natural gas

- ✓ Natural gas is found above the oil in oil well.
- ✓ It is a mixture of 50-90% methane and small amount of other hydrocarbons.
- ✓ Its calorific value ranges from 12,000-14,000 k . cal/m3 (1M)

5. Nuclear energy

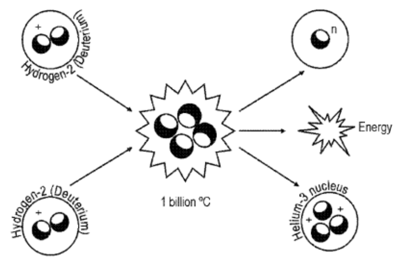
Energy released by nuclear fission or nuclear fusion.

Nuclear Fission: When a heavier nucleus split up in to two lighter nucli by bombardment of a fast moving neutron releases neutrons and tremendous energy.



(1 M)

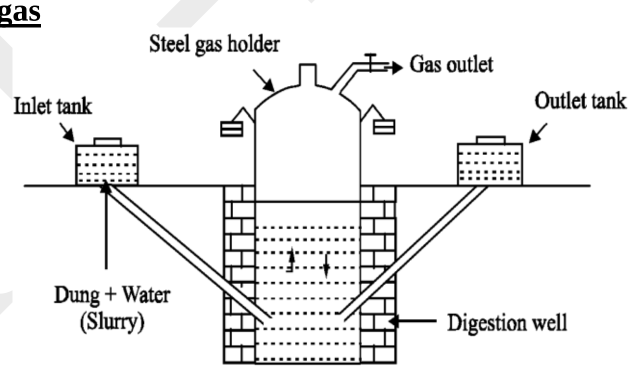
Nuclear Fusion: When two lighter nuclei combined together to form a heavier nucleus at very high temperature releases tremendous energy and neutrons.



Nuclear reactions are effectively used in nuclear power plants. (1M)

6. **Bio gas or Gobar Gas:** Mixture of various gases formed by anaerobic degradation of biological matter in the absence of oxygen. (1 M)

Production of bio gas



(1M)

Bio-gas plant or Gobar gas plant consists of a well like under ground tank (called digester) covered with dome shaped roof with a gas out let pipe. The dome of the digester acts as gas holder. On the left hand side of the digester there is a sloping inlet chamber through which cattle dung + water slurry is introduced. On the right hand side, there is a outlet chamber, through which spent dung slurry gets collected. (1M)

Working

	✓ Slurry (animal dung + water) is fed into the digester through the inlet chamber. The slurry, in the digester, is left for about two months for fermentation. ✓ Anaerobic micro-organisms are responsible for this action. As a result of anaerobic fermentation, bio-gas is collected in the dome. ✓ When sufficient amount of bio-gas is collected in the dome, it exerts a large pressure on the slurry and this in turn forces the spent slurry to the over flow tank through the outlet chamber. (1M) **<u>Uses of Bio Gas</u>** 1. Bio-gas is used for cooking food and heating water. 2. It is used to run engines. 3. It is also used as an illuminant in villages. 4. It is used for running tube-well and water pump-set engines. 5. It is directly used in gas turbines and fuel cells for producing electricity. (1M)
5.	**Discuss the following case studies on** **(a) Deforestation (2 M)** **(b) Mining (8 M)** **(c) Food resources (3 M)** **(d) Renewable and Non-renewable energy resources (2 M)** BTL4 **Answer : Page : 5.10, 5.31, 5.42, 5.64 - A. Ravikrishnan** **(a)** Deforestation (2 M) (b) Mining (8 M) (c) Food resources (3 M) (d) Renewable and Non-renewable energy resources (2 M)

<table>
<tr><td colspan="2">UNIT - IV SOCIAL ISSUES AND THE ENVIRONMENT</td></tr>
<tr><td colspan="2">From Unsustainable to Sustainable Development – Urban Problems Related to Energy – Water Conservation, Rain Water Harvesting, Watershed Management – Resettlement and Rehabilitation of People; its Problems and Concerns, Case Studies – Role of Non-Governmental Organization- Environmental Ethics: Issues and Possible Solutions – Climate Change, Global Warming, Acid Rain, Ozone Layer Depletion, Nuclear Accidents and Holocaust, Case Studies. – Wasteland Reclamation – Consumerism and Waste Products – Environment Production Act– Air (Prevention And Control Of Pollution) Act – Water (Prevention And Control Of Pollution) Act – Wildlife Protection Act – Forest Conservation Act – Enforcement Machinery Involved in Environmental Legislation- Central and State Pollution Control Boards- Public Awareness.</td></tr>
<tr><td>Q. No.</td><td>PART – A</td></tr>
<tr><td>1</td><td>Define the term sustainable development. (NOV/DEC 2005, NOV/DEC 2007, NOV/DEC 2009, APR/MAY 2011) BTL1
Sustainable development is defined as, “meeting the needs of the present without compromising the ability of future generations to meet their own needs”.</td></tr>
<tr><td>2</td><td>What are the advantages of rain water harvesting? (MAY/JUNE 2008) BTL1
Reduction in the use of current for pumping water.
• Mitigating the effects of droughts and achieving drought proofing.
• Increasing the availability of water from well.
• Rise in ground water levels.
• Minimizing the soil erosion and flood hazards.
• Upgrading the social and environmental status.
• Future generation is assured of water.</td></tr>
<tr><td>3</td><td>List the objectives of watershed management. (NOV/DEC 2009) BTL4
• To minimize the risks, of floods, drought and landslides.
• To develop rural areas in the region with clear plan for improving the economy of the region.
• To manage the watershed for developmental activities like domestic water supply, irrigation, hydropower generation etc.,
• To generate huge employment opportunities in the backward rain- fed areas to ensure livelihood security.
• 5. To promote social forestry and horticultural activity on all suitable areas of land.</td></tr>
<tr><td>4.</td><td>Define the term environmental ethics. (NOV/DEC 2011, NOV/DEC 2013) BTL1
Environmental ethics refers to the issues, principles and guidelines relating to human interactions with their environment.</td></tr>
<tr><td>5.</td><td>State a few drawbacks of pollution related acts. (NOV/DEC 2008) BTL1
• The penalties in the act are very small when compared to the damage caused by the big industries due to pollution.
• A person cannot directly file a petition in the court.
• Litigation, related to environment is expensive, since it involves technical Knowledge.</td></tr>
</table>

