JEPPIAAR INSTITUTE OF TECHNOLOGY

"Self-Belief | Self Discipline | Self Respect"

QUESTION BANK

Regulation	:	2017
Year	:	I
Semester	:	02
Batch	:	2019 - 2023

DEPARTMENT OF MECHANICAL 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.

DEPARTMENT VISION

To be the most sought-after Department in the field of Mechanical Engineering for imparting Technical Education for the upliftment of the society

MISSION

- To provide innovative solutions for industrial problems this helps in societal development.
- To inculcate students for a successful career in engineering and technology.
- To promote excellence in engineering and technology by motivating students for higher studies.

- To motivate self-employment thereby reducing migration to urban areas.
- To maintain ethical values while assimilating diverse culture without compromising with Indian value system.
- To provide excellent infrastructure and motivate lifelong learning.

Program Educational Objectives (PEOs)

PEO1: Have a successful career in Mechanical Engineering and allied industries.

PEO2: Have expertise in the areas of Design, Thermal, Materials and Manufacturing.

PEO3: Contribute towards technological development through academic research and industrial practices.

PEO4: Practice their profession with good communication, leadership, ethics and social responsibility.

PEO5: Graduates will adapt to evolving technologies through life-long learning.

Program Specific Outcomes (PSOs)

PSO 1: Apply the fundamentals of Mathematics, Science and Engineering acquaintance to solve real time problems with scientific principles under mechanical engineering profession.

PSO 2: Develop the ability to synthesize data for application in modeling and analysis software's to enhance the capabilities in simulation and demonstrate leadership qualities in activities related to sustainable development of society.

PSO 3: Understand the impact of Professional Engineering solutions in societal and environmental context, commit to professional ethics and communicate effectively.

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.

HS8251	L	T	P	C
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TECHNICAL ENGLISH

Objectives:

The Course prepares second semester engineering and Technology students to:

- Develop strategies and skills to enhance their ability to read and comprehend engineering and technology texts.
- Foster their ability to write convincing job applications and effective reports.
- Develop their speaking skills to make technical presentations, participate in group discussions.
- Strengthen their listening skill which will help them comprehend lectures and talks in their areas of specialization.

UNIT I INTRODUCTION TECHNICAL ENGLISH 12

Listening- Listening to talks mostly of a scientific/technical nature and completing information-gap exercises- **Speaking** –Asking for and giving directions- **Reading** – reading short technical texts from journals- newspapers- **Writing-** purpose statements – extended definitions – issue- writing instructions – checklists-recommendations-**Vocabulary Development**- technical vocabulary **Language Development** –subject verb agreement - compound words.

UNIT II READING AND STUDY SKILLS 12

Listening- Listening to longer technical talks and completing exercises based on them-**Speaking** – describing a process-**Reading** – reading longer technical texts- identifying the various transitions in a text- paragraphing- **Writing**- interpreting charts, graphs- **Vocabulary Development-**vocabulary used in formal letters/emails and reports**Language Development-** impersonal passive voice, numerical adjectives.

UNIT III TECHNICAL WRITING AND GRAMMAR 12

Listening- Listening to classroom lectures/ talks on engineering/technology **-Speaking** – introduction to technical presentations- **Reading** – longer texts both general and technical, practice in speed reading; **Writing**-Describing a process, use of sequence words- **Vocabulary Development-** sequence words- Misspelled words. **Language Development-** embedded sentences

UNIT IV REPORT WRITING 12

Listening- Listening to documentaries and making notes. **Speaking** – mechanics of presentations- **Reading** – reading for detailed comprehension- **Writing-** email etiquette- job application – cover letter –Résumé preparation(via email and hard copy)- analytical essays and issue based essays-**Vocabulary Development**- finding suitable synonyms-paraphrasing-. **Language Development-** clauses- if conditionals.

UNIT V GROUP DISCUSSION AND JOB APPLICATIONS 12

Listening- TED/Ink talks; **Speaking** –participating in a group discussion **-Reading**– reading and understanding technical articles **Writing**– Writing reports- minutes of a meeting- accident and survey **Vocabulary Development- verbal analogies** Language **Development-** reported speech

TOTAL: 60 PERIODS

OUTCOMES:

At the end of the course learners will be able to:

- Read technical texts and write area- specific texts effortlessly.
- Listen and comprehend lectures and talks in their area of specialisation successfully.
- Speak appropriately and effectively in varied formal and informal contexts.
- Write reports and winning job applications.

TEXT BOOKS:

1. Board of editors. **Fluency in English A Course book for Engineering and Technology.** Orient Black swan, Hyderabad: 2016
2. Sudharshana.N.P and Saveetha. C. **English for Technical Communication**. Cambridge University Press: New Delhi, 2016.

REFERENCES

1. Raman, Meenakshi and Sharma, Sangeetha- **Technical Communication Principles and Practice.**Oxford University Press: New Delhi,2014.
2. Kumar, Suresh. E. **Engineering English**. Orient Blackswan: Hyderabad,2015
3. Booth-L. Diana**, Project Work,** Oxford University Press**,** Oxford: 2014.
4. Grussendorf, Marion, **English for Presentations,** Oxford University Press, Oxford: 2007
5. Means, L. Thomas and Elaine Langlois, **English & Communication For Colleges.** Cengage Learning, USA: 2007

Students can be asked to read Tagore, ChetanBhagat and for supplementary reading.

Subject Code:HS8251 **Year/Semester: I /02**
Subject Name: TECHNICAL ENGLISH
Subject Handler: Dr. B.VIDHYA

	UNIT 1: Sharing Information Related To Oneself/Family& Friends
	Listening- Listening to talks mostly of a scientific/technical nature and completing information-gap exercises- **Speaking** –Asking for and giving directions- **Reading** – reading short technical texts from journals- newspapers- **Writing**- purpose statements – extended definitions – issue- writing instructions – checklists-recommendations-**Vocabulary Development**- technical vocabulary **Language Development** –subject verb agreement - compound words.
	PART*A

1. **Technical Vocabulary 2M BTL1**

a.contaminated i.makeeasy
b.facilitate ii. unclean
c.renowned iii.Calculate
d.estimate iv.Famous (a.- ii, b- i, c- iv, d- iii)

a.narrate i.requirement
b.necessity ii.cover
c.muffle iii.envious
d.jealous iv.Tell (a-iv ,b- i, c- ii, d- iii.)

a.identical i.joyous
b.illegible ii.complex
c.intricate iii.unreadable
d.jubilant iv.Alike (a-iv ,b- iii, c- ii, d- i)

a.gather i.swoon
b.guilty ii.Accumulate
c. faint iii.flaw
d.defect iv.Ashamed (a-ii ,b- iv, c- i, d- iii.)

a.wage i.definitely
b.undoubtedly ii.pay
c.tolerate iii.Amusement
d.recreation iv.Endure(a-ii ,b- i, c- iv, d- iii.)

Match the words inColumnA with theirantonyms inColumnB

A	B
a. whole	i. common
b. various	ii.harmful
c. useful	iii. part
d. rare	iv. Identical(a-iii,b- i, c- ii, d- iv.)
a. assist	i. detest

b. assent ii. Proud
c. ashamed iii. hinder
d. admire iv. Dissent(a-iii ,b- iv, c- ii, d- i.)

a. cautious i. welcome
b. banish ii. Forgetful
c. barren iii. polite
d. impudent iv. Fertile(a-iv ,b- i, c- ii, d- iii.)

a. moderation i. conceal
b. rapid ii. Disapprove
c. reveal iii. slow
d. recommend iv. Greed(a-iv ,b- iii, c- i, d- ii.)

3. **Subject-Verb Agreement2M BTL1**

Fill in the blanks with the correct verb that agrees with the subject. [BTL3]

1. Some of the amazing pictures taken by the contestants ____________ (is/**are)** displayed in the hall.
2. He is one of the successful business men who ______________ (**is**/are) sincere and hard working.
3. The committee ____________ (**have**/has) carefully studied the proposal for providing loan for the needy.
4. The official United Nations website for Peacekeeping_____________
   a. (Contain/**contains)** information on operations around the world.
5. Twenty five kilometers ____________ (**is**/are) a long distance to run every day.
6. The number of unemployed citizens _______________ (**are**/is) more in developing counties.
7. There ____________ (are/**is**) several reasons for implementing the new policy
8. The boy who won the two medals___________________ (are/**is**) a friend of mine
9. The person who is responsible for planning and implementing aims and objectives of the company __________________ (**is**/are) the manager.
10. According to a recent survey, the number of people who opt for purchasing Online.

II. **Choose the correct form of the verb that agrees with the subject.**
(is, are, am, was, were, has, have)

1. The price of the jeans **is** reasonable.

	2. The books borrowed from the library **are** on my desk. 3. Bread and butter **is** our daily food. 4. The quality of the candies **was/is** poor. 5. There **were** ten books in the box. 6. Many a student **were** made the same mistakes. 7. One of the books **has** been missing. 8. Fifty miles is a long distance. 9. The poor **are** suffering. 10. One of the most intelligent students **is** John. 11. She and her friends **are** at the fair. 12. The book or the pen **is** in the drawer. 13. The boy or his friends **run** (run) everyday. 14. His friends or the boy **runs** (run) everyday. 15. The committee **decides** (decide) how to proceed.
4	**IV Compound Words 2M BTL1** **Expand the following Compound Noun** 1.Animalbehavior-Thebehavior of ananimal 2.Aluminumextraction -Theextraction of aluminum 3. Batteryvalve -Valve of abattery 4. Boathouse - Boatused as a house 5. Butterflyvalve -Valve whichis in the shapeof a butterfly 6. Calculator memory - Memoryof a calculator

7. Carbondioxide - Dioxideof carbon

8. Coalgas - Gas obtained fromcoal

9. Computer language - Language used for computer operation

10. Computer manual - Manualfor operatingthecomputer

11. Computertechnology -Technology usedin computers

12. Datainput - Inputof data

13. Disk drive - Driveof a disk

14. Flood damage - Damage caused byflood

15. Gear mechanism - Mechanismfor operating thegear

Compound Nouns:

1. Inflation rate Rate of inflation
2. Information centre Centre for giving information
3. Box top Top of the box
4. Carbon steel rod Rod made of carbon steel
5. Component location Location of the component
6. Computer fuel testing Testing the fuel using the computer
7. Cylinder walls Walls of the cylinder
8. Drinking water Water for drinking purpose
9. Engine repair Repair works related to engine
10. Engine housing Housing to protect the engine
11. Ferrous oxide Oxide of ferrous
12. Gear pump Pump operates by means of gears
13. Language code Code which specifies the language
14. Pare industry Industry manufacturing paper
15. Passenger ship Ship for the purpose of carrying passengers
16. Radar scan Scan performed by radar
17. Turret lathe Lathe having a turret
18. Toy factory Factory for making toys

5	**Purpose Statement:2M BTL2** 1. A barometer **is used to** measure atmospheric pressure. 2. Another way of expressing purpose is shown in the following sentences. 3. **The purpose of** painting iron parts **is to protect** them from rust. 4. **The purpose of** a thermostat **is to maintain** temperature at a constant level 5. **The aim of the** test **is to predict** the rise in pressure. ***Use the hint below to make sentences expressing purpose(Use any of the patterns illustrated above)*** 1. **An aerial: receives broadcast signals**. An aerial is used to receive broadcast Signals **2. A feasibility report: makes recommendations on the practicality of a project** A feasibility reports is used to make recommendation on the practicality of a project 3. **Sending telegrams: ensures that the message reaches the address quickly**. Sending telegrams are used to ensure that the messages reached the address quikly. **4. An experiment: demonstrates a principle** An experiment is used to demonstrate a principle **5. Constructing a bypass road: reduces traffic congestion in a city.** Constructing a bye-pass road is used to reduce traffic congestion in a city. **6. A sheet of carbon paper: makes copies while one types.** A sheet of carbon paper is used for making copies while one types **7. A litmus test: identifies acids an alkalies.** A litmus test is used for identifying alkalies. **8. A flow chart: represents a process as a series of steps.** A flowchart is used for representing a process as a series of step. **9. A calculator: calculates with numbers** A calculator is used for calculating numbers **10. A life Boat: rescues people who are in danger at Sea** ALife boat is used for rescuing people who are in danger at Sea **11. A Compass: Finds direction** A compass is used for finding direction 12. **Robot: do Heavy and dangerous jobs**. Robot is used for doing heavy and dangerous jobs. **13. A Satellite: Collects information for communication** A satellite is used for collecting information for communication. **14. A glass bottle : stores acid.**

	A Glass bottles is used for storing acids. **15. A moderator: slows down the speed of free neutrons** A moderator is used to slow down the speed of free neutron.
	Extended Definition:2M BTL2 Example : 1 ***(Sentence definition)*** We can define an **SUV** as a vehicle which is usually driven on rough terrain. ***(Illustration)***SUV is an acronym which stands for **s**ports **u**tility **v**ehicle. ***(Description)***The engines of the SUV vehicles supply power to all four wheels, so they are better for cruising sand dunes. ***(Classification)*** SUV vehicles vary in size; some of them can seat 5 passengers, while others can seat 7 passengers. ***(causal analysis)*** SUV vehicles are quite common in Saudi Arabia due to the low cost of petrol and their fantastic performance in the desert. Example : 2 ***(Sentence definition)*****The periodic table** can be defined as an organized array of all the chemical elements in order of the atomic weight. ***(Illustration)***The elements show a periodic recurrence of certain properties. ***(Chronology)***It was first discovered in 1869 by Dmitry I. Mendeleyev. ***(Description)***Those in the same column or group of the table as usually arranged have similar properties. ***(Chronology)***In the 20th century, when the structure of atoms was understood, the table was seen to precisely reflect increasing order of atomic number. ***(Description)*** Members of the same group in the table have the same number of electrons in the outermost shells of their atoms and form bonds of the same type. Example : 3 (***Sentence definition)***Glass is a hard transparent material which is used to make windows, bottles and other objects. ***(Etymology)*** glass is an English word and was first used before the twelfth century. ***(Chronology)***Glass has been used as a decorative object indoors since ancient times. Today, glass is widely used in the construction and telecommunication sectors. ***(Description)*** It is made by cooling molten ingredients such as silica sand with sufficient rapidity to prevent the formation of visible crystals. Example :4 Appropriate technology is that technology which is affordable within the resources available, is culturally acceptable and is environmentally harmless.
	PART *B
1.	**INSTRUCTION16M BTL3** **1. To control noise pollution: (May/Jun 2011)** 1. Prohibit noise producing vehicles 2. Avoid using high sounding crackers

3. Don't use loud speakers near schools and hospitals.
4. Use a silencer to absorb noise of the vehicle
5. Establish industrial units away from residential areas
6. Plant trees to absorb noise.
7. Live away from the airport
8. Avoid using high sounding pressure horns
9. Be aware of noise pollution

2. *To reduce unemployment problem:*

1. Ensure employment to at least one person in a family
2. Increase the number of technical training institutes
3. Give loans to encourage self-employment
4. Give subsidies to encourage the entrepreneurs
5. Employ unemployed graduates for additional government duties like election duties
6. Encourage private sectors to generate employment.
7. Establish more industries in rural areas
8. Train the graduates to start small scale industries

3. *To keep the college campus clean:*

1. Keep the environment always clean
2. Plant trees in the college campus
3. Conduct awareness classes to make the students to realise the importance of cleanliness.
4. Place more number of dust bins in the campus
5. Impose punishment on these who violate the rules
6. Maintain the vehicles properly
7. Avoid cutting of trees in the name of development
8. Always maintain strict discipline

4. To maintain a computer / a laptop in good working condition (Jan 2006; May/Jun 2007; Jan 2010)

1. Don't touch the cables
2. Avoid touching the open sockets
3. Avoid touching the monitor
4. Always shut down the system when it is not in use.
5. Shut down the system properly.
6. Don't misplace and replace the equipment.
7. Don't handle the equipment roughly.
8. Don't keep your legs on the UPS.

5. *Safety instructions in a chemical engineering lab (Jan 2010)*

1. Don't work in the laboratory barefoot.
2. Don't handle the instruments roughly.
3. Don't wear gold ornaments.
4. Keep all the doors and windows open.
5. Keep your working place neat and tidy.
6. Don't wear loose clothes.
7. Wear apron and gloves while handling the chemicals.

8. Handle all glassware items carefully.
9. Don't drink or eat in lab.
10. Don't taste or sniff chemicals.
11. Identify the safety equipment.
12. Read the chemical safety instructions.

6. ***Instructions must be followed by all pedestrians (Road safety)***

1. Walk on the pavement always.
2. Use subways; though it is long.
3. Avoid crossing suddenly.
4. Don't walk on road dividers.
5. Don't ignore traffic signals.
6. Cross the road only at zebra crossing.
7. Make sure that the road is clear, before crossing the road.
8. Avoid using the cell phone while walking along the road.
9. Be familiar with the traffic rules.

7. ***Instructions to save petrol (May / Jun 2012)***

1. Keep the engine in good condition
2. Fit the vehicle with an engine that gives high mileage.
3. Don't keep the engine running while the vehicle is not in motion.
4. Inflate the tyres at an optimum level of air pressure.
5. Use the correct engine oil for the proper functioning.
6. Service the vehicle regularly.
7. Avoid clutch driving.
8. Avoid frequent change of gear to save petrol.

8. ***Instructions to maintain two/four wheelers in good working condition (May/Jun 2005/2006)***

1. Always maintain the air pressure in the tyre to the recommended levels.
2. Drive only at optimum level of speed depending on the roads.
3. Clean the air-filter regularly since clogged air filters increase fuel consumption.
4. Do not idle the engine not more than 30 seconds to warm it up when starting.
5. Avoid sudden breaks and frequent gear changing.
6. Handle the gear, brake and clutch softly.
7. Service the vehicles regularly for better performance as well as fuel saving
8. Always maintain the lubricants at the required level to ensure running of the engine.
9. Avoid pressure horns.
10. Avoid faulty silencers.

9. ***Write eight instructions to preserve environment. (May 2004/2005)***

1. Reduce the usage of plastic
2. Use the eco-friendly papers made out of alternative sources.
3. Use rechargeable batteries for frequent usages to reduce the number of dead batteries
4. Use natural fertilizers and pesticides for agriculture.
5. Don't cut trees.
6. Plant native and adaptive trees.

	7. Turn light off at office as well as at home whenever it is not needed. 8. Treat sewage and industrial effluents before discharging into the water bodies. 9. Conduct awareness programmes for preserving the environment. 10. Encourage rain water harvesting. **10.** ***Instructions for giving first aid to a victim of a road accident*** 1. Check the victim thoroughly whether the victim is breathing or not 2. Take the victim to the side of the road. 3. Try to stop the bleeding by applying pressure on the bleeding side. 4. Give artificial respiration if the victim is struggling for breathe. 5. Don't crowd round the victim and prevent airflow. 6. Handle the victim carefully. 7. Examine the head, eyes, nose, ears, chest, and abdomen to detect wounds. 8. Ask the victim to move the toes, and fingers to check their movements or function. 9. Take the victim to the hospital
9	**II Checklists 16M BTL2** **1.Checklist for an Interview** **Yes No** 1. Have I taken the ticket? ☐ ☐ 2. Have I taken the certificates? ☐ ☐ 3. Have I taken the call letter? ☐ ☐ 4. Have I taken money? ☐ ☐ 5. Have I arranged the certificates properly? ☐ ☐ 6. Have I taken my project report? ☐ ☐ 7. Have I taken my friends' contact number? ☐ ☐ 8. Have I packed the formal wear? ☐ ☐ **2. Checklist for an Industrial Visit** **Yes No** 1. Have I taken the ticket? ☐ ☐ 2. Have I taken money? ☐ ☐ 3. Have I taken the conformation letter? ☐ ☐ 4. Have I taken all the documents? ☐ ☐ 5. Have I taken my Identity Card? ☐ ☐ 6. Have I taken my cell phone and charger? ☐ ☐ 7. Have I packed the formal wear? ☐ ☐ 8. Have I taken my friends' contact number ☐ ☐

3. Checklist for conducting a two day conference **Yes** **No**

1. Have I sent the invitations?
2. Have I invited the chief guest?
3. Have I invited the Principal and staffs?
4. Have I prepared the welcome address?
5. Have I prepared the agenda?
6. Have I arranged the conference hall?
7. Have I arranged enough refreshments?
8. Have I made the stage ready?

4. Checklist for organizing a Paper Presentation session Yes **No**

1. Have I arranged the venue?
2. Have I finalized the papers?
3. Have I fixed the judges?
4. Have I arranged for refreshment and lunch for delegates?
5. Have I purchased the kits?
6. Have I prepared the certificates?
7. Have I prepared the agenda?
8. Have I prepared the welcome address?
9. Have I informed the participants?

5. Checklist for one day Training Programme in Delhi Yes **No**

1. Have I reserved the tickets?
2. Have I taken the money?
3. Have I taken the dresses?
4. Have I taken the Laptop?
5. Have I taken the documents?
6. Have I taken the notes for training?
7. Have I taken the confirmation letter?
8. Have I taken the venue address?

Recommendations 16M BTL3

I. Recommendations to preserve our water resources:-

1. It is recommended to observe rain water harvesting by all.
2. It is important to control sand smuggling.

3. It is necessary to construct rain water storage tanks.
4. It is recommended to encourage the people for afforestation.
5. It is essential to conduct awareness programmes.
6. It is advised to plant native and adaptive plants.
7. It is recommended to water gardens and fields early in the morning to avoid evaporation.
8. It is highly recommended to recycle the water.

II. RECOMMENDATIONS

1. Write a set of eight recommendations to preserve our water resources.

Ans: Title : Recommendations to preserve our water resources:-

9. It is recommended to observe rain water harvesting by all.
10. It is important to control sand smuggling.
11. It is necessary to construct rain water storage tanks.
12. It is recommended to encourage the people for a forestation.
13. It is essential to conduct awareness programmes.
14. It is advised to plant native and adaptive plants.
15. It is recommended to water gardens and fields early in the morning to avoid evaporation.
16. It is highly recommended to recycle the water.

2. Power cut is a major problem in southern parts of India and it badly affects small scale industries. Write a set of eight recommendations to ensure continuous power supply to the small scale industries. **(AUC DEC-JAN 2016)**

Ans: Title : Recommendation to ensure continuous power supply to small scale industries

1. It is recommended that UPS may be installed.
2. It is recommended to create general awareness among public and educate them to save energy resources.
3. It is recommended to introduce feasible solar systems as an alternative source of energy.
4. It is recommended to take adequate measures to implement plants to generate power through pedal power.
5. It is recommended to learn to conserve electricity.
6. It is recommended to use net metering technology which is eco-friendly and economical.
7. It is recommended to tap more alternative sources.
8. It is recommended to generate bio mass power.

3.Write a set of eight recommendations to reduce unemployment problem.

Ans: Title : Eight recommendations to reduce unemployment problem.

1. It is recommended that the government can increase the number of technical training institutes.
2. It is recommended to give loans to encourage self-employment.

3. It is recommended to introduce entrepreneurship courses in the school and college curriculum.
4. It is recommended to give subsidies to encourage the entrepreneurs.
5. It is recommended to start more industries in rural and suburban areas.
6. It is recommended to encourage private sectors to generate employment.
7. It is recommended that the government can ensure employment to at least one person in a family.
8. It is recommended to employ the unemployed graduates for additional government duties like elections duties etc.

4.There are many social problems such as poverty and hunger in India, which need to be solved. Write a set of eight recommendations to solve these problems.
Ans : Title : Eight recommendations to solve social problems such as poverty and hunger in India

1. It is recommended that the government can measures to increase exports.
2. It is recommended to concentrate on the development of the small scale industries.
3. It is recommended to provide loans for small business in rural areas.
4. It is recommended to create livelihood opportunities for the poor and the needy by the state government.
5. It is recommended that the charitable institutions can support the government to eradicate hunger and poverty.
6. It is recommended that the multinational companies can be encouraged to start business for the increase of job opportunities and income.
7. It is recommended that the children suffering from malnutrition can be adopted by social organizations.
8. It is recommended to take necessary steps to monitor whether the deserving people are benefitted of the services provided for them.

5.Write a set of eight Recommendations to make environment clean and less polluted.

Ans : Title : Eight recommendations to make environment clean and less polluted.

1. It is recommended to use renewable resources which can be replenished.
2. It is recommended to start replenish forests for producing raw materials and increasing the area under forest.
3. It is recommended to ban killing or poaching of animals.
4. It is recommended to preserve natural habitat for animals.
5. It is recommended to monitor and survey the maintenance of greenery around by the concerned officials.
6. It is recommended to encourage growing of more trees.
7. It is recommended to stop using plastics and burning of it.
8. It is recommended to use eco-friendly appliances and gadgets.

6.Write a set of eight recommendations for selecting a proper fuel.

Ans : Title : Eight recommendations for selecting a proper fuel.

1. It is recommended to select such a fuel which can burn easily.
2. It is recommended to select the fuel which produces sufficient energy.
3. It is recommended to select the fuel which is available in plenty.
4. It is recommended to select the fuel for which the storage is easy and safe.
5. It is recommended to select such a fuel which does not pollute the air on burning.
6. It is recommended to select a fuel which does not leave behind much residue.
7. It is recommended to select a fuel for which the transportation is easy and safe.
8. It is recommended to select an inexpensive fuel.

UNIT II READING AND STUDY SKILLS 12

Listening- Listening to longer technical talks and completing exercises based on them-**Speaking** – describing a process-**Reading** – reading longer technical texts- identifying the various transitions in a text- paragraphing- **Writing**- interpreting charts, graphs- **Vocabulary Development-**vocabulary used in formal letters/emails and reports**Language Development-** impersonal passive voice, numerical adjectives.

PART*A

Impersonal Passive 2M BTL1

1. **The company had manufactured high powered engines.**

   High powered Engines had been manufactured

2. **One can easily solve this problem.**

   This problem can be solved

3. **Users have maintained this pump themselves.**

   This pump has been maintained

4. **The men are laying roads in many parts of the city.**

   Roads have been laid in many parts of the city.

5. **The Cricket Board men offer to give 1400 transmitters.**

   1400 transmitters have been offered.

6. **They will start production on the new type of reactor soon**.

New type of reactors production with soon be started.

7. **We pass an electric current across the electrodes**

An electric current will be passed across the electrode.

8. **The workers are repairing the bridge.**

The bridge is being repaired .

9. **We can cast this metal into very complicated shapes**.

This metal can been casted into very complicated shapes

Write the sentence into Passive form 2M BTL1

1. I can answer the question- The question can be answered by me.
2. She would carry the box. – The box would be carried by her.
3. You should open the window – The window should be opened by you.
4. We might play cards. - Cards might be played by us.
5. You ought to wash the car. – The car ought to be washed by you.
6. He must fill in the form. – The form must be filled in by him.
7. They need not buy bread. – Bread need not be bought by them.
8. He could not read the sentence. - The sentence could not be read by him.
9. Will the teacher test our English? - will our English be tested by the teacher?
10. Could jenny lock the door? – Could the door be locked by jenny?

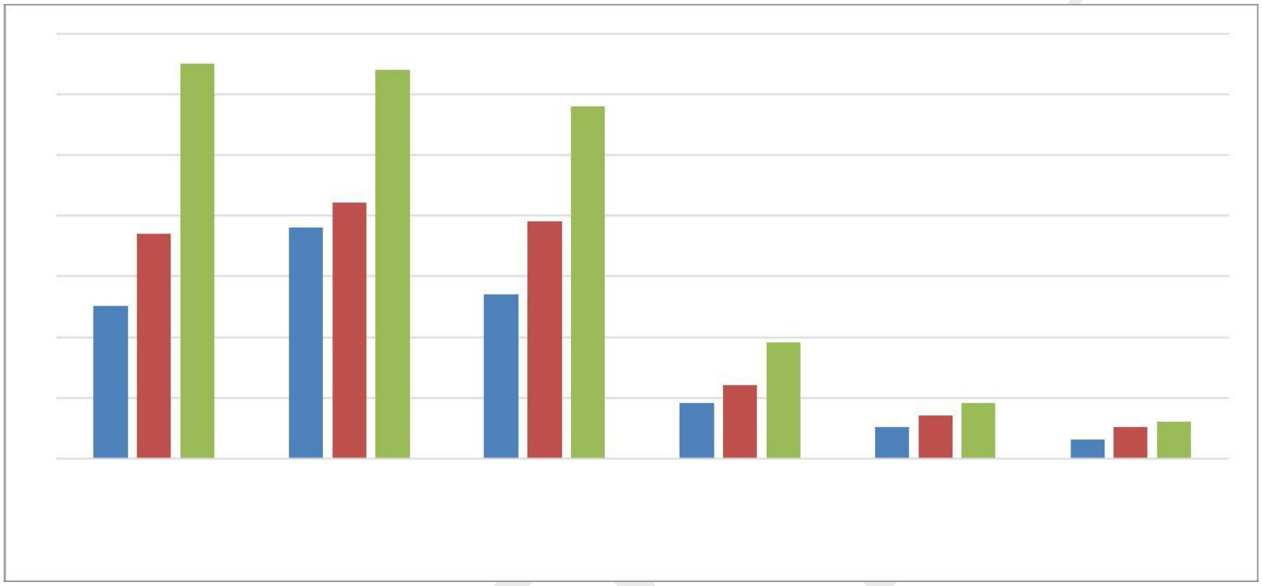
II Numerical Adjectives. 2M BTL1

Rewrite the following as numerical expressions

1. A flask with a capacity of 10 liters- A 10 liter flask
2. A journey of 20 miles- A 20 mile journey
3. A squad of 1000 men- A 1000 men squad
4. A civilization which in 2000 years old- 2000 year old civilization
5. A project of 10 years- A 10 year project.
6. A match lasting five days- A five day Lasting match.
7. At intervals of 10 minutes- A 10 minute interval
8. A DC supply of 240 volts- A 240 volt DC supply

	9. A lamp of a power of 60 watts- A 60watts power Lamp. 10. An investment of Rs. 3, 50,000- A 3, 50,000investment. 11. A book in six volume – a 6 volume book 12. An engine with 100 cc power – a 100 cc power engine 13. A walk of five kilometers – A 5 kilometer walk 14. A drive for 8 hours – A 8 hour drive 15. A committee of 6 members – A 6 member committee 16. A rope with a length of 5 meters – A 5 meter rope 17. A can with a capacity of 25 liters – A 25 liter tank 18. A training programme for 25 days - A 25 day training programme 19. An auditorium of 1000 capacity – A 1000 capacity auditorium 20. A pen drive with 16 GB storage. – A 16 GB pen drive 21. A lab with 30 computers – A 30 computer lab 22. The pipe is 3 feet long – A 3 foot pipe 23. A colony with 200 houses – A 200 house colony 24. A road measuring 100 feet – A 100 foot road 25. A video running for 40 seconds– A 40 second video.
	Interpreting charts and graphs.16M BTL-4 **Look at the following information and graph about the pass percentage of the students in the plus two examination. Analyze the given data and write a short review of the pass percentage of the student in a paragraph of not more than 120 words:** About John Higher Secondary School This school was started in a village to cater to the needs of the poor people. In 2011, many experienced teachers left the school . After reviewing the low performance of the students in the plus-two examination, the infrastructure facilities were improved and teachers were given adequate training to teach their subjects effectively Besides, the management has started giving special incentives to the teachers who give cent percent results in the examination.

II. The following chart represents the arrival of tourists from different regions. Analyze the given data and write a paragraph:

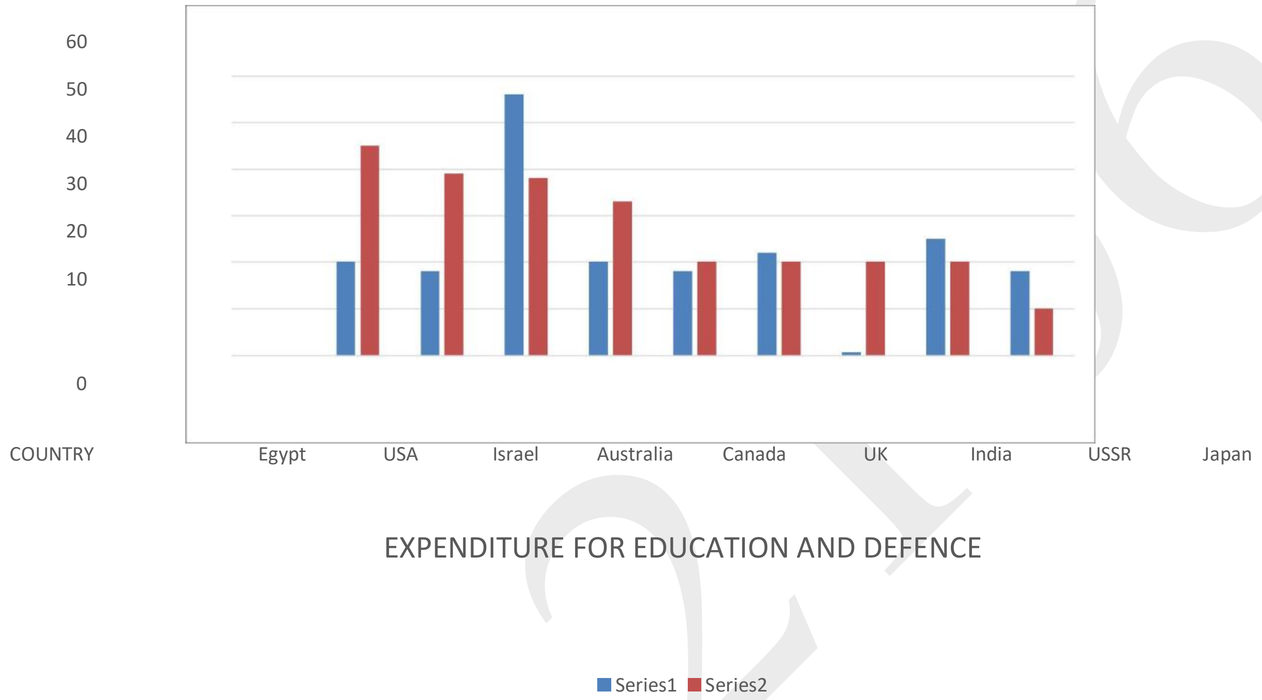


□		2012	2.5	3.8	2.7	0.9	0.5	0.3
□		2013	3.7	4.2	3.9	1.2	0.7	0.5
□		2014	6.5	6.4	5.8	1.9	0.9	0.6

X- axis – Tourists arrival from region of origin

Y-axis- Tourists who visited India in millions

Look at the following bar chart which describes the expenditure on education and defense of the total expenditure incurred by different countries. Write a paragraph presenting the information contain in it using expressions of comparison.



Unit-III

TECHNICAL WRITING AND GRAMMAR 12

Listening- Listening to classroom lectures/ talks on engineering/technology -**Speaking** – introduction to technical presentations- **Reading** – longer texts both general and technical, practice in speed reading; **Writing**-Describing a process, use of sequence words- **Vocabulary Development-** sequence words- Misspelled words. **Language Development-** embedded sentences

	PART*A
1.	I. **Sequence Words** 2M BTL1 **Fill in the blanks with appropriate sequence words**. 1. Half an hour passed, but there was no sign of bus. -------------, we decided to go home. 2. The documentswill bescrutinized by the bank officials. ------------ they will sanction the loan. 3. To reduce weight, -----------create rigorous exercise. 4. When air conditioner is used reversed. ---------reverse mechanism, hot air is propelled towarc

indoor and coolair towards outdoor.

5. How can you lay two audio tracks --------- in Windows Live Movie Maker?
6. ---------- you buy a new lay out you should decide on what you really need.
7. In the process of making chocolates, firstly the cocoa beans are finely ground. ----------,it is mixe with cocoa butter and sugar and then smoothened.
8. Cheese is a concentrated source of many of the nutrients in milk. -----the usual cheese making process, the amount of various nutrients retained depends on the

(a)Then press the "Send" option.

(b) Next type your message and add "smileys" or images, if you want.

(c) To begin with, go to "messages"

(d) After that "Add" the contact number of the recipient.

(a) Then, the tea water is filtered and is served with sugar cubes.

(b) First, water is taken in a kettle and is allowed to boil.

(c) After that, the decoction is allowed to settle down.

(d) Next, tea leaves are added to the boiling water.

(a) First, the clothes and soap powder are put in the respective slots.

(b) Water is drawn repeatedly as per requirement to wash and rinse.

(c) When the start button is pressed the machine starts to draw water from the tap and the operation starts after the tank is full.

(d) Finally clothes are dried.

(a) The image is charged with electricity.

(b) The document for taking photocopy is kept in the machine.

(c) Then, an ink powder called toner sticks to the charged parts of the image and is transferred on to paper.

(d) Secondly, a bright light reflects the image of the document on to a plate or drum.

(a) After you enter your information, click "Sign Up"

(b) On here you will need to enter your information.

(c) Towards the right side of the screen you will see a "sign up" screen.

(d) Go to www.facebook.com.

3.	**Misspelt word 2M BTL3**
	Correct the spelling of the misspelt words. 1. Occasion- occasion 2. Committee- Committee. 3. Tomorrow- tomorrow 4. Charactar- Character. 5. Greatful- Grateful 6. Neessary- Necessary 7. Sychology- Psychology 8. recieve -receive 9. leisue- Leisure. 10. Apetite- Appetite 11. Careulness-Carefulness 12. Exceled- Exceled 13. Prohiited- Prohibited 14. Groupped- grouped 15. Earnned– Earned. 16. Transmited- Transmitted. 17. Aloted– Allotted 18. Refering- Referring 19. Traping– Trapping 20. Stimuleted- Stimulated
4.	**Embedded Sentences [BTL2]** **Complete the following sentences with appropriate Embedded Clauses** 1. The music, ________________________ gave me a headache. 2. The old lady, _______________________ waited for a taxi. 3. The bus, _________________________ sped down the street. 4. The loaf of bread, ___________________ was spoilt. 5. The singer, _________________________ was the chief guest on our College Day. 6. The child, ___________________________ was crying in the super market 7. The airplane,____________________ finally landed at the airport 8. The elderly man, _________struggled to cross the road 9. The astronaut,_______________ was received warmly at the airport. 10. The boy, ____________________________ is from our college

	PART *B
	I. Describing a process 16 BMTL-4 1. Describe the process involved in opening a bank account. 2. Describe the process of mending the puncture tube of your two-wheeler. 3. Describe the process involved in making a cup of tea. 4. Describe the process involved in sending an email attachment to your friend. 5. Describe the process involved in becoming successful orator. 6. Describe the process involved in m king a glass of lemon juice **Process:** Explanation in a paragraph or two- Presentation -4 Content – 8 Sentence format- 4
	Reading Comprehension (a) Read the following passage carefully and answer the questions below it: The latest buzz word in the continuing debate about the environment is “sustainable management”- that means using plants and animals for our benefit, but ensuring that enough is left alive to guarantee the survival of the species. This sounds good, but is it practical in reality? In spite of years of scientific research, no one really kno s how much damage human beings are doing to their environment. We know that, they are responsible for many problems ranging from global arming to ozone depletion, and there is no doubt that they have a devastating effect on animal and plant life on earth. About 50,000 animal and plant species are becoming extinct every year. All species depend on some way on one another for survival. If you remove one species from this complex web of inter relationships, ehave little idea of the repercussions on the ecosystem in general. What makes things more complicated is the fact that unlike global warming - which, if the political will was there, could be reduced by cutting gas emissions -preserving bio diversity- remains a difficult dilemma. There are also questions about whether sustainable management is practical as far as protecting areas of great bio-diversi y such as the world’s tropical forest are concerned. In theory, the principle should be to cut a number of trees, but not so many as to completely destroy the forest. Sustainable Management of trees requires controls on the numb r of trees which are cut down as well as investment replacing them. Most tropical forests exist in poor countries which depend on logging to makemoney. Foremost loggers in these countries, making money means cutting down as ma y trees as Possible in the shortest time. The price of trees remains stable, varyi g by 4-5% annually, whereas theinterestratesinmostdevelopingcountriescancreate 15% or more in returns. It

	therefore makes little sense, and certainly no economic sense, to Delay tree felling. One solution could be to insist that wood comes from sustainable managed forests. In theory, consumers would buy only this wood and force logging companies to go "green" or else out of business. Unfortunately, unrestricted logging is more profitable than wood from sustainable managed forests which would cost unto 5 times more to control. Consumers would not be prepared to pay the extra sum just to protect the environment. The sad fact is that there is no practical solution to protect vegetation and wildlife of tropical forests in the future. It is estimated that these forests contain anything form 50-90 percent of all animal and plant species of the earth. In one study of kilometer square area of rain forest in Peru, for example, scientists counted 1300 species of butterfly and 600 species of birds. In the entire USA only 400 species of butterfly and 700 species of birds have been recorded. Sustainable Management represents gigantic experiment. If this doesn't work, we cant move to another planet to escape. It is a case of one planet, one experiment! Complete the following statements choosing from one of the given alternatives (i) The extent of the damage being inflicted on our environment....... 1. can be estimated by years of scientific research. 2. is being calculated by scientific research exactly. 3. is impossible to assess despite years of scientific research. 4. is thanks to years of scientific research, on the decrease. (ii) The term "Sustainable Management" means using plants and animals for our own benefit, but.......