	• For small unit it is very expensive to install Effluent Treatment – Plant • The position of chairman of the boards is occupied by political appointee. Hence it is difficult to implement the act without political interference.
6.	**What is meant by ISO 14000? (NOV/DEC 2008)** BTL1 ISO 14000 is the environmental management standards which exist to help Organizations minimize how their operations negatively affect the environment and Comply with applicable laws and regulations.
7	**What are the objectives of public awareness?** BTL1 • To create awareness among people of rural and city about ecological imbalances, local environment, technological development and various development plants. • To organize meetings, group discussion on development, tree plantation programmers, exhibitions. • To focus on current environment problems and situations • To train our planners, decision – makers, politicians and administrators. • To eliminate poverty by providing employment that overcome the basic environmental issues. • To learn to live simple and eco-friendly manner
8.	**What are the objectives of environmental impact assessment (EIA)?** BTL1 EIA is defined as a formal process of predicting the environmental consequences of any Development projects. It is used to identify the environmental, social and economic impacts of the Project prior to decision making. Objectives of EIA • To identify the main issues and problem of the parties. • To identify who is the party. • To identify what are the problems of the parties. • To identify why the problems are arise.
9.	**Define urbanization. (NOV/DEC 2010)** BTL1 Urbanization is the movement of human population from rural area to urban area for the want of better education, communication, health and employment.
10	**How can global warming be controlled? (NOV/DEC 2010, APR/MAY 2011)** BTL2 • By reducing the use of fossil fuels. • Utilize renewable resources such as wind, solar and hydropower. • Plant more trees. • Stabilize population growth. • Remove atmospheric CO_2 by utilizing photo synthetic algae.
11	**Mention any four fundamental rights of the individual. (NOV/DEC 2010)** BTL1 • Human right to freedom. • Human right to property. • Human right to religion. • Human right to culture and education. • Human right to equality.
12.	**What is E-Waste? (NOV/DEC 2011)** BTL2 The waste of electronic equipment like computers, printers and mobile phones, Xerox machines, calculators, etc. are e-waste.

13.	**What do we mean by environment refugees? (NOV/DEC 2011)** BTL2 Environmental refugee is a person displaced due to environment causes, especially land loss, and degradation and natural disaster.
14.	**List the objectives of Forest Conservation act. (NOV/DEC 2013)** BTL1 • To protect and conserve the forest • To ensure judicious use of forest
15.	**What are the objectives of water act? (NOV/DEC 2014)** BTL1 • Prevention and control of water pollution. • Maintaining or restoring the wholesomeness of water. • Establishing central and state boards for the prevention and control of water pollution.
16	**Define consumerism and disaster. (NOV/DEC 2015)** BTL2 Consumerism refers to the interrelationship between sellers and buyer. Disaster is a geological process and is defined as an event concentrated in time and space, in which a society or sub-division of a society undergoes severe danger and causes loss of its members and physical property.
17	**What are landslides? (MAY/JUNE 2008, NV/DEC 2014)** BTL2 The movement of earthy materials like coherent rock, mud, soil and debris from higher region to lower region due to gravitational pull is called landslides.
18	**What are the harmful effects of landslides?** BTL2 • Landslides block the roads and diverts the passage • Erosion of soil increases. • Sudden landslides damage the houses, crop yield, live stock etc.
19.	**Define the term Tsunami.** BTL2 A tsunami is a large wave that is generated in a water body when the sea floor is deformed by seismic activity. This activity displaces the overlying water in the ocean.
20	**Give comprehensive definition for air pollution. (NOV/DEC 2010, APR/MAY 2011)** BTL2 The presences of one are more contaminants like dust, smoke, mist and dour in the atmosphere, which are injurious to human beings, plants and animal.
21	**Mention four causes of floods. (NOV/DEC 2010)** BTL2 • Heavy rain, rainfall during cyclone causes flood. • Sudden snow melt also raises the quantity of water in streams and causes flood. • Clearing of forests for agriculture has also increased severity of floods. • Reduction in the carrying capacity of the channel, due to accumulation of Sediments cause floods.
22	**List the objectives of Forest Conservation Act. (NOV/DEC 2013)** BTL1 • Illegal non-forest activity within a forest area can be immediately stopped under this act. • Provides conservation of all types of forests. Non forest activities include clearing of forest land for cultivation of any types of crops.
23	**What are the important aspects of sustainable development?** BTL2 • Inter – generational equity It states that we should hand over a safe, healthy and resourceful environment to our future generations.

	• Intra – generational equity It states that the technological development of rich countries should support the economic growth of the poor countries and help in narrowing the wealth gap and lead to sustainability
24	**Explain the need for water conservation.** BTL2 • Though the resources of water are more, the quality and reliability are not high due to changes in environmental factors. • Better lifestyles require more fresh water. • As the population increases, the requirement of water is also more. • Due to deforestation, the annual rainfall is also decreasing. • Over exploitation of ground water, lead to drought. • Agricultural and industrial activities require more fresh water.
25	**Define the term environmental ethics. (NOV/DEC 2011, NOV/DEC 2013)** BTL2 "Environmental ethics refers to the issues, principles and guidelines relating to human interactions with their environment".
26	**What is meant by environmental audit? (NOV/DEC 2008)** BTL2 Environmental audits are intended to quantify environmental performance and Environmental position. In this way they perform analogous function to financial Audits. It also aims to define what needs to be done to improve on indicators of such Performance and position.
27.	**What is consumerism? List any two objectives of consumerism.** BTL1 The consumption of resources by the people is known as consumerism. Objectives It improves the rights and powers of the buyer It forces the manufacturer to reuse and recycle the product after usage.
28.	**What is Eco-mark?** BTL1 Environmentally friendly products are generally indicated by the symbol called Eco-mark. Eco-mark is a certification mark issued by the Bureau of Indian Standard (BIS) to the environmental friendly products.
PART – B	
1	**What are the salient features of the Air pollution act, Water pollution act and Environment protection Act? Give the reason for why do we prefer environmental protection act as an Umbrella act. (13 M) (MAY/JUNE 2005, NOV/DEC 2005, JAN 2006, NOV/DEC 2006, NOV/JUNE 2007, NOV/DEC 2009, NOV/DEC 2010, MAY/JUNE 2011, NOV/DEC 2013, DEC 2014)** BTL4 **Answer : Refer : 6.34 – 6.38 - A. Ravikrishnan** • Objectives and features of environment protection act (5 M) • Objectives and features of air pollution act (4 M) • Objectives and features of water pollution act (4 M)
2	**Explain in detail the strategies adopted for conservation of water. (6 M) (NOV/DEC 2009, APR/MAY 2010, NOV/DEC 2010, APR/MAY 2011, NOV/DEC 2014)** BTL2 **Answer : Refer : 6.7 – 6.8 - A. Ravikrishnan** • Reducing evaporation loss (1 M) • Reducing irrigation loss (1 M) • Re-use of water (1 M) • Preventing wastage of water (1 M) • Decreasing run-off losses (1 M)