	1. assuring none are left alive to guarantee the survival of the species. 2. making sure that enough are left alive to guarantee survival of the species.
	The newlyweds agreed to be very ***frugal*** in their shopping because they wanted to save enough money to buy a house. **1. economical** 2. wasteful 3. interested
	Although Alex usually looks ***unkempt,*** he had a very neat appearance at his job interview. 1. orderly 2. handsome **3. messy**
5.	Paragraph writing 16M BTL3
	1. Write two paragraphs comparing the newspaper and the television as media of mass communication. Each of the paragraphs should not exceed 200 words. 2. Write two paragraphs, one describing the benefits of technology the other describing the drawbacks of technology. Each paragraph should not exceed 200 words. 3. Imagine yourself to be in the year 2050 and you are in your early 70's. The fuel position is very bad. Describe how life was fifty years ago when fuel was easily available. Write this in about 170-200 words. 4. Describe in about 170-200 words the utility, function with advantages and disadvantages of a washing machine. 5. Imagine yourself to be living in the year 2050 and you are in your early 70's. The fuel position is very bad. Describe how life was fifty years ago when fuel was easily available. Write this for about 170- 200 words. 6. Write two paragraphs, one describing the advantages and disadvantages of Mass media. 7. Write a paragraph on Population explosion. 8. Write a paragraph on Information Technology in India. Content- 6 Sentence completion 2 Grammar/ spellings 4 Presentation 4 a. The importance of social media in today's world. b. Donate blood and save lives. c. Student's approach to library in the current scenario. d. Going away from nature is happening naturally- Discuss. e. Outdoor and Indoor Games.
6.	

	1. Objective/ Multiple type: 1 per question 2. True or False: 1m/ Question 3. Short note: 2m if any

UNIT IV	REPORT WRITING 12
Listening- Listening to documentaries and making notes. **Speaking** – mechanics of presentations- **Reading** – reading for detailed comprehension- **Writing**- email etiquette- job application – cover letter –Résumé preparation(via email and hard copy)- analytical essays and issue based essays-**Vocabulary Development**-finding suitable synonyms-paraphrasing-. **Language Development-** clauses- if conditionals.	
Sr.No	**PART* A**
1	**Clauses- If conditional**2M BTL2 1. If he communicates effectively, **he will get selected**. 2. If he had performed well, **he would have passed** 3. If I got up earlier, **I would catch the train**. 4. If the new material had come in time, **we would have transferred the goods**. 5. If you planned well, **you could finish the project**. 6. If I had a net connection, **I would send the email**. 7. If I were you, **I would enjoy the trip**. 8. If you went for a walk every day, **you would maintain your health well**. 9. If people follow traffic rules, **the city can avoid traffic congestion**. 10. If you practised hard, you **would pass** (pass) the exam easily. 11. If the traffic rules are followed, there ---------**will be**----------- (be) very less accidents. 12. If I drop this, it _______**will explode**_________ (explode). 13. If I had seen you, I **__would have invited_** (invite) you. 14. If the child goes out in the rain, it ______ (catch) cold.**Ans : will catch** 15. If I were an astronaut, I ______ (visit) the space station.**Ans : would visit** 16. If the boys do not practice, they ______ (lose) in the finals.**Ans : will lose** 17. If there had been good rains, the corps ______ (grow) well.**Ans : would have grown** 18. If I get a new job, _____________________ **Ans : If I get a new job, I will take my family to a holy place for prayer.** 19. _________________ , she would have completed her journey. **Ans : If Rita has joined the crew, she would have completed her journey.**
3	**PART* B**

Ten Quick Tips on Writing a Professional Email 16M BTL3

1. Always fill in the subject line with a topic that means something to your reader. Not "Decals" or "Important!" but "Deadline for New Parking Decals."
2. Put your main point in the opening sentence. Most readers won't stick around for a surprise ending.
3. Never begin a message with a vague "This." ("This needs to be done by 5:00.") Always specify what you're writing about.
4. Don't use ALL CAPITALS (no shouting!), or all lower-case letters either (unless you're e. e. cummings).
5. As a general rule, PLZ avoid textspeak (abbreviations and acronyms): *you* may be ROFLOL (rolling on the floor laughing out loud), but your reader may be left wondering WUWT (what's up with that).
6. Be brief *and* polite. If your message runs longer than two or three short paragraphs, consider (a) reducing the message, or (b) providing an attachment. But in any case, don't snap, growl, or bark.
7. Remember to say "please" and "thank you." And mean it. "Thank you for understanding why afternoon breaks have been eliminated" is prissy and petty. It's *not* polite.
8. Add a signature block with appropriate contact information (in most cases, your name, business address, and phone number, along with a legal disclaimer if required by your company). Do you *need* to clutter the signature block with a clever quotation and artwork? Probably not.
9. Edit and proofread before hitting "send." You may think you're too busy to sweat the small stuff, but unfortunately your reader may think you're a careless dolt.
10. Finally, reply promptly to serious messages. If you need more than 24 hours to collect information or make a decision, send a brief response explaining the delay.

1. **Start with a salutation**

Your email should open by addressing the person you're writing to. Sure, you can get away with leaving out the salutation when you're dashing off an email to your friend, but business-like messages should begin with:

- *Dear Mr Jones,* or *Dear Professor Smith,* (for someone you don't know well, especially if they're a superior)
- *Dear Joe,* or *Dear Mandy,* (if you have a working relationship with the person)

It's fine to use "Hi Joe", "Hello Joe" or just the name followed by a comma ("Joe,") if you know the person well – writing "Dear Joe" to one of your team-mates will look odd!

2. Write in short paragraphs

Get straight to the point – don't waste time waffling. Split your email into two to four short paragraphs, each one dealing with a single idea. Consider using bullet-points for extra clarity, perhaps if you are:

- Listing several questions for the recipient to answer
- Suggesting a number of alternative options
- Explaining the steps that you'll be carrying out

Put a double line break, rather than an indent (tab), between paragraphs.

3. Stick to one topic

If you need to write to someone about several different issues (for example, if you're giving your boss an update on Project X, asking him for a review meeting to discuss a payrise, and telling him that you’ve got a doctor’s appointment on Friday), then don’t put them all in the same email. It’s hard for people to keep track of different email threads and conversations if topics are jumbled up.

4. Use capitals appropriately

Emails should follow the same rules of punctuation as other writing. Capitals are often misused. In particular, you should:

- Never write a whole sentence (or worse, a whole email) in capitals
- Always capitalise “I” and the first letter of proper nouns (names)
- Capitaliseacronymns*(USA, BBC, RSPCA)*
- Always start sentences with a capital letter.

This makes your email easier to read: try retyping one of the emails you’ve received in ALL CAPS or all lower case, and see how much harder it is to follow!

5. Sign off the email

For short internal company emails, you can get away with just putting a double space after your last paragraph then typing your name. If you’re writing a more formal email, though, it’s essential to close it appropriately.

- Use *Yours sincerely,* (when you know the name of your addressee) and *Yours faithfully,* (when you’ve addressed it to “Dear Sir/Madam”) for very formal emails such as job applications.
- Use *Best regards,* or *Kind regards,* in most other situations.
- Even when writing to people you know well, it’s polite to sign off with something such as “All the best,” “Take care,” or “Have a nice day,” before typing your name.

6. Use a sensible email signature

Hopefully this is common sense – but don’t cram your email signature with quotes from your favourite TV show, motivational speaker or witty friend. Do include your name, email address, telephone number and postal address (where appropriate) – obviously, your company may have some guidelines on these.

It makes it easy for your correspondents to find your contact details: they don’t need to root through for the first message you sent them, but can just look in the footer of any of your emails.

Putting it all together

Compare the following two job applications. The content of the emails are identical – but who would you give the job to?

i’ve attached my resume i would be grateful if you could read it and get back to me at your earliest convenience. i have all the experience you are looking for – i’ve worked in a customer-facing environment for three years, i am competent with ms office and i enjoy working as part of a team. thanks for your time

Or

Dear Sir/Madam,

I’ve attached my resume. I would be grateful if you could read it and get back to me at your earliest convenience. I have all the experience you are looking for:

- *I’ve worked in a customer-facing environment for three years*
- *I am competent with MS office*
- *I enjoy working as part of a team*

Thanks for your time.

Yours faithfully,

	Joe Bloggs **E-Mail Writing**16MBTL3 1. Send an email to your friend sharing your experience about your College. 2. Send an email to your mother sharing your first weekend experience with your friends. 3. Imagine yourself to be the Team Leader in TCS and send a mail to your team appreciating successful completion of the Project. **Scheme of Marks :** **Format** – 6M **Key Words –** 4M **Presentation-** 2M **Content -** 4M
4.	**Letter of Job Application** 16MBTL 4 From M. Raja, 45, Ragav Apartments, Rajaji Nagar, Chennai – 73 To The Executive Director, Godrej Company Limited, 455, Greams Road, Chennai – 600 035 Sir, Sub: Application for the post of Production Manager – Reg. Ref: With reference to the advertisement in "The Hindu" dated 18.02.2012 I am a Mechanical Engineering graduate. I have been working in "Prakash Furniture Ltd" as Production Manager for three years. I have managerial skills and inter-personal skills. I have enclosed my resume for your perusal. Expecting your intimation letter Thanking you, Yours faithfully,

(M.Raja)

RESUME

M. Raja
45, Ragav Apartments,
Rajaji Nagar,
Chennai – 73
raja.m@gmail.com

Mobile: 9944488077
E-mail:

OBJECTIVE

To pursue a challenging position in whatever I do and to contribute towards the growth of the organization.

EDUCATIONAL QUALIFICATION:

B.E	-	Mechanical Engineering – 90% ABC Engineering College, Chennai – 13 May 2008
HSC	-	Govt. Higher Secondary School - 85% Chennai – 73 May 2004

EXPERIENCE:

July 2009 – till date	-	Production Manager, Prakash Furniture Ltd, Trichy.
July 2008 – July 2009	-	Junior Production Manager, Rahul Furniture Ltd., Rasipuram, Namakkal. (Dt)

ACHIEVEMENTS:

- University gold medalist at UG Level.
- Won the best project award.
- Presented many papers in conferences and seminars.

RESPONSIBILITIES:

- Sports secretary in 12^{th} std.

- Class representative from 10th std.
- Captain of college football team.

REFERENCES:

1. Dr. V. M. Periasamy,
   Principal,
   BSA Engineering College,
   Nagarkoil.

2. Mr. Ashok Kumar,
   The General Manager,
   Prakash Furniture Ltd.,
   Trichy.

PERSONAL PROFILE:

Name	: M. Raja
Date of Birth	: 12.08.1987
Age	: 29
Gender	: Male
Father's Name	: R. Manikkavasagam
Nationality	: Indian
Religion	: Hindu
Languages Known	: Tamil, English.

DECLARATION

I hereby solemnly declare that all the information made is true to the best of my knowledge and belief.

Thank you,

Yours faithfully,

Place: Chennai
Date: 20.02.12

(M. Raja)

1 .Write a letter of application for the post of an Assistant Engineer to The Human Resource Manager, HRC Communication Ltd., 390, Lake View Road, Santhome, Chennai – 600 004. Attach a separate resume with your letter. **(AU, May/June 2014)**

2.Write a letter of application for the post of Team Leader to The Human Resource Manager, Mayday Motors Ltd., 327, G.T. Naidu Road, Coimbatore. Write the details of your qualification and experience within the application letter. **(AU, May/June 2014)**

3.Write a letter of application for the post of a Junior Engineer to the Divisional Engineer, Mambalam Division, Chennai Telephones, 786, Anna Salai, Chennai – 35. Attach a suitable bio-data with the application.

4. The Chief Engineer of Public Works Department, Kancheepuram, wants to make you a member of the technical committee on Road Developments in Kancheepuram. Write a letter of thanks to him and also enclose your resume with your letter. **(AU, May/June 2013)**

5. Draft a letter of Job Application in response to the following advertisement. Candidates holding a bachelor's / master's degree with a background in engineering are required for work on company for the post of engineer. Applicants' must also possess excellent writing skills and the ability to effectively and CV to Mr.Promod Tiwari, Human Resources Dept., Exclusive software, North Main Street, Chennai – 67. **(AU, May/June2012)**

6.You have come across the following advertisement in the newspaper on 12th June 2014. Write a letter of application and detailed CV to one of the posts selected:

A leading private sector company in India needs the following engineers for the various projects in India **(AU, May/June2015)**

1. CIVIL/MECHANICAL ENGINEERS
2. ELECTRICAL / MANUFACTURING ENGINEERS
3. CHEMICAL ENGINEERS
4. COMPUTER SCIENCE ENGINEERS

1 to 3 years of experience
Should be able to work in a team
Good communication skills

Apply to
The Managing Director,
L and T Ltd.,
Bangalore – 5
Email ID : landtl4@gmail.com

7. You come across the following advertisement

(AU, May/June2015)

Company Name : Way Staffing Location : Thane, Pune Nationality : India Salary : 6.50 – 8.50 lacs Experience : 3 – 8 yrs Education : B.E. / B.Tech • IT • Manufacturing/ Engineering / R&D Posted on : 30th August 2018	Role : Technical Support Engineer Civil Engineer Electrical Engineer Industry : Engineering, Procurement Construction

8. Prepare a detailed CV to be uploaded in the website.

8. Read the following advertisement published in "The Times of India" and write a letter of application. Enclose your resume with the letter of application. **(AU, Nov/Dec, 2014)**

Job : Software Engineer Company : Kamal Info Systems Private Limited Location: Hyderabad Eligibility : B.E. / B.Tech Skills: Capital Markets, Object Oriented Project Planning, Design Patterns in Java, C++ Send your application with the resume to: The HR Manager, Kamal Info Systems Private Limited, No.14, Greams Road, Hyderabad – 500 002.

Scheme of Marks :
Format – 6M
Presentation- 4M
Content - 6M

	UNIT V **GROUP DISCUSSION AND JOB APPLICATIONS** **12**
	Listening- TED/Ink talks; **Speaking** –participating in a group discussion -**Reading**– reading and understanding technical articles **Writing**– Writing reports- minutes of a meeting- accident and survey **Vocabulary Development- verbal analogies Language Development-** reported speech
	PART* A
1	**Reported Speech**2M BTL 3 1. "I will work hard to get first class" said Lazar (D.S.) Lazar said he would work hard to get first class. (I.S.)

2. "You can do this work" said Nelson to Johnsi (D.S.)
Nelson told Johnsi that he could do that work. (I.S.)

3. He says, "I am glad to be here this evening"(D.S.)
He says that he is glad to be there that evening. (I.S.)

4. "I'm going to the library now" said David (D.S.)
David said that he was going to the library then. (I.S.)

5. "Don't talk in the class" said the teacher to the boys. (D.S.)
The teacher advised the boys not to talk in the class. (I.S.)

6. "Please give me something to eat. I am hungry" the old man said to them. (D.S.)
The old man requested them to give him something to eat and said that he was hungry (I.S.)

7. Mohan said to Stalin, "Why did you not attend the meeting yesterday"? (D.S.)
Mohan asked Stalin why he had not attended the meeting the day before. (I.S.)

8. "How often do you go to the theatre?" said David to John. (D.S.)
David asked John how often he went to the theatre. (I.S.)

9. Alas! I have broken my brother's watch" said he.
He exclaimed sorrowfully that he had broken his brother's watch. (I.S.)

10. "How beautiful the flower is!" said Kumar. (D.S.)
Kumar exclaimed joyfully that the flower was very beautiful. (I.S.)

11. "Won't you help me to caary this box?" said I to my friend. (D.S.)
I asked my friend if he would not help me to carry that box. (I.S.)

12. Mohan said to Stalin, "Why did not you attend the meeting yesterday"? (D.S.)
Mohan asked Stalin why he had not attended the meeting the day before. (I.S.)

13. "How often do you go to the theatre?" said David to John. (D.S.)
David asked John how often he went to the theatre. (I.S.)

14. Mohamed said to Sultan, "Do you like mangoes?" (D.S.)

Mohamed asked Sultan if he liked mangoes. (I.S.)

15. The teacher has said to the pupils, "Sea-water is different from the river water.".

The teacher has told the pupils that sea-water is different from river water.

16. David answered, "The Mines are under the ground".

David answered that the Mines are under the ground.

	17. John said to his brother, "The U.N.O. is a world organization". John told his brother that the U.N.O. is a world organisaiton. **18. The Science teacher told the class, "Ice floats on water.".** The Science teacher told the class that ice floats on water. **19. "I don't know the way. Do you?" he asked.** He said that he didn't know the way and asked her if she did. **20. She said, "Oh! It's a snake. Don't go near it, children."** She exclaimed with disgust that it was a snake and told the children not to go near it. **21. "I the floods get any worse we must leave the house", he said.** (must = will have to) He said that if the floods got any worse they would have to leave the house. **22. "I have just received a letter", he said; "I must go home at once".** He said that he had justreceived a letter and would have to go home at once. **23.** Angel said, "I brought a pen yesterday". (D.S) Angel said that she had bought a pen the day before. (I.S) **24. John said, "I am going to church". (D.S)** John said that he was going to church. (I.S) **25. He said, "I have been reading a novel". (D.S)** He said that he had been reading a novel. (I.S)
2	**Verbal Analogies: 2M BTL3** **1. Sing : hum :: Talk : ______** a. murmur b. whisper c. **mumble** d. shout **2. Liquid : liter** a**. Weight : kilogram** b. Land : seismometer c. Bushel : corn d. Fame : television **3. If Dawn: Morning, then Dusk: ________** a. **Evening :**b. Night : c. Darkness :d. Fog **4. If Parson lives in Parsonage, then Pioneer lives in _________** a. Cottage :b.**Wagon :** c.Monastery : d. Barracks **5. If Ravens: Croak, then Ducks: __________** a. Talk :b. Gobble : c. Squeak : d. **Quack** **6. If Bears: Growl, then Asses: ______** a. Growl :b. **Bray** : c. Purr : d. Bleat **7. ______ : trail:: grain : grail**

	a. train : b. path : c. wheat : d. holy **8. particular : fussy :: ______ : subservient** a. meek : b. above : c. cranky : d. uptight **9. ______ : horse :: board : train** a. stable : b. shoe : c. ride : d. mount **10. tureen : ______ ::goblet : wine** **a.** napkin : b. soup : c. spoon : d. pilsner **11. son : nuclear :: ______ : extended** a. father : b. mother : c. cousin : d. daughters **12. coif : hair :: ______ : musical** a. Shower : b. close : c. praise : d. score **13. feta : Greek :: provolone : ______** a. salad : b. Swiss : c. blue : d. Italian **14. moccasin : snake :: ______ : shoe** a. alligator : b. w**aders** : c. asp : d. loafer **15. ______ : zenith :: fear : composure** a. apex : b. **heaven :** c. heights : d. nadir **16. pill : bore :: core : ______** a. **center** : b. mug : c. bar : d. placebo **17. pilfer : steal :: ______ : equip** a. return : b. damage : c. exercise : d. furnish 18. **native : aboriginal :: naïve : ______** a. learned : b. **arid** : c. unsophisticated : d. tribe **19. junket : ______ :: junk : trash** a. trounce : b. trip : c. refuse : d. trinket **20. _____ : festive :: funeral : somber** a. tension : b. soiree : c. eulogy : d. **sari** **21. fetish : fixation :: slight : ______** a. flirt : b. sloth : c. insult : d. confuse **22. hovel : dirty :: hub : ______** a. unseen : b. prideful : c. **busy** : d. shove **23.bog : ______ :: slumber : sleep** a. dream : b. **foray** : c. marsh : d. night **24. ______: segue :: throng : mass** a. **subway :** b. church : c. transition : d. line
	PART * B
3.	**Minutes of a Meeting 16M BTL 3** **1.** Write the minutes of the meeting of organizing a cultural event in the college. Discuss about the budget, responsibilities for organizing functions, Programme, guests and honor, food, stage decoration, logistics, food, publicity. As the secretary, write the minutes of meeting. **2.** Write Minutes of meeting for the class committee meeting held on 19^{th} January 2019.

	3. Write Minutes of meeting for the research meeting over the project with the panel members held on 20th January 2019. **4.** Write Minutes of meeting for the celebration of College day on 24th of march 2018. **5.** Write Minutes of meeting for the meeting between the officer in the Environment Pollution Authority and the Transport Department authority regarding air pollution. **Scheme of Marks :** **Format** – 6M **Presentation-** 4M **Content** - 6M
4.	**Report Writing 16M BTL 4** 1. You are working as a Technical Manager in a Software Company, Hidalco Inc. There was a fire accident in your warehouse which resulted in the damage of goods stored there. Your MD asks you to investigate the cause of the accident and send a report. (2018) 2. Your college administration wants to find what students feel about your college's environment and facilities. As student advisor you have been asked to conduct a survey among students about college infrastructure and environment. Conduct a survey on these topics and submit a report to your Dean.(2018) 3. A company is planning to set up a small shoe unit in a small village 20km from Ranipet. You are asked to prepare a suitable report about the feasibility of starting the factory. Mention the availability of raw materials and labour in your area. 4. Write a survey report on the reading habits of engineering students for submission to your college principal. Also give a set of recommendations for enhancing the reading habits of technical students. 5. You are the Works Manager in Industrial Gases Limited where LPG Cylinders are filled for utilization by the consumers. Write a report about an accident that happened in the LPG section in which three workers were seriously injured. **Scheme of Marks :** **Format** – 6M **Presentation-** 4M **Content** - 6M formal report may include the following points 1. Title Page 2. Executive Summary 3. Abstract 4. Objective 5. Technical details 6. Cost estimation 7. Management Plan 8. Conclusion 9. Recommendations Title Page

	Imagine that you are going to start a language lab in your Institution. Write a detailed proposal about the need for establishing the lab to the General Manager. A PROPOSAL TO ESTABLISH THE LANGUAGE LAB SUBMITTED TO Mr. R. Ravichandran The General Manager ABC Group of Institutions Chennai-28 SUBMITTED BY Mr. G. Sathiaraj Department of English ABC Engineering College Chennai- 28 DATE 10th April 2013

A. Executive Summary

1. Project Title : Establishing Computer Assisted Language Lab
2. Name & Designation of the Department : Mr. G. Sathiaraj., Asst. Prof
Department of English
ABC Engineering College
Chennai- 28
3. Duration of the Project : 3 Months
4. Amount Required : 20 lakhs

B. Abstract

Communication skills become inevitable in today's survival. Communication skill is expected by every IT firms. Everyone must have a good proficiency in English Language.
To meet these expectations, it is proposed to establish a computer assisted language lab in our institution. So, the student could have been provided an independent learning opportunity and acquire the language proficiency.

C. Objective

To establish Computer Assisted language lab to improve and impart the language proficiency of the learning community.

D. Technical plan

It is planned to install 60 students systems with one Teacher control server. 15 different softwares for practice.

E. Cost Estimation

Product	Cost per Unit	Required Unit	Total Cost	Remarks
P-IV computer with 360 GB HD	35000	1	35000	
P-IV computer with 180 GB HD	30000	60	1800000	
Head Phones with Mike	500	61	30500	
Language Learning Softwares	15	1 each	300000	
Split A/C 1.5 ton	25000	2	50000	
Total			1946000	

F. Management Plan

1. The lab may be taken care by Department of English
2. Lab hours may be included in the Regular Time Table
3. One Technical Assistant may be appointed to assist.
4. One staff may be given in-charge.

G. Recommendations

So, It is recommended to establish a Computer Assisted Language Lab at our institution.

SYLLABUS

MA8251 ENGINEERING MATHEMATICS – II L T P C
3 1 0 4

OBJECTIVES:

- To make the student acquire sound knowledge of techniques in solving ordinary differential equations that model engineering problems.
- To acquaint the student with the concepts of vector calculus, needed for problems in all engineering disciplines.
- To develop an understanding of the standard techniques of complex variable theory so as to enable the student to apply them with confidence, in application areas such as heat conduction, elasticity, fluid dynamics and flow the of electric current.
- To make the student appreciate the purpose of using transforms to create a new domain in which it is easier to handle the problem that is being investigated.

UNIT I MATRICES 9+3

Eigenvalues and Eigenvectors of a real matrix - Characteristic equation - Properties of eigenvalues and eigenvectors - Statement and applications of Cayley-Hamilton Theorem - Diagonalization of matrices - Reduction of a quadratic form to canonical form by orthogonal transformation –Nature of quadratic forms.

UNIT II VECTOR CALCULUS 9+3

Gradient, divergence and curl – Directional derivative – Irrotational and solenoidal vector fields –Vector integration – Green's theorem in a plane, Gauss divergence theorem and Stokes' theorem(excluding proofs) – Simple applications involving cubes and rectangular parallelopipeds.

UNIT III ANALYTIC FUNCTIONS 9+3

Functions of a complex variable – Analytic functions: Necessary conditions – Cauchy-Riemann equations and sufficient conditions (excluding proofs) – Harmonic and orthogonal properties of analytic function – Harmonic conjugate – Construction of analytic functions – Conformal mapping: $w = z+k$, kz, $1/z$, z^2, e^z and bilinear transformation.

UNIT IV COMPLEX INTEGRATION 9+3

Complex integration – Statement and applications of Cauchy's integral theorem and Cauchy's integral formula – Taylor's and Laurent's series expansions – Singular points – Residues –

Cauchy's residue theorem – Evaluation of real definite integrals as contour integrals around unit circle and semi-circle (excluding poles on the real axis).

UNIT V LAPLACE TRANSFORM **9+3**

Laplace transform – Sufficient condition for existence – Transform of elementary functions – Basic properties – Transforms of derivatives and integrals of functions - Derivatives and integrals of transforms - Transforms of unit step function and impulse functions – Transform of periodic functions. Inverse Laplace transform -Statement of Convolution theorem – Initial and final value theorems – Solution of linear ODE of second order with constant coefficients using Laplace transformation techniques.

TOTAL: 60 PERIODS

TEXT BOOKS:

1. Bali N. P and Manish Goyal, "A Text book of Engineering Mathematics", Eighth Edition, Laxmi Publications Pvt Ltd.,(2011).

2. Grewal. B.S, "Higher Engineering Mathematics", 41 st Edition, Khanna Publications, Delhi, (2011).

REFERENCES:

1. Dass, H.K., and Er. RajnishVerma," Higher Engineering Mathematics", S. Chand Private Ltd., (2011)

2. Glyn James, "Advanced Modern Engineering Mathematics", 3rd Edition, Pearson Education, (2012).

3. Peter V. O'Neil," Advanced Engineering Mathematics", 7th Edition, Cengage learning, (2012).

4. Ramana B.V, "Higher Engineering Mathematics", Tata McGraw Hill Publishing Company, New Delhi, (2008).

	UNIT-I MATRICES	
	Eigen values and Eigenvectors of a real matrix – Characteristic equation – Properties of Eigen values and Eigenvectors – Cayley-Hamilton theorem – Diagonalization of matrices – Reduction of a quadratic form to canonical form by orthogonal transformation – Nature of quadratic forms.	
Q.No.	**PART-A**	
1	**State Cayley Hamilton theorem and give its two uses. (NOV/DEC 2015)(MAY/JUNE 2012)**BTL1 Every square matrix satisfies its own characteristic equation. It is used to calculate i. The positive integral powers ii. The inverse of a square matrix.	
2	**If $\lambda_1, \lambda_2, \ldots \lambda_n$ are Eigen values of a matrix A then show that $\frac{1}{\lambda_1}, \frac{1}{\lambda_2}, \ldots \frac{1}{\lambda_n}$ are Eigen values of A^{-1}.**BTL2 If λ_i and X_i are corresponding Eigen value and Eigen vector of A where i=1,2...,n. $AX_i =_i X_i A^{-1}(AX_i) = A^{-1}(\lambda_i X_i)$ $\Rightarrow IX_i = \lambda_i A^{-1} X_i$ $\Rightarrow X_i = \lambda_i A^{-1} X_i$ $\Rightarrow A^{-1} Xi = 1/\lambda_i X_i$ $\Rightarrow A^{-1} = 1/\lambda_i$ $\therefore 1/\lambda_i$ is an Eigen values of A^{-1}	
3	**If $\lambda_1, \lambda_2, \ldots \lambda n$ are Eigen values of an n x n matrix A then show that $\lambda_1^3, \lambda_2^3 \ldots \lambda_n^3$ are Eigen values of A^3.**BTL2 Let λ be Eigen value of A and let X be Eigen vector of A. $\therefore$ AX = λ X $A^2X = A\lambda X = \lambda (AX) = \lambda (\lambda X) = \lambda^2 X$ $\therefore A^2 = \lambda$ Similarly, $A^3X = \lambda^3 X \Rightarrow A^3 = \lambda^3$ $\therefore \lambda^3$ is an Eigen value of A^3.	

4	**If λ is the eigenvalue of the matrix *A*, then prove that λ^2 is the eigenvalue of A^2.**(APR/MAY 2019) Let λ be Eigen value of A and let X be Eigen vector of A. $\therefore \quad AX = \lambda X$ $A^2X = A\lambda X = \lambda (AX) = \lambda (\lambda X) = \lambda^2 X$ $\therefore A^2 = \lambda$.	
5	**Two Eigen values of A=**$\begin{pmatrix} 2 & 2 & 1 \\ 1 & 3 & 1 \\ 1 & 2 & 2 \end{pmatrix}$ **are equal and are** $\frac{1}{5}$ **times to the third. Find them.** **(NOV/DEC 2014)**BTL1 Let $\lambda_1, \lambda_2, \lambda_3$ be Eigen values of A. Given $\lambda_1 = \lambda_2 = \frac{1}{5}\lambda_3$ We know sum of Eigen values = sum of diagonal elements $\lambda_1 + \lambda_2 + \lambda_3 = 7$ $\frac{1}{5}\lambda_3 + \frac{1}{5}\lambda_3 + \lambda_3 = 7$ $\frac{7}{5}\lambda_3 = 7$ $\therefore \lambda_3 = 5$ $\therefore \lambda_1 = \lambda_2 = 1$.	
5	**Find the Eigen values of A^2 given A=**$\begin{pmatrix} 1 & 2 & 3 \\ 0 & 2 & -7 \\ 0 & 0 & 3 \end{pmatrix}$**.Also find A^3, A^{-1}, $2A^2$.**BTL1 We know the Eigen values of a triangular matrix are just the diagonal elements. Here given matrix is a upper triangular matrix $\therefore$ Eigen values of A are 1,2,3. We know that "if $\lambda_1, \lambda_2, \ldots\lambda_n$ are Eigen values of a matrix A,then $\lambda_1^m, \lambda_2^m, \ldots \lambda_n^m$ are Eigen values of A^m." $\therefore$ Eigen values of A^2 are 1,4,9. $\therefore$ Eigen values of A^3 are 1,8,27. We know that if $\lambda_1, \lambda_2, \ldots\lambda_n$ are Eigen values of A then $k\lambda_1, k\lambda_2, \ldots k\lambda_n$ are Eigen values of KA $\therefore$ Eigen values of $2A^2$ are 2,8,18	
6	**If A is an orthogonal matrix Show that A^{-1} is also orthogonal.** BTL2	

	Let A be orthogonal matrix i.e. $A^T = A^{-1}$ Let $A^T = A^{-1} = B$ $B^T = (A^{-1})^T = (A^T)^{-1} = B^{-1}$ Therefore B is orthogonal. i.e. A^{-1} is an orthogonal matrix.	
7	**Prove that the product of 2 orthogonal matrices is an orthogonal matrix.** BTL5 Let A be an n^{th} order orthogonal matrix. $\therefore \quad AA' = A'A = I$ Let B be an n^{th} order orthogonal matrix. $BB' = B'B = I$ Now $(AB)(AB)' = AB\,B'A'$ $= AIA'$ $= AA'$ $= I$ Now $(AB)'(AB) = B'A'AB$ $= B'IB$ $= B'B$ $= I$ Since $(AB)(AB)' = (AB)'(AB) = I$. AB is orthogonal matrix.	
8	**If 1 and 2 are Eigen values of a 2 x2 matrix A, what are the Eigen values of A^2 and A^{-1}.** BTL1 Eigen values of A^2 are 1 and 4 Eigen values of A^{-1} are 1 and $\frac{1}{2}$.	
9	**If 2, 3 are the Eigen value of $A=\begin{pmatrix} 2 & 0 & 1 \\ 0 & 2 & 0 \\ b & 0 & 2 \end{pmatrix}$ then find the value of b?** **(NOV/DEC 2013)** BTL1 Given Eigen values are $\lambda_1 = 2, \lambda_3 = 3$ Sum of the Eigen values = Sum of the main diagonal elements $\lambda_1 + \lambda_2 + \lambda_3 = 6$ $2+3+\lambda_3 = 6$ $5+\lambda_3 = 6$ $\lambda_3 = 1$ Product of the Eigen value $= \|A\|$	

	$(2)(3)(1)=8-2b$ $6=8-2b$ $b=1$	
10	**If the sum of two Eigen values and trace of a 3 x 3 matrix A are equal, find the value of |A|.**BTL1 Let $\lambda_1,\lambda_2,\lambda_3$ be the Eigen values of A. Then we have $\lambda_1+\lambda_2$ = trace of A $\Rightarrow \lambda_1+\lambda_2=\lambda_1+\lambda_2+\lambda_3 \Rightarrow \lambda_3=0$. Hence |A| = product of Eigen values = $\lambda_1\lambda_2\lambda_3=0$	
11	**For a given matrix A of order 3, |A| = 32 and two of its Eigen values are 8 and 2. Find the sum of the Eigen values.** BTL1 Given Eigen value be $\lambda_1=8,\lambda_2=2$. Then (8)(2)(λ_3) = |A| = 32 $\Rightarrow \lambda_3$ = 2 Let the third Eigen value be λ_3 = 2 Hence the sum of the Eigen values = $\lambda_1+\lambda_2+\lambda_3=8+2+2=12$	
12	**Find the sum and product of the Eigen values of the square matrix** $A=\begin{pmatrix}8&1&6\\3&5&7\\4&9&2\end{pmatrix}$. **(NOV/DEC 2010)**BTL1 Sum of the Eigen values = sum of the main diagonal elements = 8+5+2=15 Product of the Eigen values = $\|A\|=8(10-63)-1(6-28)+6(27-20)=-360$	
13	**Find the sum of the Eigen values of 2A if** $A=\begin{pmatrix}8&-6&2\\-6&7&-4\\2&-4&3\end{pmatrix}$. BTL1 If λ_1, λ_2, λ_3 are the Eigen values of A, then $\lambda_1+\lambda_2+\lambda_3=18$. We know that $2\lambda_1$, $2\lambda_2$, $2\lambda_3$ are the Eigen values of 2A. Therefore the sum of Eigen values of 2A = $2(\lambda_1+\lambda_2+\lambda_3)=2(18)=36$	
14	**If the Eigen value of A are 3x3 are 2,3 and 1, then find the Eigen values of adjA. (NOV/DEC 2003)**BTL1 The Eigen values of are 2,3,1 The Eigen value of A^{-1} are $\frac{1}{2},\frac{1}{3},1$	

	The product of Eigen values are $(2)(3)(1)=\|A\|$ $\therefore \|A\|=6$ We know that $A^{-1}=\frac{1}{\|A\|}adjA$ $adjA=\|A\|A^{-1}$ The Eigen value of adjA are $(6)\left(\frac{1}{2}\right),(6)\left(\frac{1}{3}\right),(6)1$ $\Rightarrow 3,2,6$	
	If the eigenvalue of the matrix *A* of the order 3x3 are 2, 3 and 1, then find the determinant of *A*. (APR/ MAY 2019) The Eigen values of are 2,3,1 The product of Eigen values are $(2)(3)(1)=\|A\|$ $\therefore \|A\|=6$.	
15	**Find the sum of the squares of the Eigen values of** $A=\begin{pmatrix}3&1&4\\0&2&6\\0&0&5\end{pmatrix}$**.** **(NOV/DEC 2016)**BTL1 A is a triangular matrix. Therefore the Eigen values of A are 3, 2 and 5. The sum of squares of the Eigen values of $A^2 = 3^2 + 2^2 + 5^2 = 9 + 4 + 25 = 38$	
16	**Find the Eigen values of 2A – I, given** $A=\begin{pmatrix}-4&1\\3&-2\end{pmatrix}$**.** BTL1 $2\boldsymbol{A}-\boldsymbol{I}=\begin{pmatrix}-8&2\\6&-4\end{pmatrix}-\begin{pmatrix}1&0\\0&1\end{pmatrix}=\begin{pmatrix}-9&2\\6&-5\end{pmatrix}$ The Characteristic equation of 2A - I is given by $\|2\boldsymbol{A}-\boldsymbol{I}-\lambda\boldsymbol{I}\|=0\Rightarrow\begin{vmatrix}-9-\lambda&2\\6&-5-\lambda\end{vmatrix}=0$ $\Rightarrow \lambda^2+14\lambda+33=(\lambda+11)(\lambda+3)=0$ $\Rightarrow \lambda=-3,-11$	
17	**Prove that A and A^T have the same Eigen values.** BTL5 $\|\boldsymbol{A}^T-\lambda\boldsymbol{I}\|=\|\boldsymbol{A}^T-(\lambda\boldsymbol{I})^T\|=\|(\boldsymbol{A}-\lambda\boldsymbol{I})^T\|=\|\boldsymbol{A}-\lambda\boldsymbol{I}\|$.	

	$\Rightarrow$A and A^T have the same characteristic equation and hence they have the same Eigen values.	
18	**Prove that Similar matrices have the same characteristic roots.** BTL5 LetA and Bbe two similar matrices, then there exists a matrix P such that $B = P^{-1}AP$. Hence $\lvert \boldsymbol{B}-\lambda \boldsymbol{I}\rvert = \lvert \boldsymbol{P}^{-1}\boldsymbol{AP}-\boldsymbol{P}^{-1}\lambda \boldsymbol{IP}\rvert = \lvert \boldsymbol{P}^{-1}\rvert\lvert \boldsymbol{A}-\lambda \boldsymbol{I}\rvert\lvert \boldsymbol{P}\rvert = \lvert \boldsymbol{A}-\lambda \boldsymbol{I}\rvert\lvert \boldsymbol{PP}^{-1}\rvert$ $= \lvert \boldsymbol{A}-\lambda \boldsymbol{I}\rvert$ i.e., A and B have the same characteristic equation. Therefore, they have the same Characteristic roots.	
19	**Is the matrix** $B=\begin{pmatrix}\cos\theta & \sin\theta & 0\\ -\sin\theta & \cos\theta` & 0\\ 0 & 0 & 1\end{pmatrix}$ **orthogonal? Justify.** BTL5 $\mathbf{BB^T}=\begin{bmatrix}\cos\theta & \sin\theta & 0\\ -\sin\theta & \cos\theta & 0\\ 0 & 0 & 1\end{bmatrix}\begin{bmatrix}\cos\theta & -\sin\theta & 0\\ \sin\theta & \cos\theta & 0\\ 0 & 0 & 1\end{bmatrix}=\begin{bmatrix}1 & 0 & 0\\ 0 & 1 & 0\\ 0 & 0 & 1\end{bmatrix}=\mathbf{I}$ Similarly, $B^TB = I$. Hence B is orthogonal.	
20	**Use Cayley-Hamilton theorem to find** $A^4\text{-}4A^3\text{-}5A^2\text{+}A\text{+}2I$ **where** $A=\begin{pmatrix}1 & 2\\ 4 & 3\end{pmatrix}$**.**BTL3 $\lvert \mathbf{A}-\lambda \boldsymbol{I}\rvert=0 \Rightarrow \begin{vmatrix}1-\lambda & 2\\ 4 & 3-\lambda\end{vmatrix}=0 \Rightarrow \lambda^2-4\lambda-5=0 \Rightarrow \boldsymbol{A}^2-4\boldsymbol{A}-5\boldsymbol{I}=0$ **(**By Cayley-Hamilton Theorem) $\Rightarrow \boldsymbol{A}^2(\boldsymbol{A}^2-4\boldsymbol{A}-5\boldsymbol{I})=0 \Rightarrow \boldsymbol{A}^4-4\boldsymbol{A}^3-5\boldsymbol{A}^2=0$ $\Rightarrow A^4-4A^3-5A^2+A+2I=0+A+2I=\begin{bmatrix}1 & 2\\ 4 & 3\end{bmatrix}+\begin{bmatrix}2 & 0\\ 0 & 2\end{bmatrix}=\begin{bmatrix}3 & 2\\ 4 & 5\end{bmatrix}.$	
21	**Can** $A=\begin{pmatrix}1 & 0\\ 0 & 1\end{pmatrix}$ **be diagonalised? Why?(MAY/JUNE 2016)** BTL1 Yes. Even if the Eigen values of A are equal, namely 1, 1, it is possible to find two linearly independent Eigen vectors corresponding to the Eigen value 1.	
22	**Find the matrix of the quadratic from** $2x^2+2y^2+3z^2+2xy-4xz-4yz$**.** BTL1	