	• Avoid discharge of sewage (1 M)
3	**Discuss in detail about Wild life protection act 1972 and Forest conservation act 1980. (13 M) (NOV/DEC 2010, NOV/DEC 2014)** BTL4 **Answer : Refer : 6.38 – 6.40 - A. Ravikrishnan** • Objectives of Wildlife protection act (2 M) • features of wildlife protection act (4 M) • Objectives of Forest conservation act (2 M) • Features of Forest conservation act (5 M)
4	**Explain the following** **(a) Sustainable development (6 M)** BTL2 **(b) Urban problems related to energy. (7 M) (NOV/DEC 2005, NOV/DEC 2006, MAY/JUNE 2007, NOV/DEC 2010, NOV/DEC 2011, MAY/JUNE 2013)** BTL2 **i. Answer : Refer : 6.21 – 6.6 - A. Ravikrishnan** Sustainable development : • World summit (Agenda) (2 M) • Aspects (2 M) • Concept and significance (2 M) **ii. Answer : Refer : 6.21 – 6.6 - A. Ravikrishnan** Urban problems related to energy : • Definition of urbanization (2 M) Urbanization is the movement of human population from rural areas to urban areas for the want of better education, communication, health, employment, etc. • Energy demanding activities (3 M) • Solution for urban energy problem (2 M)
5	**Discuss the phenomenon of global warming and the factors contributing to it. (13 M)** BTL4 • Explanation of phenomenon of global warming (7 M) • Contributing factors (6 M)
6	**Give a note on nuclear accidents and holocausts. (6 +7 M) (MAY/JUNE 2013, NOV/DEC 2013)** BTL4 **Answer : Refer : 6.24 – 6.26 - A. Ravikrishnan** • Nuclear energy and nuclear accidents (2 M) • Types of nuclear accidents (4 M) • Effect of nuclear holocaust (4 M) • Control measures of holocausts (3 M)
7.	**State the 12 principles of green chemistry. (7 M)** BTL1 **Answer : Refer : - A. Ravikrishnan** • **Prevention.** It is better to prevent waste than to treat or clean up waste after it is formed. • **Atom Economy.** Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product. • **Less Hazardous Chemical Synthesis.** Whenever practicable, synthetic methodologies should be designed to use and generate substances that possess little or no toxicity to human health and the environment. • **Designing Safer Chemicals**. Chemical products should be designed to preserve

efficacy of the function while reducing toxicity.

- **Safer Solvents and Auxiliaries**. The use of auxiliary substances (solvents, separation agents, etc.) should be made unnecessary whenever possible and, when used, innocuous.
- **Design for Energy Efficiency.** Energy requirements should be recognized for their environmental and economic impacts and should be minimized. Synthetic methods should be conducted at ambient temperature and pressure
- **Use of Renewable Feed stocks.** A raw material or feedstock should be renewable rather than depleting whenever technically and economically practical.
- **Reduce Derivatives.** Unnecessary derivatization (blocking group, protection/deprotection, temporary modification of physical/chemical processes) should be avoided whenever possible .
- **Catalysis**. Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.
- **Design for Degradation**. Chemical products should be designed so that at the end of their function they do not persist in the environment and instead break down into innocuous degradation products.
- **Real-time Analysis for Pollution Prevention**. Analytical methodologies need to be further developed to allow for real-time in-process monitoring and control prior to the formation of hazardous substances.
- **Inherently Safer Chemistry for Accident Prevention**. Substance and the form of a substance used in a chemical process should be chosen so as to minimize the potential for chemical accidents, including releases, explosions, and fires (7 M)

8.

What is rain water harvesting? What are the purposes survived by it? (7 M) BTL2

Answer : Refer : 6.8 - A. Ravikrishnan

Rain water harvesting : A technique of capturing and storing of rain water for further utilization (1 M)

Objective:

- To meet increasing demands of water
- Raise water table by recharging ground water
- Reduce ground water contamination from salt water intrusion
- To reduce the surface run-off losses
- To reduce storm water and soil erosion
- To increase hydrostatic pressure to stop land subsidence
- To reduce water crises and water conflicts (1 M)

Roof top rainwater harvesting

- Involves collecting water that falls on roof of house
- Rainwater from roof top, road surface, playground diverted to surface tank. Explanation (2 M)
- Diagram (2 M)

Advantages of rainwater harvesting

- Increases the well water availability § Raise ground water level
- Minimizes soil erosion and flood hazards
- Upgrading the environmental and social status
- Reduction in the use of current for pupping water

	• Future generation is assured for water (1 M)
9.	**What is wasteland? Mention its types and sources. Explain the objectives and methods of wasteland reclamation. (7 M)** BTL2 **Answer : Refer : 6.28 - A. Ravikrishnan** The land which is not in use is named as wasteland. Types: 1. Uncultivable wasteland 2. Cultivatable wasteland (1 M) Causes of wasteland (1 M) Objectives of wasteland reclamation (1 M) Methods of wasteland reclamation (4 M)
10.	**List the traditional rights of seller and buyer. Describe the objectives of consumerism and factors affecting consumerism. (7 M)** BTL2 **Answer : Refer : 6.31 - A. Ravikrishnan** Traditionally favourable rights of seller (1 M) Traditional buyer rights (1 M) Objectives of consumerism (3 M) Factors affecting comsumerism (2 M)
11.	**What is biomedical waste? Describe types and the various steps involved in management of biomedical waste. (7 M)** BTL2 **Answer : Refer : 6.41 - A. Ravikrishnan** Waste generated from health care activities. (1 M) Types of biomedical waste (3 M) Three steps involved in management of biomedical waste (3 M)
12.	**Define watershed and watershed management? Explain the concept of watershed management in detail. (13 M)** BTL2 **Answer : Refer : 6.11 - A. Ravikrishnan** Watershed – The land area from which water drains under the influence of gravity into a stream, lake, reservoir or other body of surface water, (1 M) Watershed management – The management of rainfall and resultant runoff is called watershed management. (1 M) Factors affecting watershed management (1 M) Objectives of watershed management (2 M) Watershed management techniques (2 M) Components of integrated watershed management (6 M)
	PART–C
1	**What is an earthquake? Write about its causes, effects and measures to face the earthquake. (15 M) (APR/MAY 2008, NOV/DEC 2008, NOV/DEC 13, NOV/DEC 2014)** BTL4 **Answer : Refer : 6.58 – 5.58 - A. Ravikrishnan** • Definition: An earthquake is a sudden vibration caused on the earth's surface due to the sudden release of tremendous amount of energy stored in the rocks under the earth's crust. (2 M) • Causes (4 M) • Effects (4 M) • Preventive measures (5 M)
2	**Give a note on**