	The required matrix $A=\begin{bmatrix} coeff\ x^2 & \frac{1}{2}coeff\ \ xy & \frac{1}{2}coeff\ xz \\ \frac{1}{2}coeff\ \ yx & coeff\ \ y^2 & \frac{1}{2}coeff\ yz \\ \frac{1}{2}coeff\ zx & \frac{1}{2}coeff\ \ zy & coeff\ z^2 \end{bmatrix}$ $A=\begin{pmatrix} 2 & 1 & -2 \\ 1 & 2 & -2 \\ -2 & -2 & 3 \end{pmatrix}$	
23	**Find the nature of the quadratic form** $x_1^2+2x_2^2+x_3^2-2x_1x_2+2x_2x_3$ **.(MAY/JUNE 2010)**BTL1 $A=\begin{bmatrix} coeffx_1^2 & \frac{1}{2}coeffx_1x_2 & \frac{1}{2}coeffx_1x_3 \\ \frac{1}{2}coeffx_2x_1 & coeffx_2^2 & \frac{1}{2}coeffx_2x_3 \\ \frac{1}{2}coeffx_3x_1 & \frac{1}{2}coeffx_3x_2 & coeffx_3^2 \end{bmatrix}$ $D_1=\begin{vmatrix} 1 & -1 & 0 \\ -1 & 2 & 1 \\ 0 & 1 & 1 \end{vmatrix}=\lvert a_{11}\rvert=1$ $D_2=\begin{vmatrix} 1 & -1 & 0 \\ -1 & 2 & 1 \\ 0 & 1 & 1 \end{vmatrix}=\begin{vmatrix} 1 & -1 \\ -1 & 2 \end{vmatrix}=2-1=1$ $D_3=\lvert A\rvert=1$ The nature positive definite since all are positive values.	
24	**Write down the matrix corresponding to the quadratic form** $x^2+y^2+z^2+2zx+4\sqrt{2}yz$ BTL1 The required matrix $A=\begin{bmatrix} coeff\ x^2 & \frac{1}{2}coeff\ \ xy & \frac{1}{2}coeff\ xz \\ \frac{1}{2}coeff\ \ yx & coeff\ \ y^2 & \frac{1}{2}coeff\ yz \\ \frac{1}{2}coeff\ zx & \frac{1}{2}coeff\ \ zy & coeff\ z^2 \end{bmatrix}$	

	$A=\begin{pmatrix}1 & 0 & 1\\ 0 & 1 & 2\sqrt{2}\\ 1 & 2\sqrt{2} & 1\end{pmatrix}$	
25	**Write down the Quadratic Form corresponding to the matrix** $A=\begin{pmatrix}2 & 1 & -2\\ 1 & 2 & -2\\ -2 & -2 & 3\end{pmatrix}$**.** BTL1 The Quadratic Form of the matrix is $2x^2+2y^2+3z^2+2xy-4yz-4zx$	
26	**Define index and signature of a quadratic form. Find the index and signature of the quadratic form** $x_1^2+2x_2^2-3x_3^2$**.**BTL1 The number (p) of positive terms in the canonical form of a QF is called the index of the QF. The number of positive terms minus the number of negative terms is called the signature of the QF Index = 2 , Signature = 1	
27	**Find the constant 'a' and 'b' such that the matrix** $A=\begin{pmatrix}a & 4\\ 1 & b\end{pmatrix}$ has 3 and -2 as eigen values. BTL1 Give the Eigen values are 3 and -2 Sum of the Eigen value of A are 'a' and 'b' Sum of the Eigen value $a+b=3-2=1$ $\therefore a+b=1$……………………….(1) Product of the Eigen value $3(-2)=-6$ Product of the Eigen value of A are $\lvert A\rvert=ab-4$ $\therefore ab-4=-6$ $ab=-2$………………..(2) $(1)\Rightarrow\ b=1-a$	

	$(2)\Rightarrow\ ab=-2$ $a(1-a)=-2$ $a^2-a-2=0$ $(a-2)(a+1)=0 \quad \therefore a=2\,\&\,a=-1$ $when\ \ a=2\ then\ b=-1$ $when\ \ a=-1\ then\ b=2$ $\therefore a=2,b=-1\ or\ a=-1,b=2$	
28	**Find the Eigen values of 3A+2I , where** $A=\begin{pmatrix}5&4\\0&3\end{pmatrix}$**.(MAY/JUNE 2007)**BTL1 The Eigen values of A are 5 and 2, The Eigen values of 3A+2I are 3(5)+2 and 3(2)+2 The Eigen values of 3A+2I are 17 and 8	
29	**If 3 and 5 are two Eigen valuesof the matrix** $A=\begin{pmatrix}8&-6&2\\-6&7&-4\\2&-4&3\end{pmatrix}$ **then find its thirdEigen value and hence** $\lvert A\rvert$ **.(MAY/JUNE 2018 R-17)**BTL1 Given Eigen value be $\lambda_1=3,\lambda_2=5$. Sum of the Eigen values= Trace of A $\lambda_1+\lambda_2+\lambda_3=8+7+3=18$ $\therefore\lambda_3=18-8=10$ Product of the Eigen value $\lvert A\rvert=150$	
30	**Show that Eigen values of a null matrix are zero (MAY/JUNE 2018 R-17)**BTL1 Let $A=\begin{pmatrix}0&0&0\\0&0&0\\0&0&0\end{pmatrix}$ TheCharacteristic Equation is $\lambda^3=0$ $\therefore\lambda_1=0,\lambda_2=0,\lambda_3=0$	
	PART-B	
1.	**Find the Eigen values and Eigen vectors of** $\begin{pmatrix}2&2&0\\2&1&1\\-7&2&-3\end{pmatrix}$**. (8M)**BTL1	

	Answer : Refer Page No.1.8-Dr.M.CHANDRASEKAR • The Eigen values are $\lambda = -4, 1, 3$. **(2 M)** • Eigen vectors $X_1 = \begin{bmatrix} 1 \\ -3 \\ 13 \end{bmatrix}; X_2 = \begin{bmatrix} 2 \\ -1 \\ -4 \end{bmatrix}; X_3 = \begin{bmatrix} 2 \\ 1 \\ 4 \end{bmatrix}$ **(6M)**
2.	**Find the Eigen values and Eigen vectors of** $\begin{pmatrix} 11 & -4 & -7 \\ 7 & -2 & -5 \\ 10 & -4 & -6 \end{pmatrix}$ **(May/June-2018 R-17) (8M)** BTL1 **Answer : Refer Page No.1.21-Dr.M.CHANDRASEKAR** • The Eigen values are $\lambda = 0, 1, 2$ **(2 M)** • Eigen vectors $X_1 = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix}; X_2 = \begin{bmatrix} 1 \\ -1 \\ 2 \end{bmatrix}; X_3 = \begin{bmatrix} 2 \\ 1 \\ 2 \end{bmatrix}$ **(6M)**
3.	**Find the Eigen values and Eigen vectors of** $\begin{pmatrix} 1 & 0 & -1 \\ 1 & 2 & 1 \\ 2 & 2 & 3 \end{pmatrix}$ **(DEC/JAN-2016 R-13) (8M)** BTL1 **Answer : Refer Page No.1.10-Dr.M.CHANDRASEKAR** • The Eigen values are $\lambda = 1, 2, 3$ **(2 M)** • Eigen vectors $X_1 = \begin{bmatrix} 1 \\ -1 \\ 0 \end{bmatrix}; X_2 = \begin{bmatrix} 2 \\ -1 \\ -2 \end{bmatrix}; X_3 = \begin{bmatrix} 1 \\ -1 \\ 2 \end{bmatrix}$ **(6M)**
4.	**Find the Eigen values and Eigen vectors of** $\begin{pmatrix} 2 & 2 & 1 \\ 1 & 3 & 1 \\ 1 & 2 & 2 \end{pmatrix}$ **(DEC/JAN-2014 R-13) (8M)** BTL1 **Answer : Refer Page No.1.15-Dr.M.CHANDRASEKAR** • The Eigen values are $\lambda = 1, 1, 5$ **(2 M)**

	• Eigen vectors $X_1=\begin{bmatrix}1\\1\\1\end{bmatrix};X_2=\begin{bmatrix}0\\1\\-2\end{bmatrix};X_3=\begin{bmatrix}1\\0\\-1\end{bmatrix}$ **(6M)**	
5.	**Find the Eigen values and Eigen vectors of** $\begin{pmatrix}6&-2&2\\-2&3&-1\\2&-1&3\end{pmatrix}$ **(APR/MAY-2015 R-13) (8M)** BTL1 **Answer : Refer Page No.1.17-Dr.M.CHANDRASEKAR** • The Eigen values are $\lambda=2,2,8$ **(2 M)** • Eigen vectors $X_1=\begin{bmatrix}2\\-1\\1\end{bmatrix};X_2=\begin{bmatrix}0\\1\\1\end{bmatrix};X_3=\begin{bmatrix}1\\2\\0\end{bmatrix}$ **(6M)**	
6.	**Find the eigenvalues and the eigenvectors of the matrix** $A=\begin{pmatrix}8&-6&2\\-6&7&-4\\2&-4&3\end{pmatrix}$ **.(APR/MAY 2019)(8M)** BTL3 • The Eigen values are $\lambda=0,3,15$ **(4M)** • Eigen vectors $X_1=\begin{bmatrix}1\\2\\2\end{bmatrix};X_2=\begin{bmatrix}2\\1\\-2\end{bmatrix};X_3=\begin{bmatrix}2\\-2\\1\end{bmatrix}$ **(4M)**	
7.	**Verify Cayley-Hamilton theorem and hence find the inverse of the matrix** $\begin{pmatrix}1&2&-1\\3&-3&1\\2&1&-2\end{pmatrix}$ **(DEC/JAN-2014 R-13) (8M)** BTL3 **Answer : Refer Page No.1.45-Dr.M.CHANDRASEKAR** • The Characteristic Equation is $\lambda^3+4\lambda^2-4\lambda-12=0$ **(2 M)** • For Proving $A^3+4A^2-4A-12I=0$ **(3 M)** • $A^{-1}=\frac{1}{12}\begin{pmatrix}5&3&-1\\8&0&-4\\9&3&-9\end{pmatrix}$ **(3 M)**	

8.	**Verify Cayley-Hamilton theorem and hence find the inverse of the matrix** $\begin{pmatrix} 1 & 0 & 3 \\ 2 & 1 & -1 \\ 1 & -1 & 1 \end{pmatrix}$ **(DEC/JAN-2015 R-13) (8M)** BTL3 **Answer : Refer Page No.1.47-Dr.M.CHANDRASEKAR** • The Characteristic Equation is $\lambda^3 - 3\lambda^2 - \lambda + 9 = 0$ **(2 M)** • For Proving $A^3\text{-}3A^2 \text{ - } A + 9I = 0$. **(3 M)** • $A^{-1} = \frac{-1}{9}\begin{pmatrix} 0 & -3 & -3 \\ -3 & -2 & 7 \\ -3 & 1 & 1 \end{pmatrix}$ **.(3 M)**
9.	**Using Cayley-Hamilton theorem to find the inverse of the matrix** $\begin{pmatrix} 1 & 2 & 1 \\ 2 & 2 & 1 \\ 1 & 1 & 3 \end{pmatrix}$ **(May/June-2018 R-17) (8M)** BTL3 **Answer : Refer Page No.1.56-Dr.M.CHANDRASEKAR** • The Characteristic Equation is $\lambda^3 - 6\lambda^2 + 5\lambda + 5 = 0$ **(2 M)** • For Proving $A^3\text{-}6A^2 + 5A + 5I = 0$ **(3 M)** • $A^{-1} = \frac{-1}{5}\begin{pmatrix} -5 & 5 & 0 \\ 5 & -2 & -1 \\ 0 & -1 & 2 \end{pmatrix}$ **(3 M)**
10.	**Use Cayley-Hamilton theorem to find the** A^4 **of the matrix** $\begin{pmatrix} 2 & -1 & 1 \\ 0 & 1 & 2 \\ 1 & 0 & 1 \end{pmatrix}$ **(DEC/JAN-2016 R-13) (8M)** BTL3 **Answer : Refer Page No.1.48-Dr.M.CHANDRASEKAR** • The Characteristic Equation is $\lambda^3 - 4\lambda^2 + 4\lambda + 1 = 0$ **(2 M)** • $A^4 = \begin{pmatrix} 22 & -19 & -5 \\ 24 & -9 & 14 \\ 19 & -12 & 3 \end{pmatrix}$ **(6 M)**

11.	**Use Cayley-Hamilton theorem to find** $A^8-5A^7+7A^6-3A^5+A^4-5A^3+8A^2-2A+I$ **of** $A=\begin{pmatrix}2&1&1\\0&1&0\\1&1&2\end{pmatrix}$ **(DEC/JAN-2006,APR/MAY 2005) (8M)** BTL3 **Answer : Refer Page No.1.51-Dr.M.CHANDRASEKAR** • The Characteristic Equation is $\lambda^3-5\lambda^2+7\lambda-3=0$ **(2 M)** • For Proving $A^8-5A^7+7A^6-3A^5+A^4-5A^3+8A^2-2A+I=A^2+A+I$ **(3 M)** • $A^8-5A^7+7A^6-3A^5+A^4-5A^3+8A^2-2A+I=\begin{pmatrix}8&5&5\\0&3&0\\5&5&8\end{pmatrix}$ **(3 M)**	
12.	**Reduce the quadratic form** ***2xy-2yz+2xz*** **into a canonical form by an orthogonal reduction. (APR/MAY 2019)(16M)** BTL3 **Answer : Refer Page No.1.119-Dr.G. BALAJI** • The Eigen values are $\lambda=1,1,-2$ **(4M)** • Eigen vectors $X_1=\begin{bmatrix}1\\2\\-1\end{bmatrix}$, $X_2=\begin{bmatrix}1\\0\\1\end{bmatrix}$, $X_3=\begin{bmatrix}-1\\1\\1\end{bmatrix}$, **(4M)** • $D=\begin{pmatrix}1&0&0\\0&1&0\\0&0&-2\end{pmatrix}$ **(6M)** • Canonical form = $-2y_1^2+y_2^2+y_3^2$. **(2M)**	
13.	**Diagonalize** $A=\begin{pmatrix}8&-6&2\\-6&7&-4\\2&-4&3\end{pmatrix}$ **by means of orthogonal transformation.(12M)**BTL1 **Answer : Refer Page No.1.72-Dr.M.CHANDRASEKAR** • The Eigen values are $\lambda=0,3,15$ **(2 M)** • Eigen vectors $X_1=\begin{bmatrix}1\\2\\2\end{bmatrix}$; $X_2=\begin{bmatrix}2\\1\\-2\end{bmatrix}$; $X_3=\begin{bmatrix}2\\-2\\1\end{bmatrix}$ **(4M)**	

	• $D=N^TAN=\begin{pmatrix}0&0&0\\0&3&0\\0&0&15\end{pmatrix}$ **(6M)**	
14.	**Diagonalize** $A=\begin{pmatrix}3&1&1\\1&3&-1\\1&-1&3\end{pmatrix}$ **by means of orthogonal transformation. (12M)** BTL1 **Answer : Refer Page No.1.77-Dr.M.CHANDRASEKAR** • The Eigen values are $\lambda=1,4,4$ **(2 M)** • Eigen vectors $X_1=\begin{bmatrix}-1\\1\\1\end{bmatrix};X_2=\begin{bmatrix}1\\1\\0\end{bmatrix};X_3=\begin{bmatrix}-1\\1\\-2\end{bmatrix}$ **(4M)** • $D=N^TAN=\begin{pmatrix}1&0&0\\0&4&0\\0&0&4\end{pmatrix}$ **(6M)**	
15.	**Diagonalize** $A=\begin{pmatrix}6&-2&2\\-2&3&-1\\2&-1&3\end{pmatrix}$ **by means of orthogonal transformation.** BTL1 **(DEC/JAN-2015 R-13) (12M)** **Answer : Refer Page No.1.87-Dr.M.CHANDRASEKAR** • The Eigen values are $\lambda=2,2,8$ **(2 M)** • Eigen vectors $X_1=\begin{bmatrix}2\\-1\\1\end{bmatrix};X_2=\begin{bmatrix}1\\1\\-1\end{bmatrix};X_3=\begin{bmatrix}0\\1\\1\end{bmatrix}$ **(4M)** • $D=N^TAN=\begin{pmatrix}8&0&0\\0&2&0\\0&0&2\end{pmatrix}$ **(6M)**	
16.	**Reduce the quadratic form** $10x_1^2+2x_2^2+5x_3^2+6x_2x_3-10x_3x_1-4x_1x_2$ **to a canonical form. Discuss its nature.(16M)** BTL1 **Answer : Refer Page No.1.99-Dr.M.CHANDRASEKAR**	

	• The Eigen values are $\lambda = 0,3,14$ **(2 M)** • Eigen vectors $X_1 = \begin{bmatrix} 1 \\ -5 \\ 4 \end{bmatrix}; X_2 = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix}; X_3 = \begin{bmatrix} 3 \\ -1 \\ -2 \end{bmatrix}$ **(4M)** • $D = N^T AN = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 3 & 0 \\ 0 & 0 & 14 \end{pmatrix}$ **(6M)** • Canonical form= $0y_1^2 + 3y_2^2 + 14y_3^2$ **.(2 M)** • Rank=2, Index=2, Signature=2; Nature = Positive Semi definite. **(2 M)**
17.	**Reduce the quadratic form** $6x_1^2 + 3x_2^2 + 3x_3^2 - 2x_2x_3 + 4x_3x_1 - 4x_1x_2$ **to a canonical form. Discuss its nature.(DEC/JAN-2016, JAN-2014 R-13) (16M)**BTL1 **Answer : Refer Page No.1.102-Dr.M.CHANDRASEKAR** • The Eigen values are $\lambda = 2,2,8$ **(2 M)** • Eigen vectors $X_1 = \begin{bmatrix} 2 \\ -1 \\ 1 \end{bmatrix}; X_2 = \begin{bmatrix} 1 \\ 2 \\ 0 \end{bmatrix}; X_3 = \begin{bmatrix} 2 \\ -1 \\ -5 \end{bmatrix}$ **(4M)** • $D = N^T AN = \begin{pmatrix} 2 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 8 \end{pmatrix}$ **(6M)** • Canonical form= $2y_1^2 + 2y_2^2 + 8y_3^2$ **(2 M)** • Rank=3, Index=3, Signature=3; Nature = Positive definite **(2 M)**
18.	**Reduce the quadratic form** $6x_1^2 + 3x_2^2 + 3x_3^2 - 2x_2x_3 + 4x_3x_1 - 4x_1x_2$ **to a canonical form by orthogonal reduction. (16M)**BTL1 **Answer : Refer Page No.1.104-Dr.M.CHANDRASEKAR** • The Eigen values are $\lambda = 2,3,6$ **(2 M)** • Eigen vectors $X_1 = \begin{bmatrix} 1 \\ 0 \\ -1 \end{bmatrix}; X_2 = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix}; X_3 = \begin{bmatrix} 1 \\ -2 \\ 1 \end{bmatrix}$ **(4M)**

	• $D=N^TAN=\begin{pmatrix}2&0&0\\0&3&0\\0&0&6\end{pmatrix}$ **(8M)** • Canonical form= $2y_1^2+3y_2^2+6y_3^2$ **(2 M)**	
19.	**Reduce the quadratic form $x^2+5y^2+z^2+2xy+2yz+6zx$ to a canonical form through an orthogonal transformation. (DEC/JAN-2015 R-13) (16M)**BTL1 **Answer : Refer Page No.1.109-Dr.M.CHANDRASEKAR** • The Eigen values are $\lambda=-2,3,6$ **(2 M)** • Eigen vectors $X_1=\begin{bmatrix}-1\\0\\1\end{bmatrix};X_2=\begin{bmatrix}-1\\1\\-1\end{bmatrix};X_3=\begin{bmatrix}1\\2\\1\end{bmatrix}$ **(4M)** • $D=N^TAN=\begin{pmatrix}-2&0&0\\0&3&0\\0&0&6\end{pmatrix}$ **(8M)** • Canonical form= $-2y_1^2+3y_2^2+6y_3^2$ **(2 M)**	
20.	**Reduce the quadratic form $8x_1^2+7x_2^2+3x_3^2-8x_2x_3+4x_3x_1-12x_1x_2$ to a canonical form by orthogonal reduction. (16M)** BTL1 **Answer : Refer Page No.1.111-Dr.M.CHANDRASEKAR** • The Eigen values are $\lambda=0,3,15$ **(2 M)** • Eigen vectors $X_1=\begin{bmatrix}1\\2\\2\end{bmatrix};X_2=\begin{bmatrix}2\\1\\-2\end{bmatrix};X_3=\begin{bmatrix}2\\-2\\1\end{bmatrix}$ **(4M)** • $D=N^TAN=\begin{pmatrix}0&0&0\\0&3&0\\0&0&15\end{pmatrix}$ **(8M)** • Canonical form= $0y_1^2+3y_2^2+15y_3^2$ **(2 M)**	
21.	**Reduce the quadratic form $2x_1^2+5x_2^2+3x_3^2+4x_1x_2$ to a canonical form by orthogonal reduction. (May/June-2018 R-17) (16M)**BTL1 **Answer : Refer Page No.1.113-Dr.M.CHANDRASEKAR**	

	• The Eigen values are $\lambda=1,3,6$ **(2 M)** • Eigen vectors $X_1=\begin{bmatrix}2\\-1\\0\end{bmatrix}; X_2=\begin{bmatrix}0\\0\\1\end{bmatrix}; X_3=\begin{bmatrix}1\\2\\0\end{bmatrix}$ **(4M)** • $D=N^TAN=\begin{pmatrix}1&0&0\\0&3&0\\0&0&6\end{pmatrix}$ **(8M)** • Canonical form= $1y_1^2+3y_2^2+6y_3^2$ **(2 M)**	
22.	**Reduce the quadratic form $x_1^2+2x_2^2+x_3^2+2x_2x_3-2x_1x_2$ to a canonical form through orthogonal transformation and hence show that it is positive semi-definite. Also give a non-zero set of values (x_1,x_2,x_3) which makes this quadratic form zero (16M)** BTL1 **Answer : Refer Page No.1.121-Dr.M.CHANDRASEKAR** • The Eigen values are $\lambda=0,1,3$ **(2 M)** • Eigen vectors $X_1=\begin{bmatrix}1\\1\\-1\end{bmatrix}; X_2=\begin{bmatrix}1\\0\\1\end{bmatrix} X_3=\begin{bmatrix}-1\\2\\1\end{bmatrix}$ **(4M)** • $D=N^TAN=\begin{pmatrix}0&0&0\\0&1&0\\0&0&3\end{pmatrix}$ **(6M)** • Canonical form= $0y_1^2+1y_2^2+3y_3^2$ **(2 M)** • $x_1=1, x_2=1, x_3=-1$ which makes Q.F is zero **(1 M)** • For proving Positive Semi definite **(1 M)**	
	UNIT-IIVECTOR CALCULUS	
	Gradient and directional derivative – Divergence and curl – Vector identities – Irrotational and Solenoidal vector fields – Line integral over a plane curve – Surface integral – Area of a curved surface – Volume integral – Green's, Gauss divergence and Stokes theorems – Verification and application in evaluating line, surface and volume integrals.	
	PART-A	
1	**State Stokes theorem. (DEC/JAN-2015)** BTL1 The surface integral of the normal component of the curl of a vector point function $\vec{F}$ over an open surface 'S' is equal to the line integral of the tangential component of $\vec{F}$ around the	

	closed curve 'C' bounding 'S' $\int_C \overrightarrow{F}.\overrightarrow{dr} = \iint_S (\nabla \times \overrightarrow{F}).\hat{n}\, ds$	
2	**State Gauss divergence theorem**. **(DEC/JAN-2013) (NOV/DEC-2015)**BTL1 The surface integral of the normal component of a vector function $\vec{F}$ over a closed surface S enclosing volume V is equal to the volume integral of the divergence of $\vec{F}$ taken throughout the volume V $\iint_S \overrightarrow{F}.\hat{n}\, ds = \iiint_V \nabla.\overrightarrow{F} dv$	
3	**State Green's theorem**. **(DEC/JAN-2009) (NOV/DEC-2010)**BTL1 If $u, v, \frac{\partial u}{\partial y}, \frac{\partial v}{\partial x}$ are continuous and single valued functions in the region R enclosed by the curve C, then $\int_C udx + vdy = \iint_R \left(\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}\right) dxdy$	
4	**Find curl $\vec{F}$ if $\vec{F} = xy\vec{i} + yz\vec{j} + zx\vec{k}$.**BTL1 $curl\, \vec{F} = \nabla \times \vec{F}$ $= \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ \partial/\partial x & \partial/\partial y & \partial/\partial z \\ xy & yz & zx \end{vmatrix} = \vec{i}(0 - y) - \vec{j}(z - 0) + \vec{k}(0 - x)$ $= -y\vec{i} - z\vec{j} - x\vec{k} = -(y\vec{i} + z\vec{j} + x\vec{k})$	
5	**Prove that $\vec{F} = yz\vec{i} + zx\vec{j} + xy\vec{k}$ is irrotational.**BTL5 $\nabla \times \vec{F} = \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ \partial/\partial x & \partial/\partial y & \partial/\partial z \\ yz & zx & xy \end{vmatrix} = \sum \vec{i}\left[\frac{\partial}{\partial y}(xy) - \frac{\partial}{\partial z}(zx)\right]$ $= \sum \vec{i}\,[x - x] = 0\vec{i} + 0\vec{j} + 0\vec{k} = \vec{0}$. Hence, $\vec{F}$ is irrotational.	
6	**Is the position vector $\vec{r} = x\vec{i} + y\vec{j} + z\vec{k}$ irrotational? Justify. (DEC/JAN-2016)** BTL5 $\nabla \times \vec{r} = \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ \partial/\partial x & \partial/\partial y & \partial/\partial z \\ x & y & z \end{vmatrix}$ $= \vec{i}\left[\frac{\partial}{\partial y}(z) - \frac{\partial}{\partial z}(y)\right] - \vec{j}\left[\frac{\partial}{\partial x}(z) - \frac{\partial}{\partial z}(x)\right] + \vec{k}\left[\frac{\partial}{\partial x}(y) - \frac{\partial}{\partial y}(x)\right]$ $= 0\vec{i} + 0\vec{j} + 0\vec{k} = \vec{0}$. Hence, $\vec{r}$ is irrotational.	

7	**Prove that $3x^2y\vec{i} + (yz - 3xy^2)\vec{j} - \frac{z^2}{2}\vec{k}$ is a solenoidal.** BTL5 $$\nabla.\vec{F} = \frac{\partial}{\partial x}(3x^2y) + \frac{\partial}{\partial y}(yz - 3xy^2) + \frac{\partial}{\partial z}\left(-\frac{z^2}{2}\right)$$ $$= (6xy) + (z - 6xy) + (\frac{-2z}{2}) = 0$$ $\therefore\ \vec{F}$ is Solenoidal.
8	**Show that $\vec{F} = (y^2 - z^2 + 3yz - 2x)\vec{i} + (3xz + 2xy)\vec{j} + (3xy - 2xz + 2z)\vec{k}$ is both solenoidal and irrotational.** BTL2 $$\nabla.\vec{F} = \frac{\partial}{\partial x}(y^2 - z^2 + 3yz - 2x) + \frac{\partial}{\partial y}(3xz + 2xy) + \frac{\partial}{\partial z}(3xy - 2xz + 2z)$$ $$= (-2) + (2x) + (-2x + 2)$$ $$= 0$$ $\therefore\ \vec{F}$ is Solenoidal. $$\nabla \times \vec{F} = \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ \partial/\partial x & \partial/\partial y & \partial/\partial z \\ y^2 - z^2 + 3yz - 2x & 3xz + 2xy & 3xy - 2xz + 2z \end{vmatrix}$$ $$= \vec{i}\left[\frac{\partial}{\partial y}(3xy - 2xz + 2z) - \frac{\partial}{\partial z}(3xz + 2xy)\right]$$ $$-\vec{j}\left[\frac{\partial}{\partial x}(3xy - 2xz + 2z) - \frac{\partial}{\partial z}(y^2 - z^2 + 3yz - 2x)\right]$$ $$+\vec{k}\left[\frac{\partial}{\partial x}(3xz + 2xy) - \frac{\partial}{\partial y}(y^2 - z^2 + 3yz - 2x)\right]$$ $$= [3x - 3x]\vec{i} - [(3y - 2z) - (-2z + 3y)]\vec{j} + [(3z + 2y) - (2y + 3z)]\vec{k}$$ $$\nabla \times \vec{F} = 0\vec{i} + 0\vec{j} + 0\vec{k} = \vec{0}$$ Hence, $\vec{F}$ is irrotational.
9	**Find α such that $\vec{F} = (3x - 2y + z)\vec{i} + (4x + \alpha y - z)\vec{j} + (x - y + 2z)\vec{k}$ is solenoidal.** BTL1 Given $\nabla.\vec{F} = 0$ $$\frac{\partial}{\partial x}(3x - 2y + z) + \frac{\partial}{\partial y}(4x + \alpha y - z) + \frac{\partial}{\partial z}(x - y + 2z) = 0$$ $$3 + \alpha + 2 = 0$$ $$\alpha + 5 = 0 \therefore \alpha = -5$$
10	**Find the constants a, b, c so that $\vec{F} = (x + 2y + az)\vec{i} + (bx - 3y - z)\vec{j} + (4x + cy + 2z)\vec{k}$ is irrotational.(DEC/JAN-2012) (May/June-2018 R-17)** BTL1 $$\nabla \times \vec{F} = \vec{0}$$

	$$\begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ \partial/\partial x & \partial/\partial y & \partial/\partial z \\ x+2y+az & bx-3y-z & 4x+cy+2z \end{vmatrix} = \vec{0}$$ $$\vec{i}[c+1]-\vec{j}[4-a]+\vec{k}[b-2]=0\vec{i}-0\vec{j}+0\vec{k}$$ i.e., $c+1=0, 4-a=0, b-2=0$ $$\therefore \boldsymbol{c=-1, a=4, b=2}$$	
11	**Prove that div $\vec{r}=3$ and curl $\vec{r}=\vec{0}$.(DEC/JAN-2016) (NOV/DEC-2010)** BTL5 $$\vec{r}=x\vec{i}+y\vec{j}+z\vec{k}$$ $$\nabla.\vec{r}=\frac{\partial}{\partial x}(x)+\frac{\partial}{\partial y}(y)+\frac{\partial}{\partial z}(z)=1+1+1=3$$ $$\nabla\times\vec{r}=\begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ \partial/\partial x & \partial/\partial y & \partial/\partial z \\ x & y & z \end{vmatrix}$$ $$=\vec{i}\left[\frac{\partial}{\partial y}(z)-\frac{\partial}{\partial z}(y)\right]-\vec{j}\left[\frac{\partial}{\partial x}(z)-\frac{\partial}{\partial z}(x)\right]+\vec{k}\left[\frac{\partial}{\partial x}(y)-\frac{\partial}{\partial y}(x)\right]$$ $$\boldsymbol{=0\vec{i}+0\vec{j}+0\vec{k}=\vec{0}}$$	
12	**Prove that curl $(\mathbf{grad}\ \emptyset)=\vec{0}$. (NOV/DEC-2008)** BTL5 $$grad\ \emptyset=\nabla\emptyset$$ $$=\vec{i}\frac{\partial\emptyset}{\partial x}+\vec{j}\frac{\partial\emptyset}{\partial y}+\vec{k}\frac{\partial\emptyset}{\partial z}$$ $$curl\ (grad\ \emptyset)=\nabla\times(\nabla\emptyset)$$ $$=\begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ \partial/\partial x & \partial/\partial y & \partial/\partial z \\ \frac{\partial\emptyset}{\partial x} & \frac{\partial\emptyset}{\partial y} & \frac{\partial\emptyset}{\partial z} \end{vmatrix}$$ $$=\sum\vec{i}\left[\frac{\partial^2\emptyset}{\partial y\partial z}-\frac{\partial^2\emptyset}{\partial z\partial y}\right]$$ $$=\sum\overrightarrow{i[0]}\ (Since\ mixed\ partial\ derivatives\ are\ equal)$$ $$=0\vec{i}+0\vec{j}+0\vec{k}=\vec{0}$$	
13	**In what direction from $(3,1,-2)$ is the directional derivative of $\emptyset=x^2y^2z^4$ maximum? Find also the magnitude of this maximum.** BTL1 $$\nabla\emptyset=\vec{i}\frac{\partial\emptyset}{\partial x}+\vec{j}\frac{\partial\emptyset}{\partial y}+\vec{k}\frac{\partial\emptyset}{\partial z}$$ $$=\vec{i}[2xy^2z^4]+\vec{j}[2x^2yz^4]+\vec{k}[4x^2y^2z^3]$$ $$\nabla\varphi_{(3,1,-2)}=\vec{i}\left[2(3)(1)(16)\right]+\vec{j}\left[2(9)(1)(16)\right]+\vec{k}\left[4(9)(1)(-8)\right]$$	

	$=96\vec{i}+288\vec{j}-288\vec{k}$ $=96\left(\vec{i}+3\vec{j}-3\vec{k}\right)$ The directional derivative is maximum in the direction of $96\left(\vec{i}+3\vec{j}-3\vec{k}\right)$ Maximum value is $\lvert\nabla\varphi\rvert=\left\lvert 96\left(\vec{i}+3\vec{j}-3\vec{k}\right)\right\rvert$ $=\sqrt{92^2(1+9+9)}$ $=96\sqrt{19}$	
14	**Find the unit vector normal to the surface $\mathbf{x^2+y^2=z}$ at $(\mathbf{1},\mathbf{-2},\mathbf{5})$.**BTL1 Given $\phi=x^2+y^2-z$ Unit normal vector $\hat{n}=\dfrac{\nabla\phi}{\lvert\nabla\phi\rvert}$ ………… (1) $\nabla\phi=\vec{i}\dfrac{\partial\phi}{\partial x}+\vec{j}\dfrac{\partial\phi}{\partial y}+\vec{k}\dfrac{\partial\phi}{\partial z}$ $=\vec{i}[2x]+\vec{j}[2y]+\vec{k}[-1]$ $\nabla\phi_{(1,-2,5)}=\vec{i}[2]+\vec{j}[-4]+\vec{k}[-1]$ $=2\vec{i}-4\vec{j}-\vec{k}$ $\lvert\nabla\phi\rvert=\sqrt{2^2+(-4)^2+(-1)^2}$ $=\sqrt{4+16+1}=\sqrt{21}$ $\therefore(1)\Rightarrow\hat{n}=\dfrac{2\vec{i}-4\vec{j}-\vec{k}}{\sqrt{21}}$	
15	**Find the greatest rate of increase of $\boldsymbol{\emptyset=xyz^2}$ at $(\mathbf{1},\mathbf{0},\mathbf{3})$.** BTL1 $\nabla\emptyset=\vec{i}\dfrac{\partial\emptyset}{\partial x}+\vec{j}\dfrac{\partial\emptyset}{\partial y}+\vec{k}\dfrac{\partial\emptyset}{\partial z}$ $=\vec{i}[yz^2]+\vec{j}[xz^2]+\vec{k}[2xyz]$ $\nabla\emptyset_{(1,0,3)}=0\vec{i}+9\vec{j}+0\vec{k}$ ∴ Greatest rate of increase$=\lvert\boldsymbol{\nabla\emptyset}\rvert=\sqrt{\mathbf{9^2}}=\mathbf{9}$	
16	**State the physical interpretation of the line integral. $\int_A^B\vec{F}.\overrightarrow{dr}$** . BTL1 Physically $\int_A^B\vec{F}.\overrightarrow{dr}$ denotes the total work done by the force$\vec{F}$, in displacing a particle from A to B along the curve C.	
17	**Define Solenoidal vector function. If $\vec{V}=(x+3y)\vec{i}+(y-2z)\vec{j}+(x+2\lambda z)\vec{k}$ is Solenoidal, find the value of λ.**BTL1 If div$\vec{F}$= 0, then $\vec{F}$ is said to be Solenoidal vector. $\nabla.\vec{F}=0$.	

	$\nabla.\vec{V}=\frac{\partial}{\partial x}(x+3y)+\frac{\partial}{\partial y}(y-2z)+\frac{\partial}{\partial z}(x+2\lambda z)$ $=1+1+2\lambda$ $=2+2\lambda$ $\nabla.\vec{V}=0$ $2+2\lambda=0$ $\lambda=-1$	
18	**Find grad$(\mathbf{r^n})$where $\vec{\mathbf{r}}=\mathbf{x\vec{i}+y\vec{j}+z\vec{k}}$and** $r=\lvert\vec{r}\rvert$**.**BTL1 We know that $\frac{\partial r}{\partial x}=\frac{x}{r}$, $\frac{\partial r}{\partial y}=\frac{y}{r}$, $\frac{\partial r}{\partial z}=\frac{z}{r}$ $grad\left(r^n\right)=\sum\vec{i}\frac{\partial r^n}{\partial x}$ $=\sum\vec{i}(nr^{n-1})\frac{\partial r}{\partial x}$ $=(nr^{n-2})\vec{r}$	
19	**Find grad$(\mathbf{r})$ and grad $(\frac{\mathbf{1}}{\mathbf{r}})$ where** $\vec{r}=x\vec{i}+y\vec{j}+z\vec{k}$ **and** $r=\lvert\vec{r}\rvert$. BTL1 $\nabla\phi=\Sigma\vec{i}\frac{\partial\phi}{\partial x}=\frac{\Sigma x\vec{i}}{r}$ $=\frac{\vec{r}}{r}$ $grad(\frac{1}{r})=\Sigma\vec{i}\frac{\partial\left(\frac{1}{r}\right)}{\partial x}=\left(-\frac{1}{r^2}\right)\frac{\Sigma x\vec{i}}{r}$ $=\frac{-\vec{r}}{r^3}$	
20	**Find the unit normal to the surface** $x^2+xy+z^2=4$ at $(1,-1,2)$**.**BTL1	