	(d) Floods **(e) Cyclone** **(f) Landslides** **(15 M)** BTL2 **Answer : Refer : 6.52 – 6.57 - A. Ravikrishnan** • Definition of flood: Whenever the magnitude of water flow exceeds the carrying capacity of the channel within its banks, the excess of water over flows on the surroundings causes floods (1 M) • Causes and effects (2 M) • Preventive measures of floods (2 M) • Definition: Cyclone is a meteorological phenomenon, intense depressions forming over the open oceans and moving towards the land. On reaching the shores, it move into the interior of the land or along the shore lines. (1 M) • Causes and effects (2 M) • Preventive measures of cyclone (2 M) • Definition: The movement of earthy materials like coherent rock, mud, soil and debris from higher region to lower region due to gravitational pull is called landslides. (1 M) • Causes and effects (2 M) • Preventive measures of landslides (2 M)

UNIT V HUMAN POPULATION AND THE ENVIRONMENT

Population Growth, Variation Among Nations – Population Explosion – Family Welfare Programme – Environment and Human Health – Human Rights – Value Education – HIV / AIDS – Women and Child Welfare – Role of Information Technology in Environment and Human Health – Case Studies.

Q. No.	PART-A
1.	**Define immigration and emigration. (Coim A.U. Dec 2009)** BTL1 **Immigration -** Arrival of individuals from neighbouring population. **Emigration -** Dispersal of individuals from the original population to new areas
2.	**Define population and population density. (Coim A.U. Dec 2009, Chen A.U. Apr 2011)** BTL1 **Population**-Group of Individuals belonging to the same species, which live in a given area at a given time. **Population density**-Number of individuals of the population per unit area (or) unit volume
3.	**Define birth rate and death rate.** BTL1 **Birth rate or Natality**-No. of live birth per 1000 people in a population in a given year **Death rate or Mortality**-No. of deaths per 1000 people in a population in a given year
4.	**Define doubling time with reference in population growth. (Chen A.U. Dec 2008, 2013)** BTL1 Time required for a population to double its size at a constant annual rate. $Doubling\ time = Td = \frac{70}{r}$ Where, r - Annual growth rate. If a nation has 2% annual growth; its population will double in the next 35 year.
5.	**What are the reasons behind the increased population growth in the less developed nations compared with developed nations? (Chen AU Dec 2007)** BTL1 • Due to decrease in the death rate and increase in the birth rate • The availability of antibodies, immunization, increased food production, clean water and air decreases the famine-related deaths and infant mortality. • In agricultural based countries, children are required to help parents in the fields.

6.	**Write population equation. (Coim. A.U. Dec 2008)** BTL1 $Pt + 1 = Pt + (B - D) + (I - E)$ Where Pt and Pt+1 = sizes of population in an area at two different point s in time t and t+1; B-Birth rate I-Immigration; D-Death Rate; E-Emigration.
7.	**List the characteristics of population growth.** BTL4 • Exponential growth • Doubling time • Infant mortality rate • Total fertility rates (TFR) • Replacement level • Male-Female Ratio • Demographic transition
8.	**Mention the various problems of population growth.** BTL4 • Increasing demands for food and natural resources • Inadequate housings and health services • Loss of agricultural lands • Unemployment and socio-political unrest • Environmental pollution
9.	**What is population explosion? (Chen AU Jun 2007, May 2008, TCY A.U. Dec 2008, Dec 2009, Dec2010, Apr 2015)** BTL1 The enormous increase in population due to low death rate and high birth rate.
10.	**What are the effects of population explosion? (Chen A.U. Dec 2009)** BTL1 • Poverty • Environmental degradation • Over exploitation of natural resources • Renewable resources like forests, grass lands are also under threat • Will increase disease, economic inequity and communal war • Leads to development of slums • Lack of basic amenities like water supply and sanitation, education, health, etc • Unemployment and low living standard of people
11.	**How the age structure of population can be classified?** BTL4 • Pre-productive population (0-14 years) • Reproductive population (15-44 years) • Post reproductive population (Above 45 years)
12.	**State the reasons of population explosion.** BTL1 • Invention of modern medical facilities; Illiteracy • Decrease in death rate and increase in birth rate • Availability of antibiotics, Food, clean water, air, etc. • Decreases the famine-related deaths and infant mortality • In agricultural based countries- Children are required
13.	**What is family welfare programme?** BTL1 Programme implemented by the government of India. An integral part of overall national policy of growth covering human health, maternity, family welfare, child care and women's right, education, nutrition, health, employment, shelter, safe drinking water