	$\hat{n} = \frac{\nabla\phi}{\vert\nabla\phi\vert}$ $\nabla\phi = \Sigma\vec{i}\frac{\partial\phi}{\partial x}$ $Given:$ $x^2 + xy + z^2 = 4 \;\; Point(1,-1,2)$ $\nabla\phi = \vec{i} + \vec{j} + 4\vec{k}$ $\vert\nabla\phi\vert = \sqrt{1+1+16} = \sqrt{18}$ $\hat{n} = \frac{\vec{i}+\vec{j}+4\vec{k}}{3\sqrt{2}}$	
21	**Prove by Green's theorem that the area bounded by a simple closed curve is** $\frac{1}{2}\int_c (xdy - ydx)$ BTL5 By Green's theorem: $\int_C udx + vdy = \iint_R \left(\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}\right)dxdy$ $u = \frac{-y}{2}, \text{v} = \frac{v}{2} \Rightarrow \frac{\partial u}{\partial y} = \frac{-1}{2}, \frac{\partial v}{\partial x} = \frac{1}{2}$ Given that $\frac{1}{2}\int_C xdy - ydx = \iint_R \left(\frac{1}{2} + \frac{1}{2}\right)dxdy$ $= \iint_R dxdy.$ which a area bounded by a simple closed curve $'c'$	
22	**Find** $\nabla\left[\nabla.\left(\left(x^2 - yz\right)\vec{i} + \left(y^2 - xz\right)\vec{j} + \left(z^2 - xy\right)\vec{k}\right)\right]$ **at the point (1,-1,2).**BTL1 $\nabla.\vec{F} = \frac{\partial}{\partial x}(x^2 - yz) + \frac{\partial}{\partial y}(\text{y}^2 - xz) + \frac{\partial}{\partial z}(\text{z}^2 - xy)$ $= 2x + 2y + 2z$ $\nabla.\vec{F}_{(1,-1,2)} = 2 - 2 + 4$ $= 4$ $Grad(\nabla.\vec{F}) = \nabla(\nabla.\vec{F})$ $= \vec{i}\frac{\partial}{\partial x}(2x) + \vec{j}\frac{\partial}{\partial y}(2y) + \vec{k}\frac{\partial}{\partial z}(2z)$ $= 2\vec{i} + 2\vec{j} + 2\vec{k}$	
23	**Find the directional directive of** $\phi(\text{x,y,z}) = \text{xy}^2 + yz^2$ **at the point (2,-1,1) in the direction**	

	of the vector $\vec{i}+2\vec{j}+3\vec{k}$ **.(DEC/JAN-2014)**BTL1 Directional derivative(D.D)= $\nabla\phi.\dfrac{\vec{a}}{\lvert\vec{a}\rvert}$ $Given:$ $\phi(x,y,z)=xy^2+z^2y,\quad \vec{a}=\vec{i}+2\vec{j}+3\vec{k}$ $\nabla\phi_{(1,-1,2)}=\vec{i}+2\vec{j}+4\vec{k},\quad \lvert\vec{a}\rvert=\sqrt{14}$ $D.D=(\vec{i}+2\vec{j}+4\vec{k}).\dfrac{(\vec{i}+2\vec{j}+3\vec{k})}{\sqrt{14}}$ $=\dfrac{17}{\sqrt{14}}.$	
24	**If** $\vec{F}$ **is irrotational and C is closed curve then find the value of** $\int_c \vec{F}.d\vec{r}$ **.** BTL1 By Stokes theorem $\int_c \vec{F}.d\vec{r}=\iint_s\left(\nabla \times \vec{F}\right).\hat{n}ds$ Since $\vec{F}$ is irrotational $\therefore \nabla \times \vec{F}=0$ $\int_c \vec{F}.d\vec{r}=\iint_s\left(\nabla \times \vec{F}\right).\hat{n}ds$ $=\iint_s 0.\hat{n}ds$ $=0$	
25	**Prove that** $\nabla(\log r)=\dfrac{\vec{r}}{r^2}$. **(NOV/DEC-2014)**.BTL5 we have $\vec{r}=x\vec{i}+y\vec{j}+z\vec{k}$ *and* $r=\lvert\vec{r}\rvert=\sqrt{x^2+y^2+z^2}$ $r^2=x^2+y^2+z^2,\ \dfrac{\partial r}{\partial x}=\dfrac{x}{r},\ \dfrac{\partial r}{\partial y}=\dfrac{y}{r},\ \dfrac{\partial r}{\partial z}=\dfrac{z}{r}$ $\nabla(\log r)=\vec{i}\,\dfrac{\partial(\log r)}{\partial x}+\vec{j}\,\dfrac{\partial(\log r)}{\partial y}+\vec{k}\,\dfrac{\partial(\log r)}{\partial z}$ $=\vec{i}\left(\dfrac{1}{r}\dfrac{\partial r}{\partial x}\right)+\vec{j}\left(\dfrac{1}{r}\dfrac{\partial r}{\partial y}\right)+\vec{k}\left(\dfrac{1}{r}\dfrac{\partial r}{\partial z}\right)$ $=\dfrac{1}{r}\left[\dfrac{x}{r}\vec{i}+\dfrac{y}{r}\vec{j}+\dfrac{z}{r}\vec{k}\right]$ $=\dfrac{1}{r^2}\left[x\vec{i}+y\vec{j}+z\vec{k}\right]=\dfrac{\vec{r}}{r^2}$	
26	**If** $\vec{F}=(x^3)\vec{i}+(y^3)\vec{j}+(z^3)\vec{k}$ **then find div curl** $\vec{F}$. **(May/June-2018 R-17)**BTL1	

	$\nabla\times\vec{F}=\begin{vmatrix}\vec{i} & \vec{j} & \vec{k}\\ \partial/\partial x & \partial/\partial y & \partial/\partial z\\ x^3 & y^3 & z^3\end{vmatrix}=0$ Therefore **div curl** $\vec{F}=0$	
	PART-B	
1.	**Prove that** $\nabla(r^n)=\mathrm{n}r^{n-2}\,\vec{r}$. **(May/June 2003,2008) (8 M)** BTL5 **Answer : Refer Page No.2.5-Dr.M.CHANDRASEKAR** • $\frac{\partial r}{\partial x}=\frac{x}{r},\ \frac{\partial r}{\partial y}=\frac{y}{r},\ \frac{\partial r}{\partial z}=\frac{z}{r}$ **.(2 M)** • $\nabla(r^n)\ =\vec{i}\left(nr^{n-1}\frac{\partial r}{\partial x}\right)+\vec{j}\left(nr^{n-1}\frac{\partial r}{\partial y}\right)+\vec{k}\left(nr^{n-1}\frac{\partial r}{\partial z}\right)$ **(2 M)** • $\nabla(r^n)\ =\frac{nr^{n-1}}{r}\left[x\vec{i}+y\vec{j}+z\vec{k}\right]=nr^{n-2}\vec{r}$ **(4M)**	
2.	**Prove that** $\mathrm{Curl}\,(\mathrm{Curl}\,\vec{\mathrm{F}})=\nabla(div\,\vec{\mathrm{F}})-\nabla^2\,\vec{\mathrm{F}}$ **. (May/June 2003,2008) (8 M)** BTL5 **Answer : Refer Page No.2.36-Dr.M.CHANDRASEKAR** • $\nabla\times(\nabla\times\vec{F})=\begin{vmatrix}\vec{i} & \vec{j} & \vec{k}\\ \partial/\partial x & \partial/\partial y & \partial/\partial z\\ \frac{\partial F_3}{\partial y}-\frac{\partial F_2}{\partial z} & \frac{\partial F_1}{\partial z}-\frac{\partial F_3}{\partial x} & \frac{\partial F_2}{\partial x}-\frac{\partial F_1}{\partial y}\end{vmatrix}$ **(3M)** • $\nabla\times(\nabla\times\vec{F})=\sum\left\{\frac{\partial}{\partial x}(div\,\vec{\mathrm{F}})-\nabla^2\,\mathrm{F}_1\right\}\vec{i}$ **(3M)** • For proving $\mathrm{Curl}\,(\mathrm{Curl}\,\vec{\mathrm{F}})=\nabla(div\,\vec{\mathrm{F}})-\nabla^2\,\vec{\mathrm{F}}$ **(2M)**	
3.	**Prove that** $\vec{\mathrm{F}}=(y^2\cos x+\mathrm{z}^3)\,\vec{\mathrm{i}}+(2y\sin x-4)\,\vec{j}+3xz^2\,\vec{\mathrm{k}}$ **is irrotational and find its scalar potential. (8 M)**BTL5 **Answer : Refer Page No.2.33-Dr.M.CHANDRASEKAR**	

	• $\nabla\times\vec{F}=\begin{vmatrix}\vec{i} & \vec{j} & \vec{k}\\ \partial/\partial x & \partial/\partial y & \partial/\partial z\\ y^2\cos x+z^3 & 2y\sin x-4 & 3xz^2\end{vmatrix}=0$ **(2 M)** $\phi_1=y^2\sin x+xz^3+f(y,z)$ • $\phi_2=y^2\sin x-4y+f(x,z)$ **(4M)** $\phi_3=xz^3+f(x,y)$ • $\phi=y^2\sin x+xz^3-4y+c$ **.(2M)**	
4.	**Prove that** $\vec{F}=(6xy+z^3)\,\vec{i}+(3x^2-z)\,\vec{j}+(3xz^2-y)\,\vec{k}$ **is irrotational and find its scalar potential.(NOV/DEC 2015,R-13)(8 M)** BTL5 **Answer : Refer Page No.2.32-Dr.M.CHANDRASEKAR** • $\nabla\times\vec{F}=\begin{vmatrix}\vec{i} & \vec{j} & \vec{k}\\ \partial/\partial x & \partial/\partial y & \partial/\partial z\\ (6xy+z^3) & (3x^2-z) & (3xz^2-y)\end{vmatrix}=0$ **(2 M)** $\phi_1=3x^2y+xz^3+f(y,z)$ • $\phi_2=3x^2y-yz+f(x,z)$ **(4M)** $\phi_3=xz^3-yz+f(x,y)$ • $\phi=3x^2y+xz^3-yz+c$ **(2M)**	
5.	**Prove that** $\vec{F}=(y^2+2xz^2)\,\vec{i}+(2xy-z)\,\vec{j}+(2zx^2-y+2z)\,\vec{k}$ **is irrotational and find its scalar potential. (8 M)** BTL5 **Answer : Refer Page No.2.47-Dr.M.CHANDRASEKAR** • $\nabla\times\vec{F}=\begin{vmatrix}\vec{i} & \vec{j} & \vec{k}\\ \partial/\partial x & \partial/\partial y & \partial/\partial z\\ (y^2+2xz^2) & (2xy-z) & (2zx^2-y+2z)\end{vmatrix}=0$ **(2 M)** $\phi_1=xy^2+x^2z^2+f(y,z)$ • $\phi_2=xy^2-yz+f(x,z)$ **(4M)** $\phi_3=x^2z^2+xy^2-yz+f(x,y)$ • $\phi=x^2z^2+xy^2-yz+c$ **(2M)**	
6.	**Prove that** $\vec{F}=(y+z)\,\vec{i}+(z+x)\,\vec{j}+(x+y)\,\vec{k}$ **is irrotational and find its scalar potential. (8 M)** BTL5	

	Answer : Refer Page No.2.46-Dr.M.CHANDRASEKAR • $\nabla\times\vec{F}=\begin{vmatrix}\vec{i} & \vec{j} & \vec{k}\\ \partial/\partial x & \partial/\partial y & \partial/\partial z\\ (y+z) & (z+x) & (x+y)\end{vmatrix}=0$ **(2 M)** • $\phi_1=xy+xz+f(y,z)$ $\phi_2=xy+yz+f(x,z)$ **(4M)** $\phi_3=xz+yz+f(x,y)$ • $\phi=xz+xy+yz+c$ **(2M)**
7.	**Evaluate by Green's theorem** $\int_C(xy+x^2)dx+(x^2+y^2)dy$ **where C is the square formed by** $x=-1,x=1,y=-1,y=1$ **(May/June 2016 R-13) (8 M)**BTL1 **Answer : Refer Page No.2.75-Dr.M.CHANDRASEKAR** • $\int_C udx+vdy=\iint_R\left(\frac{\partial v}{\partial x}-\frac{\partial u}{\partial y}\right)dxdy$ $u=xy+x^2,\mathrm{v}=x^2+y^2\Rightarrow\frac{\partial u}{\partial y}=x,\frac{\partial v}{\partial x}=2x$ **(4M)** • $\int_C(xy+x^2)dx+(x^2+y^2)dy=\int_{-1}^{1}\int_{-1}^{1}x\,dx\,dy$ **(2M)** • $\int_C(xy+x^2)dx+(x^2+y^2)dy=0$ **(2M)**
8.	**Verify Green's theorem** $\int_C(xy+y^2)dx+(x^2)dy$ **where C is the closed curve of the region bounded by** $y=x$ and $y=x^2$ **(May/June 2013 R-13) (8 M)** BTL3 **Answer : Refer Page No.2.78-Dr.M.CHANDRASEKAR** • $\int_C udx+vdy=\iint_R\left(\frac{\partial v}{\partial x}-\frac{\partial u}{\partial y}\right)dxdy$ $u=xy+y^2,\mathrm{v}=x^2\Rightarrow\frac{\partial u}{\partial y}=x+2y,\frac{\partial v}{\partial x}=2x$ **(2M)** • $\iint_R\left(\frac{\partial v}{\partial x}-\frac{\partial u}{\partial y}\right)dxdy=\int_0^1\int_y^{\sqrt{y}}(x-2y)dx\,dy=\frac{-1}{20}$ **(2M)**

	• $\int_C (xy+y^2)dx+(x^2)dy = \text{Along OA} + \text{Along AO} = \int_0^1 (x^4+3x^3)dx + \int_1^0 (3x^2)dx$ **(2M)** • $\int_C (xy+y^2)dx+(x^2)dy = \frac{19}{20}-1 = \frac{-1}{20}$ **(2M)**	
9.	**Verify Green's theorem** $\int_C (x^2-xy^3)dx+(y^2-2xy)dy$ **where C is the square with vertices (0,0),(2,0),(2,2),(0,2) (May/June 2003) (8 M)** BTL3 **Answer : Refer Page No.2.80-Dr.M.CHANDRASEKAR** • $\int_C udx+vdy = \iint_R \left(\frac{\partial v}{\partial x}-\frac{\partial u}{\partial y}\right)dxdy$ $u = x^2-xy^3, v = y^2-2xy \Rightarrow \frac{\partial u}{\partial y} = -3xy^2, \frac{\partial v}{\partial x} = -2y$ **(2M)** • $\iint_R \left(\frac{\partial v}{\partial x}-\frac{\partial u}{\partial y}\right)dxdy = \int_0^2\int_0^2 (3xy^2-2y)dx\,dy = 8$ **(2M)** • $\int_C (x^2-xy^3)dx+(y^2-2xy)dy = \text{Along OA} + \text{Along AB} + \text{Along BC} + \text{Along CO}$ $= \int_0^2 (x^2)dx + \int_0^2 (y^2-4y)dy + \int_2^0 (x^2-8x)dx + \int_2^0 (y^2)dy$ **(2M)** • $\int_C (x^2-xy^3)dx+(y^2-2xy)dy = \frac{8}{3}-\frac{16}{3}+\frac{40}{3}-\frac{8}{3} = 8$ **(2M)**	
10.	**Evaluate by Green's theorem** $\int_C (y-\sin x)dx+(\cos x)dy$ **where C is the triangle OAB where** $\mathbf{O} = (\mathbf{0},\mathbf{0}), A = \left(\frac{\pi}{2},0\right), B = \left(\frac{\pi}{2},1\right)$ **(May/June 2015 R-13) (8 M)** BTL3 **Answer : Refer Page No.2.82-Dr.M.CHANDRASEKAR** • $\int_C udx+vdy = \iint_R \left(\frac{\partial v}{\partial x}-\frac{\partial u}{\partial y}\right)dxdy$ $u = y-\sin x, v = \cos x \Rightarrow \frac{\partial u}{\partial y} = 1, \frac{\partial v}{\partial x} = -\sin x$ **(4M)** • $\int_C (y-\sin x)dx+(\cos x)dy = \int_0^{\frac{\pi}{2}}\int_0^{\frac{2x}{\pi}} (-\sin x-1)\,dx\,dy$ **(2M)**	

	• $\int_C (y-\sin x)dx+(\cos x)dy = -\left(\frac{\pi^2+8}{4\pi}\right)$ **(2M)**	
11.	**Apply Green's theorem to evaluate** $\int_C (3x^2-8y^2)dx+(4\,\mathrm{y}-6\,\mathrm{xy})dy$ **where C is the boundary of the region defined by x=0,y=0 and x+y=1 (NOV/DEC 2014 R-13) (8 M)** BTL3 **Answer : Refer Page No.2.83-Dr.M.CHANDRASEKAR** • $\int_C udx+vdy = \iint_R \left(\frac{\partial v}{\partial x}-\frac{\partial u}{\partial y}\right)dxdy$ **(4M)** $u=-8y^2+3x^2, \mathrm{v}=4y-6xy \Rightarrow \frac{\partial u}{\partial y}=-16y, \frac{\partial v}{\partial x}=-6y$ • $\int_C (3x^2-8y^2)dx+(4\,\mathrm{y}-6\,\mathrm{xy})dy = \int_0^1\int_0^{1-y} 10y\,dx\,dy$ **(2M)** • $\int_C (3x^2-8y^2)dx+(4\,\mathrm{y}-6\,\mathrm{xy})dy = \frac{5}{3}$ **(2M)**	
12.	**Verify Gauss Divergence theorem** $\vec{\mathrm{F}}= xy^2\vec{i}+yz^2\vec{j}+zx^2\vec{k}$ over **the region bounded by** $x=0, x=1, y=0, y=2, z=0, z=3$ **(May/June 2012 R-08)(16 M)** BTL3 **Answer : Refer Page No.2.96-Dr.M.CHANDRASEKAR** • $\iint_S \vec{F}.\hat{n}\,ds = \iiint_V \nabla.\vec{F}dv$ **(2M)** • $\nabla.\vec{F} = y^2+x^2+z^2$ **(2M)** • $\iiint_V \nabla.\vec{F}dv = \int_0^3\int_0^2\int_0^1 (y^2+x^2+z^2)dxdydz = 28$ **(4M)** • $\iint_S \vec{F}.\hat{n}\,ds = 8+0+18+0+2+0=28$ **(8M)**	
13.	**Verify Gauss Divergence theorem** $\vec{\mathrm{F}}=(x^2-yz)\vec{i}+(y^2-zx)\vec{j}+(z^2-xy)\vec{k}$ over **the rectangular Parallelopiped** $0\le x\le a,\ 0\le y\le b,\ 0\le z\le c$ **(May/June 2009 R-08) (16 M)**BTL3 **Answer : Refer Page No.2.99-Dr.M.CHANDRASEKAR** • $\iint_S \vec{F}.\hat{n}\,ds = \iiint_V \nabla.\vec{F}dv$ **(2M)**	

	• $\nabla.\vec{F} = 2x+2y+2z$ **(2M)** • $\iiint_V \nabla.\vec{F}dv = 2\int_0^c\int_0^b\int_0^a (x+y+z)dxdydz = abc(\mathrm{a+b+c})$ **(4M)** $\iint_S \vec{F}.\hat{n}\,ds = \left(a^2bc - \frac{b^2c^2}{4}\right)+\left(\frac{b^2c^2}{4}\right)+\left(b^2ac-\frac{a^2c^2}{4}\right)$ • $+\left(\frac{a^2c^2}{4}\right)+\left(c^2ba-\frac{b^2a^2}{4}\right)+\left(\frac{b^2a^2}{4}\right)$ **(8M)** $\iint_S \vec{F}.\hat{n}\,ds = abc(\mathrm{a+b+c})$
14.	**Verify Gauss Divergence theorem for** $\vec{F}= x^3\vec{i}+y^3\vec{j}+z^3\vec{k}$ over **the cube bounded by** $x=0, x=a, y=0, y=a, z=0, z=a$ **(May/June 2014 R-13) (May/June-2018 R-17)(16 M)** BTL3 **Answer : Refer Page No.2.106-Dr.M.CHANDRASEKAR** • $\iint_S \vec{F}.\hat{n}\,ds = \iiint_V \nabla.\vec{F}dv$ **(2M)** • $\nabla.\vec{F} = 3y^2+3x^2+3z^2$ **(2M)** • $\iiint_V \nabla.\vec{F}dv = \int_0^a\int_0^a\int_0^a (3y^2+3x^2+3z^2)dxdydz = 3a^5$ **(4M)** • $\iint_S \vec{F}.\hat{n}\,ds = a^5+0+a^5+0+a^5+0 = 3a^5$ **(8M)**
15.	**Verify Gauss Divergence theorem for** $\vec{F}= 4xz\vec{i}-y^2\vec{j}+zy\vec{k}$ over **the region bounded by** $x=0, x=1, y=0, y=1, z=0, z=1$ **(May/June 2012 R-08) (16 M)** BTL3 **Answer : Refer Page No.2.109-Dr.M.CHANDRASEKAR** • $\iint_S \vec{F}.\hat{n}\,ds = \iiint_V \nabla.\vec{F}dv$ **(2M)** • $\nabla.\vec{F} = 4z-y$ **(2M)** • $\iiint_V \nabla.\vec{F}dv = \int_0^1\int_0^1\int_0^1 (4z-y)dxdydz = \frac{3}{2}$ **(4M)** • $\iint_S \vec{F}.\hat{n}\,ds = 2+0-1+0+\frac{1}{2}+0 = \frac{3}{2}$ **(8M)**
16.	**Verify Gauss Divergence theorem for** $\vec{F}= y\vec{i}+x\vec{j}+z^2\vec{k}$ over **the cylindrical region**

	bounded by $x^2+y^2=9, z=0$ and $z=2$ **(Dec/Jan 2015 R-13) (16 M)**BTL3 **Answer : Refer Page No.2.103-Dr.M.CHANDRASEKAR** • $\iint_S \vec{F}.\hat{n}\,ds = \iiint_V \nabla.\vec{F}dv$ **(2M)** • $\nabla.\vec{F}=2z$ **(2M)** • $\iiint_V \nabla.\vec{F}dv = \int_{-3}^{3}\int_{-\sqrt{9-x^2}}^{\sqrt{9-x^2}}\int_0^2 2z\ dxdydz = 36\pi$ **(4M)** • $\iint_S \vec{F}.\hat{n}\,ds = 0+36\pi+0=36\pi$ **(8M)**	
17.	**Verify Stokes theorem for** $\vec{F}=(x^2+y^2)\vec{i}-2xy\vec{j}$ **taken around the rectangle bounded by** $x=\pm a, y=0, y=b$ **(May/June 2004) (16 M)**BTL3 **Answer : Refer Page No.2.122-Dr.M.CHANDRASEKAR** • $\int_C \overrightarrow{F}.\overrightarrow{dr} = \iint_S (\nabla\times\overrightarrow{F}).\ \hat{n}\,ds$ **(2M)** • $\nabla\times\vec{F}=\begin{vmatrix}\vec{i} & \vec{j} & \vec{k}\\ \partial/\partial x & \partial/\partial y & \partial/\partial z\\ (x^2+y^2) & -2xy & 0\end{vmatrix}=-4y\vec{k}$ **(2M)** • $\iint_S (\nabla\times\overrightarrow{F}).\ \hat{n}\,ds = \int_0^b\int_{-a}^{a}(-4\,y)dxdy=-4ab^2$ **(4M)** • $\int_C \overrightarrow{F}.\overrightarrow{dr} = AB+BC+CD+DA=\left(\frac{2a^3}{3}\right)-\left(ab^2\right)-\left(2ab^2+\frac{2a^3}{3}\right)-\left(ab^2\right)=-4ab^2$ **(8 M)**	
18.	**Verify Stokes theorem for** $\vec{F}=(x^2-y^2)\vec{i}+2xy\vec{j}$ **taken around the rectangle bounded by** $x=0, x=a, y=0, y=b$ **(May/June 2004) (16 M)**BTL3 **Answer : Refer Page No.2.124-Dr.M.CHANDRASEKAR** • $\int_C \overrightarrow{F}.\overrightarrow{dr} = \iint_S (\nabla\times\overrightarrow{F}).\ \hat{n}\,ds$ **(2M)**	