14.	**Define population stabilization ratio.** BTL1 Ratio of crude death rate to crude birth rate.
15.	**What are the objectives of family welfare programme? (TNV A.U. Dec 2009)** BTL1 • Slowing down the population explosion by reducing the fertility • Pressure on the environment due to over exploitation of natural resources is reduced
16.	**List the factors influencing family size.** BTL4 • Reduce infant mortality rate to below 30 per 1000 infant • Achieve 100% registration of births, deaths, marriage and pregnancy • Encourage late marriage, late child-bearing, breast feeding • Enables to improve women's health, education and employment • Prevent and control of communicable disease and AIDS/HIV • Promote vigorously the family norms • Making school education up to age 14 free and compulsory
17.	**What is meant by NIMBY syndrome? (Chen A.U. Dec 2008)** BTL1 NIMBY-**N**ot **I**n **M**y **B**ack **Y**ard. Describes the opposing of residents to the nearby location of something they consider undesirable, even clearly a benefit for many
18.	**List the factors influencing human health.** BTL4 • Nutritional Factors • Biological Factors • Chemical Factors • Psychological Factors
19.	**What is meant by human rights?** BTL1 The fundamental rights which are possessed by all human beings irrespective of their caste, nationality, sex and language. These cannot be taken away by any legislature. Every citizen must enjoy certain rights and also has certain duties towards the country.
20.	**List the features of draft declaration of human rights**. BTL4 • Human rights to freedom • Human rights to property • Human rights to freedom of religion • Human rights to culture and education • Human rights to constitutional remedies • Human rights to equality • Human rights against exploitation • Human rights to food and environment • Human rights to good health
21.	**What is education? List its types.** BTL1 **Education-**learning through which knowledge about the particular thing can be acquired **Types of Education** • **Formal Education**-Self related. Will read, write, get jobs and tackle the problems • **Value Education**–Instrument to analyse our behavior and provide proper direction to youth. Teaches distinction between right and wrong, helpful, loving, etc. • **Value-based environmental education**-Provide knowledge on principles of ecology, fundamentals of environment and biodiversity
22.	**Write the importance of value education. (Chen A.U. Dec 2008, 2013)** BTL2

	• Improve the integral growth of human being • Create attitudes and improvement towards sustainable lifestyle • Increase awareness about our national history, cultural heritage, constitutional rights, national integration, community development and environment • Create and develop awareness about the values, role and their significance
23.	**What is role playing element of value education?** BTL1 Acting out the true feelings of the actors by taking the role of another person but without the risk of reprisals.
24.	**Mention the types of values imported through value education.** BTL1 • Universal Values or Social Values • Cultural Values • Individual Values • Global Values • Spiritual Values
25.	**Define the term HIV/AIDS.** BTL1 **HIV**-**H**uman **I**mmunodeficiency **V**irus; **AIDS**-**A**cquired **I**mmuno **D**eficiency **S**yndrome; a condition in humans in which the immune system begins to fail, leading to life-threatening opportunistic infections.
26.	**What are the factors which do not influence transmission of HIV?** BTL1 Tears, food, air, cough, handshake, mosquito, flies, insect bites, urine, saliva during kissing, sharing of utensils, cloths, toilet, bathroom etc.
27.	**Mention some effects of HIV/AIDS. (Chen A.U. Dec 2008, 2011, 2014)** BTL1 • Large number of death occurs, which affect environment and natural resources • Loss of labour and level of production decreases • Required more water for maintaining hygiene in AIDS affected locality • People affected by HIV, cannot perform work well, due to lack of energy and frequent fever and sweating
28.	**What are the major precautions to avoid AIDS? (Chen AU May 2008)** BTL1 • Avoid indiscriminate sex and encourage the use of condoms and also avoid the use of sharing razors needles and syringes • Prevention of blood borne HIV transmission • Aids awareness programmes should be encouraged • Counseling services should be provided • Drug treatment
29.	**State the role of information technology in Environment. (Coim A.U. Dec 2009, Chen AU Jan 2006)** BTL4 • Plays a vital role in the field of environmental education. • Means collection, processing, storage and dissemination of information. • Numbers of software have been developed to study about the environment. • The internet facilities, information through satellites, World Wide Web, and geographical information systems provide us up-to-date information on various aspects of environment and weather.
30.	**What is value education? Give its significance. (NOV/DEC 2013)** BTL4 An instrument used to analyse our behavior and provide proper direction to our youths. Teaches them the distinction between right and wrong, to be compassionate, helpful, loving, generous and

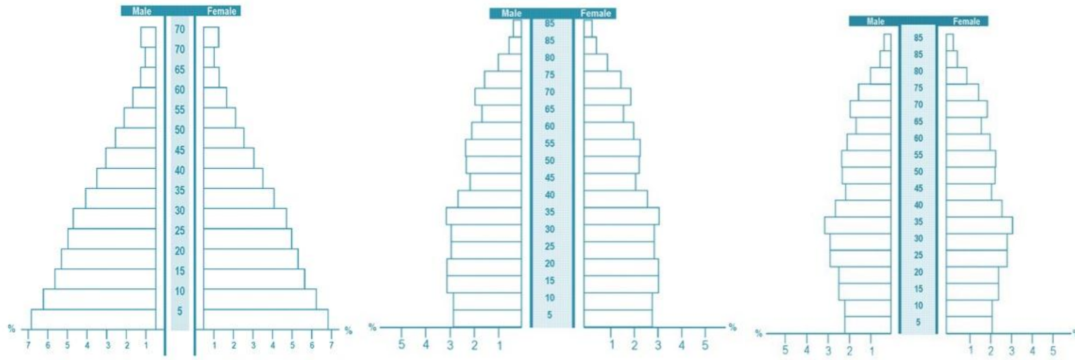
	tolerant. So that a youth can move towards the sustainable future.
31.	**What do you mean by Doubling Time? (NOV/DEC 2013)** BTL1 Period of time required for a quantity to double in size or value. Generally applied to denote the population growth.
32.	**State the role of Information Technology in health protection.** BTL1 • Health organization turning to package solution of IT for streamlining services oriented work in effective manner. • Health service technology such as finance and accounting, pathology, patient administration • Helps the doctor to monitor the health of the people effectively • Online help of expert doctors can be used for the patient • The outbreak of epidemic diseases can be conveyed easily • Effective function of a hospital • Drugs and its replacement can be administered efficiently • The data regarding birth and death rate, immunization and sanitation programmes can be maintained accurately with the help of computers
33.	**What is environmental impact assessment?** BTL1 Formal process of predicting the environmental consequences of any development projects. Used to identify the environmental, social and economic impacts of the project prior to decision making.
34.	**What is GIS?** BTL1 Graphical Information System (GIS) acts as a technique of superimposing various thematic maps with the use of digital data on a large number of inter-related aspects. Considered to be an effective tool in environmental management.
35.	**List out the benefits of EIA.** BTL4 • Reduce the cost and time • Performance of the project improved • Waste treatment and cleaning expenses are minimized • Usages of resources are decreased • Biodiversity is maintained • Human health is improved (
36.	**Mention the key element of EIA.** BTL1 • **Scoping** – To identify the key issues of the concern in the planning process at early stage, aid site selection and identify any possible alternatives. • **Screening -**To decide whether an EIA is required or not. • **Identifying and evaluating alternatives-**Knowing alternative sites and techniques and their impacts. • **Mitigation measures dealing with uncertainty-**Action taken to prevent adverse effect of a project. • **Environmental statements-**Final stage of EIA process which reports the findings of the EIA.
37.	**What is child welfare? Mention the schemes towards child welfare.** BTL1 **Child Welfare** • Children occupy 40% of the total population. • Out of 21 Million Children born every year in India, 20 Million are estimated to be

	working as Child Labour in hazardous industries
	Organizations towards Child Welfare
	• UN Conventions on Rights of Child or International Laws
	• Rights of child
	    • …Right to Survival
	    • …Right to Participation
	    • …Right to Development
	    • …Right to Protection
	• Ministry of HRD
	• Centre for Science and Environment (CSE)
	• Environment degradation and child welfare
	So it is essential to keep our environment clean to children for better and healthy life Poverty

38.	**What is women welfare? List the various organization function towards women welfare.** BTL1 Welfare to improve the status of the women by providing opportunities in education, employment and economic independence (1M) **Organizations Towards Women Welfare** • NNWM (National Network for Women and Mining): Fighting for the "Gender Audit" of India's mining companies • UNDW (United Nations Decade for Women): Women welfare related issues on international agenda • CEDAW (Convention on Elimination of all forms of Discrimination against Women) • NGO's as Mahila Mandals • Ministry for Women and Child Welfare (1M)
PART – B	
1.	

	(i) Can you recall population characteristics & variations among nations? (7M) BTL1
	(ii) What is population explosion and state the views on population growth. (6M) BTL2
	
	(i) Answer: Page: 7.3 – 7.8-**A. Ravikrishnan**
	Characteristics of population growth
	• Exponential growth
	• Doubling time
	• Infant mortality rate
	• Total fertility rates
	• Replacement level
	• Male-Female ratio
	• Demographic transition (3M)
	Variation of population among nation based on age structure
	• Pre-productive population (0-14 years)
	• Reproductive population (15-44 years)
	• Post Reproductive population (above 45 years)
	    • Pyramid shaped variation of population (Increase)
	    • Bell shaped variation of population (Stable)

- Urn shaped variation of population (Decrease) (2M)



- Diagrams (2M)

(ii) Answer: Page: 7.8 – 7.11-**A. Ravikrishnan**

Population explosion–Enormous increase in population due to low death rate and high birth rate is termed as population explosion. (1M)

Causes of population explosion

- Invention of modern medical facilities; Illiteracy
- Decrease in death rate and increase in birth rate
- Availability of antibiotics, Food, clean water, air, etc.
- Decreases the famine-related deaths and infant mortality
- In agricultural based countries- Children are required (3M)

Effect of Population Explosion

Poverty; Environmental degradation; Unsustainable environment; Over exploitation of natural resources; Renewable resources become under threat; Increase disease, economic inequity and communal war; development of slums; lake of basic amenities; Unemployment. (2M)

2.

(i) How would you explain the family welfare programs (8M) BTL2

(ii) Show family planning in Indian context. (5M) BTL2

(i) Answer: Page: 7.11 – 7.14-A. Ravikrishnan.

Family welfare programme

- An integral part of overall national policy of growth covering human health, maternity, family welfare, child care and women's right, education, nutrition, health, employment, shelter, safe drinking water (1M)

Objectives of family welfare programme

- Slowing down the population explosion by reducing the fertility
- Pressure on the environment is reduced (1M)

Objectives of family planning

- Reduce infant mortality rate to below 30 per 1000 infant
- Achieve 100% registration of births, deaths, marriage and pregnancy
- Encourage late marriage and late child-bearing.
- Encouraging breast feeding
- Enables to improve women's health, education and employment
- Making family planning available to all women who wanted do

	• Constrain the spread of AIDS/HIV • Prevent and control of communicable disease • Promote vigorously the family norms • Making school education up to age 14 free and compulsory (3M) **Methods of family planning** • Traditional method • Modern method • Temporary method (3M) **(ii) Answer: Page: 7.14-A. Ravikrishnan.** (BTL2) **Family planning in India** • It was started in the year 1952 • In 1970's Indian government forced family planning campaign all over the country • In 1977, national family programme and ministry of health and family welfare redesigned • In 1978, the government legally raised the minimum age of marriage for men from 18 to 21 and for women 15 to 18 • In 1981, census report showed that there was no drop in population. Since then funding for family planning programmes has been increased further • The first country that implemented the family welfare programme at government level • Centrally sponsored programme. For this, the states receive 100% assistance from central government • The ministry of health and family welfare have started the operational aims and objectives of family welfare o To promote the adoption of small family size norm, on the basis of voluntary acceptance o To ensure adequate supply of contraceptives to all eligible couples within easy each o Extensive use of public health education for family planning (5M)
3.	
	Discuss the influence of environmental parameters and pollution on human growth. (13M) BTL2 **Answer: Page: 7.14 – 7.17-A. Ravikrishnan** **Factors influencing human health**-A state of complete physical, mental, social and spiritual well-being and not merely the absence of disease or infirmity. "The Ability To Lead A Socially And Economically Productive Life." • Nutritional factors • Biological factors • Chemical factors • Psychological factors (3M) **Holistic concept of health-**Recognizes the strength of social, economic, political and environmental influences on health **Determinants of health**- Heredity, Health and family welfare services, Environment, Life-style Socio-economic conditions. Disease result from complex interaction between man and the environment. **Disease-**"Maladjustment of the human organism to the environment". (2M)

	Environmental degradation due to population explosion • All that which is external to man is the environment • The concept of environment is complex • The external environment or the Macro-environment to be responsible for millions of preventable diseases originating in it (1M) **Environmental hazards** • **Physical:** Air, water, soil, housing, climate, geography, heat, light, noise, debris, radiation, etc. and their health effects • **Biological**: bacteria, viruses, parasites, microbial agents, insects, rodents, animals and plants, etc. and their health effects • **Chemical**: Combustion of fossil fuel liberates SO_2, NO_2, CO_2 ; Industrial effluents; Pesticides; Heavy metals; Chloro fluoro carbons and their health effects • **Psychosocial**: Cultural values, customs, beliefs, habits, attitudes, morals, religion, education, lifestyles, health services, social and political organization and their health effects (7M)
4.	
	(i) Write short notes on human rights. (5M) BTL4 **(ii) Discuss the salient features of draft declaration of Human Rights and environment. (8M)** BTL2 **(i) Answer: Page: 7.17-7.19 A. Ravikrishnan.** **Human rights** • The fundamental rights which are possessed by all human beings irrespective of their caste, nationality, sex and language • These cannot be taken away by any legislature or an government act • Seen as belonging to men and women by their very nature • India is a democratic country • Aim of India is to ensure happiness to all the citizens with equal rights, opportunities and comforts • Every citizen must enjoy certain rights and also has certain duties towards the country • Include civil and political rights, such as the right to life and liberty, freedom of expression, and equality before the law; and social, cultural and economic rights, including the right to participate in culture, the right to food, the right to work, and the right to education. • All human beings are born free and equal in dignity and rights • They are endowed with reason and conscience and should act towards one another in a spirit of brotherhood (5 M) **(ii) Answer: Page:** 7.17-7.19**-A. Ravikrishnan.** BTL2 **Features of draft declaration of human rights** • Human rights to freedom • Human rights to property • Human rights to freedom of religion • Human rights to culture and education • Human rights to constitutional remedies • Human rights to equality

	• Human rights against exploitation • Human rights to food and environment • Human rights to good health (8M)
5.	
	Summarize the objectives, concepts, types of values and elements of value education? How can the same be achieved? (13M) BTL3 **Answer: Page: 7.20 – 7.24-A. Ravikrishnan** **Education-**learning through which knowledge about the particular thing can be acquired **Types of Education** • Formal Education-Self related • Value Education–Instrument to analyse our behavior and provide proper direction to youth • Value-based environmental education-Provide knowledge on principles of ecology, fundamentals of environment and biodiversity (1M) **Objectives of value education** • To improve the internal growth of human beings. • To create attitudes and improvement towards sustainable life style. • To increase awareness on national history, our cultural heritage, constitutional rights, national integration, community development and environment. • To create and develop awareness about the values and their significance and role. • To understand about our natural environment in which land and, air and water are interlinked. (2M) **Concepts of value education** • Why and how can we use less resources and energy? • Why do we need to keep our surrounding clean? • Why should we use less fertilizers and pesticides? • Why it is important for us to save water and keep our water sources clean? • Separate our garbage into degradable and non-degradable types before disposal (2M) **Types of values** • **Universal Values or Social Values**: Expresses the human nature reflected as joy, compassion, tolerance, service, truth, etc • **Cultural Values:** To reflect true and the false behaviour of human beings in language, aesthetics, education, law, economics, etc • **Individual Values:** Parents and Teachers shape individual values to a greater extent • **Global Values:** To reduce disturbance of Harmony leading to ecological imbalance • **Spiritual Values:** To become more self-disciplined (3M) **Elements of value education–How the objectives can be achieved** • Telling Modeling • Role playing • Problem solving • Studying biographies of great man (5M)
6.	
	Explain the objectives, benefits and key elements of EIA (13M) (TNV AU Dec. 2009) BTL2

	Answer: Page:7.32 – 7.34-A. Ravikrishnan **Objectives of EIA** • To identify the main issues and problems of the parties • To identify who is the party • To identify what are the problems of the parties • To identify why are the problems arise (2M) **Benefits of EIA** • Reduce the cost and time • Performance of the project improved • Waste treatment and cleaning expenses are minimized • Usages of resources are decreased • Biodiversity is maintained • Human health is improved (2M) **Key element of EIA** • **Scoping** – To identify the key issues of the concern in the planning process at early stage, aid site selection and identify any possible alternatives. (2M) • **Screening -**To decide whether an EIA is required or not. (2M) • **Identifying and evaluating alternatives-**Knowing alternative sites and techniques and their impacts. (1M) • **Mitigation measures dealing with uncertainty-**Action taken to prevent adverse effect of a project. (2M) • **Environmental statements-**Final stage of EIA process which reports the findings of the EIA. (2M)
7.	
	Explain in details about women welfare and child welfare. (13M) BTL2 **Answer: Page: 7.28 – 7.32-A. Ravikrishnan** **Women welfare** Welfare to improve the status of the women by providing opportunities in education, employment and economic independence (1M) **Need for Women Welfare** • As women suffer Gender Discrimination • Due to physical and mental torture given to them • Violation of Human Rights to Women. • Neglecting of Women in Policy making and decision making (2M) **Objectives of Women Welfare** • To provide Education • To impart Vocational Training • To generate awareness about the environment • To improve employment opportunities • To restore Dignity, Status and Equality (2M) **Objectives National Commission for Women by Government of India** • To examine constitutional and human rights for women. • To review existing legislations. • To sensitize the enforcement and administrative machinery to women's causes (1M)

	Organizations Towards Women Welfare
	• NNWM (National Network for Women and Mining): Fighting for the "Gender Audit" of India's mining companies
	• UNDW (United Nations Decade for Women): Women welfare related issues on international agenda
	• CEDAW (Convention on Elimination of all forms of Discrimination against Women)
	• NGO's as Mahila Mandals
	• Ministry for Women and Child Welfare (2M)
	Child Welfare
	• Children occupy 40% of the total population.
	• Out of 21 Million Children born every year in India, 20 Million are estimated to be working as Child Labour in hazardous industries (1M)
	Reason for Child Labour
	• Poverty
	• Want of Money (1M)
	Organizations towards Child Welfare
	• **UN Conventions on Rights of Child or International Laws**-Formulated a set of International Standards to promote and protect the wellbeing of Children in our society
	• **Rights of child**
	  ◦ …Right to Survival
	  ◦ …Right to Participation
	  ◦ …Right to Development
	  ◦ …Right to Protection
	• **Ministry of HRD**-Concentrates on child's health, education, nutrition, clean and safe drinking water, sanitation and environment
	• **Centre for Science and Environment (CSE)**-Scientific report says that "Children consume more water, food and air than adults and hence more susceptible to environmental contamination
	• **Environment degradation and child welfare**-Children are more affected due to environmental pollution. So it is essential to keep our environment clean to children for better and healthy life Poverty (3M)

8.	
	Write a note on Indian constitution. (13M) BTL1 **Answer: Page: 7.19 – 7.20-A. Ravikrishnan** **Indian constitution; Article 14-30 .** • Article 14: Provides Equality before Law • Article 15: Prohibits Discrimination • Article 16: Provides Equal Opportunity • Article 19: Provides Freedom of Speech and Expression • Article 20: Provides Protection from Conviction • Article 22: Lays down the Rights of a person in Custody • Article 23: Prohibits forms of Forced Labour • Article 24: Prohibits appointment of Child Labour • Article 25: Provides Freedom to Practice any Religion

- Article 26: Right to establish Charitable Institutions
- Article 27: Prohibits Tax for Promoting Religion
- Article 28: Guarantees Secular Character in Education
- Article 29: Right to conserve their Language for Minorities
- Article 30: Right of Minority to run Educational Institutions
- Article 32: Right to Constitutional Remedies for enforcement of Rights by proceeding in Supreme Court (13M)

PART-C

1.

(i) Narrate the role of information technology in environment protection (TNV AU Dec.2008 Dec. 2009, June 2013, Nov. 2011) (8M) BTL4

(ii) Describe the case studies on role of IT in environment protection. (7M) BTL5

Answer: Page: 7.34 – 7.37-A. Ravikrishnan

(i) Role of IT in environment

Software for environment education

- **Remote Sensing**-Gather information about an object without contact with it
  - In agriculture
  - In forestry
  - In land cover
  - Water resources Remote sensing (2M)
- **Data base**
  - The ministry of environment and forest
  - National Management Information System (NMIS)
  - Environment Information System (ENVIS) (1M)
- **Geographical Information System (GIS) –**Superimposing various thematic maps
  - Water resources, soil type, forest land
  - Interpretations of polluted zones, degraded lands
  - Check unplanned growth and environmental problems (1M)
- **Satellite data**
  - Forest cover information
  - Information on monsoon, ozone layer depletion, smog etc.
  - Discovery of new reserves of oils, minerals, etc. (1M)
- **World Wide Web**
  - Online learning centers
  - Provides the current and relevant information on principles, queries, and applications of environmental science.
  - Stores all digital files related to teaching (1M)
- **General applications**
  - Easily Accessible around The World
  - Disaster Management-Suitable warning system, disaster preparedness
  - Opened up a large number of scientific and technological resources and skills to reduce disaster risk.
  - Internet

	• Aerial sensor technologies to detect and classify objects on earth. • To capture, store, manipulate, analyse, manage and present geographical data. • Store books, pictures and other data that reduces paper waste that helps us in saving trees. • E-bills has significantly increased, which also contribute in saving trees. (2M) **(ii) Answer: Page: 7.38 – 7.39-A. Ravikrishnan** **Case studies on Role of IT in environment** • Study on polluted back waters of Kerala • Ocean study monitor (OCM) to study phytoplanktons • GIS for forest management • National Emission Data System (NEDS) • Environment Information System (ENVIS) (7M)
2.	
	(i) **Explain the role of IT in protection of human health. (10 M) (AU June 2013, Dec. Nov. 2009)(10M)** BTL4 **(ii) Explain the case study on role of IT in human health protection. (5M)** BTL5 **(i) Answer: Page: 7.39–7.40-A. Ravikrishnan** **Role of IT in human protection** • Health service technology- Finance and accounting, pathology, patient administration. • Helps the doctor to monitor the health of the people effectively. • Online help of expert doctors can be used for the patient. • The outbreak of epidemic diseases can be conveyed easily. • Effective function of a hospital. • Drugs and its replacement can be administered efficiently. • The data maintenance- birth and death rate, immunization and sanitation programmes • Spreading awareness about diseases and preventive measures to be taken. • Reduces panic and provides information about prevention and treatment options. • Airports-Screened passengers for high temperature and other symptoms • Robots that emulate or simulate living biological organisms. • Nano-Robots act as delivery systems within the organism • e-Health for healthcare practice. • Gaining momentum in academic research as well as in psychology, clinical work, and mental health counselling. • Statistics about diseases like malaria, fluorosis, AIDS, etc. • DNA databases about population, medical records, fingerprints, etc • Saves lives in critical care and emergency situations. • Bioinformatics for drug discovery and thus contributing to human health. • Provide a great support in maintaining individual fitness. (10M) (ii) **Answer: Page: 7.40–7.41-A. Ravikrishnan** **Case study** Health services on New south wales (3 M) National Institute of Occupational health (2M)
3.	

Explain HIV/AIDS, its sources, diagnosis, mode of transmission of HIV infection and control and preventive measures.(15M) BTL2

Answer: Page: 7.24 – 7.28-**A. Ravikrishnan**

HIV-Human **I**mmunodeficiency **V**irus; **AIDS-A**cquired **I**mmuno **D**eficiency **S**yndrome; a condition in humans in which the immune system begins to fail, leading to life-threatening opportunistic infections. (2M)

Sources of HIV infection.

- AIDS has spread from Africa.
- HIV has transferred to human from African monkey or Chimpanzees.
- HIV contaminated polio vaccine, prepared from monkey's kidney.
- Spread through hepatitis-B viral vaccine in Los Angels New York.
- Spread through small pox vaccine programme of Africa. (2 M)

Symptoms or diagnosis of HIV/AIDS

Minor symptoms

- Persistent cough for more than one month
- General skin disease
- Viral infection
- Fungus infection in mouth and throat
- Frequent fever, headache, fatigue

Major symptoms

- Fever for more than one month
- Diarrhea for more than one month
- Cough and TB for more than six months
- Fall of hair from the head
- 10% of body weight get reduced within a short period. (4M)

Mode of transformation of HIV.

- Sexual transmission, presence of STD increases likelihood of transmission.
- Exposure to infected blood or blood products.
- Use of contaminated clotting factors by hemophiliacs.
- Sharing contaminated needles.
- Transplantation of infected tissues or organs.
- Certain body fluids from an HIV-infected person-Blood, Semen, Rectal fluids, vaginal fluids, Breast milk.
- Having unprotected sex with someone who has HIV.
- Receiving blood transfusions, blood products, or organ/tissue transplants that are contaminated with HIV.
- Contact between broken skin, wounds, or mucous membranes and HIV-infected blood or blood-contaminated body fluids.
- Women are more vulnerable to HIV. Transmission of HIV to their new born babies happen easily.
- Women around 18-20 years are at risk, since their cervical tissue is more vulnerable to invading HIV. (5M)

Control and preventive measure

- Education

	• Prevention of blood borne HIV transmission • Primary health care • Counselling services • Drug treatment (2M)