	• $\nabla\times\vec{F}=\begin{vmatrix}\vec{i} & \vec{j} & \vec{k}\\ \partial/\partial x & \partial/\partial y & \partial/\partial z\\ (x^2-y^2) & 2xy & 0\end{vmatrix}=4y\vec{k}$ **(2M)** • $\iint_S(\nabla\times\overrightarrow{F}).\ \hat{n}\,ds=\int_0^b\int_0^a(4\,y)dxdy=2ab^2$ **(4M)** • $\int_C\overrightarrow{F}.\overrightarrow{dr}=OA+AB+BC+CO=\left(\frac{a^3}{3}\right)+\left(ab^2\right)+\left(ab^2-\frac{a^3}{3}\right)+\left(0\right)=2ab^2$ **(8 M)**
19.	**Verify Stokes theorem for** $\vec{F}=x^2\vec{i}+xy\vec{j}$ **integrated around the square in z=0 plane whose sides are along the lines** $x=0,x=a,y=0,y=a$ **(May/June 2008) (16 M)** BTL3 **Answer : Refer Page No.2.126-Dr.M.CHANDRASEKAR** • $\int_C\overrightarrow{F}.\overrightarrow{dr}=\iint_S(\nabla\times\overrightarrow{F}).\ \hat{n}\,ds$ **(2M)** • $\nabla\times\vec{F}=\begin{vmatrix}\vec{i} & \vec{j} & \vec{k}\\ \partial/\partial x & \partial/\partial y & \partial/\partial z\\ x^2 & xy & 0\end{vmatrix}=y\vec{k}$ **(2M)** • $\iint_S(\nabla\times\overrightarrow{F}).\ \hat{n}\,ds=\int_0^a\int_0^a(\,y)dxdy=\frac{a^3}{2}$ **(4M)** • $\int_C\overrightarrow{F}.\overrightarrow{dr}=OA+AB+BC+CO=\left(\frac{a^3}{3}\right)+\left(\frac{a^3}{2}\right)+\left(-\frac{a^3}{3}\right)=\left(\frac{a^3}{2}\right)$ **(8 M)**
20.	**Verify Stokes theorem for** $\vec{F}=(y-z+2)\vec{i}+(yz+4)\vec{j}-xz\vec{k}$ **where S is the open surface of the cube** $x=0,x=2,y=0,y=2,z=0,z=2$ **above the xy-plane (May/June 2005) (May/June-2018 R-17)(16 M)** BTL3 **Answer : Refer Page No.2.132-Dr.M.CHANDRASEKAR** • $\int_C\overrightarrow{F}.\overrightarrow{dr}=\iint_S(\nabla\times\overrightarrow{F}).\ \hat{n}\,ds$ **(2M)** • $\nabla\times\vec{F}=\begin{vmatrix}\vec{i} & \vec{j} & \vec{k}\\ \partial/\partial x & \partial/\partial y & \partial/\partial z\\ y-z+2 & yz+4 & -xz\end{vmatrix}=-y\vec{i}+(z-1)\vec{j}-\vec{k}$ **(2M)**

	• $\iint_S (\nabla\times\overrightarrow{F}).\hat{n}\,ds = (-4)+(4)+(4)+(-4)+(-4) = -4$ **(4M)** • $\int_C \overrightarrow{F}.\overrightarrow{dr} = OA+AC+CB+BO = (4)+(8)+(-8)+(-8) = (-4)$ **(8 M)**	
21.	**Using Stokes theorem to Evaluate** $\int_C \overrightarrow{F}.\overrightarrow{dr}$ **where** $\vec{F} = (y^2)\vec{i} + (x^2)\vec{j} - (x+z)\vec{k}$ **and C is the boundary of the triangle with vertices (0,0,0), (1,0,0) and (1,1,0) (8 M)**BTL3 **Answer : Refer Page No.2.137-Dr.M.CHANDRASEKAR** • $\int_C \overrightarrow{F}.\overrightarrow{dr} = \iint_S (\nabla\times\overrightarrow{F}).\hat{n}\,ds$ **(2M)** • $\nabla\times\vec{F} = \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ \partial/\partial x & \partial/\partial y & \partial/\partial z \\ y^2 & x^2 & -(x+z) \end{vmatrix} = \vec{j} + 2(x-y)\vec{k}$ **(2M)** • $\iint_S (\nabla\times\overrightarrow{F}).\hat{n}\,ds = \int_0^1\int_0^x 2(\mathrm{x}-\mathrm{y})\,dydx = \frac{1}{3}$ **(4M)**	
	UNIT-IIIANALYTIC FUNCTIONS	
	Analytic functions – Necessary and sufficient conditions for analyticity in Cartesian and polar coordinates – Properties – Harmonic conjugates – Construction of analytic function – Conformal mapping – Mapping by $w = z+c, cz, \frac{1}{z}, z^2$ – Bilinear transformation	
	PART-A	
1.	**Show that the function** $f(z) = \bar{z}$ **is no where differentiable. (DEC/JAN-2013) (NOV/DEC-2015)**BTL2 Given $w = f(z) = \bar{z}$ $\therefore u+iv = x-iy \Rightarrow u = x, v = -y$ $u_x = 1, v_x = 0$ $u_y = 1, v_y = -1$ $\therefore u_x \neq v_y$ So C-R equations are not satisfied for any x and y. $\therefore f(z)$ is not differentiable anywhere.Hence not analytic anywhere.	
2	**Test the analyticity of the function** $w = \sin z$.BTL4	

	$\text{Given } w=\sin z$ $u+iy=\sin(x+iy)$ $=\sin x\cos iy+\cos x\sin(iy)$ $=\sin x\cosh y+i\cos x\sinh y$ $\Rightarrow u=\sin x\cosh y\ ;\quad v=\cos x\sinh y$ $\therefore\ u_x=\cos x\cosh y;\quad v_x=-\sin x\sinh y$ $u_y=\sin x\sinh y\ ;\quad v_y=\cos x\cosh y$ $\therefore u_x=v_y,\quad u_y=-v_x$ So C-R equations are satisfied forall any x and y and $u_x, ,u_y, v_x,v_y$ are continuous $\therefore f(z)$ is analytic everywhere.	
3	**Find the constants a,b,c if** $f(z)=x+ay+i(bx+cy)$ **is analytic. (DEC/JAN-2014)** BTL1 Let $u+iv=f(z)$ Since $f(z)$ is analytic, u and v satisfy the C-R Equations. $u_x=v_y,\quad u_y=-v_x$ $here\, u=x+ay, v=bx+cy$ $u_x=1,\ v_x=b$ $u_y=a,\ v_y=c$ $\therefore u_x=v_y\Rightarrow c=1;$ $u_y=-v_x\Rightarrow a=-b$	
4	**Show that** $u=2x-x^3+3xy^2$ **is harmonic**BTL2 Given $u=2x-x^3+3xy^2$ $u_x=2-3x^2+3y^2; u_y=6xy$ $u_{xx}=-6x;\qquad u_{yy}=6x$ $\therefore u_{xx}+u_{yy}=-6x+6x=0.$ Therefore u is harmonic	
5	**Show that the function** $u=y+e^x\cos y$ **is harmonic.**BTL2 Given	

	$u = y + e^x \cos y$ $u_x = e^x \cos y, \ \ u_y = 1 + e^x(-\sin y)$ $u_{xx} = e^x \cos y, \ u_{yy} = -e^x \cos y$ $u_{xx} + u_{yy} = e^x \cos y - e^x \cos y = 0$ Therefore u is harmonic	
6	**Show that** $x^2 + iy^3$ **is not analytic anywhere.** BTL2 Let $u + iv = x^2 + iy^3$ $\therefore u = x^2, \quad v = y^3$ $u_x = 2x, \ v_x = 0$ $u_y = 0 \ , \ \ v_y = 3y^2$ $\therefore u_x \neq v_y, \ \ u_y = -v_x$ $\therefore$ The function is not analytic. But, when $x = 0, y = 0$ the C-R Equations are satisfied.	
7	**For the conformal mapping** $f(z) = z^2$, **find the scale factor at** $z = i$ .BTL1 Given $f(z) = z^2,$ $\therefore f'(z) = 2z$ Scale factor at $z = i$ is $\lvert f'(i) \rvert = \lvert 2i \rvert = 2$	
8	**Find the image of** $x = 2$ **under the transformation** $w = \frac{1}{z}$ .BTL1 Given $w = \frac{1}{z} \Rightarrow z = \frac{1}{w} = \frac{\overline{w}}{w\overline{w}}$ $\Rightarrow \quad x + iy = \frac{u - iv}{u^2 + v^2}$ $\therefore x = \frac{u}{u^2 + v^2}$ $\therefore$ The image of $x = 2$ *is* $\frac{u}{u^2 + v^2} = 2 \Rightarrow u^2 + v^2 - \frac{u}{2} = 0$ which is a circle in the w – plane.	
9	**Find the image of** $x = k$ **under the transformation** $w = \frac{1}{z}$ **.**BTL1	

	$\text{Given } w=\frac{1}{z}\Rightarrow z=\frac{1}{w}=\frac{\overline{w}}{w\overline{w}}$ $\Rightarrow \quad x+iy=\frac{u-iv}{u^2+v^2}$ $\therefore x=\frac{u}{u^2+v^2}$ $\therefore$ The image of $x=k$ is $\frac{u}{u^2+v^2}=k\Rightarrow u^2+v^2-\frac{u}{k}=0$ which is a circle in the w – plane	
10	**Find the image of the circle** $\|z\|=2$ **under the transformation** $w=3z$ **.(NOV/DEC-2014)** BTL1 Given $w=3z$ $\|w\|=3\|z\|$ $=3\times 2$ $=6$ $\therefore$ The image of the circle $\|z\|=2$ is the circle $\|w\|=6$ in the w-plane. $\therefore \sqrt{u^2+v^2}=6,$ $\Rightarrow u^2+v^2=36,$ which is a circle	
11	**Find the image of the circle** $\|z\|=2$ **under the transformation** $w=z+3+2i$ .BTL1 Given $w=z+3+2i$ $u+iv=x+iy+3+2i$ $\therefore\ u=x+3\Rightarrow\ x=u-3$ $v=y+2\Rightarrow\ y=v-2$ $\|z\|=2\Rightarrow\sqrt{x^2+y^2}=2$ $\Rightarrow\ x^2+y^2=4$ $\Rightarrow (u-3)^2+(v-2)^2=4$	
12	**Find the image of the line** $x-y+1=0$ **under the map** $w=\frac{1}{z}$ .BTL1 $\text{Given } w=\frac{1}{z}\Rightarrow z=\frac{1}{w}=\frac{\overline{w}}{w\overline{w}}$ $\Rightarrow \quad x+iy=\frac{u-iv}{u^2+v^2}$ $\therefore x=\frac{u}{u^2+v^2}\ ,\ y=\frac{-v}{u^2+v^2}$ The image of the line $x-y+1=0$ is $\frac{u}{u^2+v^2}+\frac{v}{u^2+v^2}+1=0$ $\Rightarrow u^2+v^2+u+v=0$ which is a circle in the w−plane	

13	**Findthe fixed points of the transformation** $w=\frac{6z-9}{z}$ **.**BTL1 The given transformation $w=\frac{6z-9}{z}$ **.** The fixed points are given points by $w=z$ $\Rightarrow \; z=\frac{6z-9}{z}$ $\Rightarrow \; z^2=6z-9$ $\Rightarrow \; z^2-6z-9=0$ $\Rightarrow \; (z-3)^2=0$ $\Rightarrow \; z=3,3$	
14	**Find the fixed points of the mapping** $w=\frac{3-z}{1+z}$ **.**BTL1 The given maps $w=\frac{3-z}{1+z}$ The fixed points are given by $w=z$ $\therefore \; z=\frac{3-z}{1+z} \Rightarrow z+z^2=3-z$ $\Rightarrow z+z^2-3+z=0$ $\Rightarrow z^2+2z-3=0$ $\Rightarrow (z+3)(z-1)=0$ $\Rightarrow z=-3,1$	
15	**Find the fixed points of the mapping** $w=\frac{2z+6}{z+7}$. **(DEC/JAN-2015)**BTL1 The given map is $w=\frac{2z+6}{z+7}$. The fixed points are given by $w=z$ $\therefore \; z=\frac{2z+6}{z+7} \Rightarrow 7z+z^2=2z+6$ $\Rightarrow 7z+z^2-2z+6=0$ $\Rightarrow z^2+5z-6=0$ $\Rightarrow (z+6)(z-1)=0$ $\Rightarrow z=1,-6$	
16	**Find the bilinear map which maps points** $\infty, i, 0$ **of the z plane onto** $0, i, \infty$ **of the w-plane.** BTL1 Given $z_1=\infty, z_2=i, z_3=0$ which are mapped onto $w_1=0, w_2=i, w_3=\infty$ Since $z_1=\infty$ & $w_3=\infty$, omitting the factors involving z_1 & w_3 The Bilinear map is,	

	$\frac{w-w_1}{w_2-w_1}=\frac{z_2-z_3}{z-z_3}$ $\frac{w-0}{i-0}=\frac{i-0}{z}$ $\Rightarrow w=-\frac{1}{z}$	
17	**Define the Conformal Mapping**.BTL1 A transformation that preserves angles between every pair of curves through a Point, both in magnitude and sense, is said to be conformal at that point.	
18	**State sufficient condition for analytic function. (DEC/JAN-2016)** BTL1 If the partial derivatives u_x, u_y, v_x, and v_y areall continuous in D and $u_x=v_y,\ \ u_y=-v_x$.Then the function *f(z)*is analytic in a domain D.	
19	**Find the constants a, b if $f(z)=x+2ay+i(3x+by)$ is analytic.**BTL1 Given $f(z)=x+2ay+i(3x+by)$ is analytic. $\Rightarrow u_x=v_y,\ \ u_y=-v_x$ ....(1) Here $u=x+2ay$ and $v=3x+by$ Thus (1) gives $1=b$ and $2a=-3$ $\Rightarrow a=-\frac{3}{2}$ and $b=-1$	
20	**State the Cauchy Riemann equations in polar coordinates satisfied by an analytic Function.**BTL1 Cauchy Riemann equations in polar coordinates are given by $u_r=\frac{1}{r}v_\theta$ and $v_r=-\frac{1}{r}u_\theta$ where u and v are functions of r *and* θ.	
21	**Find the critical points of the transformation$w=1+\frac{2}{z}$. (NOV/DEC-2016)** BTL1 The critical points of the transformation are obtained by $f'(z)=2z$ $Hence\ -\frac{2}{z^2}=0$ $\Rightarrow -\frac{2}{0}=z^2$ $\Rightarrow z=\infty$ is the critical point of the given transformation.	
22	**Find the image of the region $x>c$, where $c>0$ under the transformation $w=\frac{1}{z}$.**BTL1 $$w=\frac{1}{z}.\Rightarrow z=\frac{1}{w}$$ Let $z=x+iy$ and$w=u+iv$	

	$$x+iy=\frac{1}{u+iv}=\frac{u-iv}{(u+iv)(u-iv)}=\frac{u-iv}{u^2+v^2}$$ $$\therefore x=\frac{u}{u^2+v^2}\ and\ y=\frac{-v}{u^2+v^2}$$ $$\boldsymbol{x}>c\Rightarrow x=\frac{u}{u^2+v^2}>c$$ $$u>cu^2+cv^2$$ $$u^2+v^2<\frac{u}{c}$$ $$u^2+v^2-\frac{u}{c}<0.$$ This refers to the inside of the circle center $(\frac{1}{2c},0)$ and radius $\frac{1}{2c}$.	
23	**Show that an analytic function with constant real part is constant.** BTL2 Let $f(z)=u+iv$ be analytic. $$\Rightarrow u_x=v_y\ and\ u_y=-v_x$$ Given that $u=constant.=c(say).\Rightarrow u_x=0\ \ and\ \ v_y=0\Rightarrow u_y=0\ \ and\ \ -v_x=0$ $\Rightarrow$v is independent of x and y.$\Rightarrow v$ is constant $\Rightarrow f(z)=u+iv=c+ic$ is a constant.	
24	**Find the critical points of the transformation $\boldsymbol{w^2=(z-\alpha)(z-\beta)}$.(DEC/JAN-2010) (NOV/DEC-2016)**BTL1 Let $w^2=(z-\alpha)(z-\beta)$. Then,$2w\frac{dw}{dz}=(z-\alpha).1+(z-\beta).1$ The Critical points of $w=f(z)$ is given by, $\frac{dw}{dz}=0\Rightarrow(z-\alpha).1+(z-\beta).1=0 \qquad \Rightarrow z=\frac{\alpha+\beta}{2}$. Also,$\frac{dz}{dw}=0\Rightarrow\frac{2w}{(z-\alpha)+(z-\beta)}=0.\Rightarrow w=0,(z-\alpha)+(z-\beta)=0\Rightarrow z=\alpha,\beta.$ The critical points are $z=\alpha,\beta,\frac{\alpha+\beta}{2}$.	
25	**Write cross ratio of four points. (NOV/DEC-2018)** BTL1 The cross ratio of four points.$\frac{(w_1-w_2)(w_3-w_4)}{(w_2-w_3)(w_4-w_1)}=\frac{(z_1-z_2)(z_3-z_4)}{(z_2-z_3)(z_4-z_1)}$is invariant under the bilinear transformation	
26	**Verify f(z)= z^3 is analytic or not.** BTL3 Let $f(z)=u+iv=z^3=(x+iy)^3$ $$u+iv=(x^3-3xy^2)+i(3x^2y-y^3)$$ $$u=(x^3-3xy^2)\text{and }\ v=(3x^2y-y^3)$$ $$u_x=(3x^2-3y^2)\ and\ u_y=-6xy$$ $$v_x=6xy\ \ and\ \ v_y=(3x^2-3y^2)$$ $u_x=v_y$and$u_y=-v_x$.Hence the C-R Equations are satisfied. Therefore f(z)= z^3 is analytic	
27	**If $\boldsymbol{f(z)=u+iv}$ is an analytic function ,prove that u is a harmonic function.**BTL5	

	$f(z) = u + iv$be analytic.$\frac{\partial u}{\partial x} = \frac{\partial v}{\partial y}$; $\frac{\partial u}{\partial y} = \frac{-\partial v}{\partial x}$ ……………(1) Now, $\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = \frac{\partial}{\partial x}\left(\frac{\partial u}{\partial x}\right) + \frac{\partial}{\partial y}\left(\frac{\partial u}{\partial y}\right) = \frac{\partial}{\partial x}\left(\frac{\partial v}{\partial y}\right) + \frac{\partial}{\partial y}\left(\frac{-\partial v}{\partial x}\right)$ (since by (1)) $= \frac{\partial^2 v}{\partial x \partial y} - \frac{\partial^2 v}{\partial y \partial x} = 0$ $\therefore u$ is harmonic	
28	**If $f(z) = r^2(\cos 2\theta + i \sin p\theta)$ is an analytic function ,then find the value of p(MAY/JUNE 2018 R-17)** BTL5 C-R Equations are $u_r = \left(\frac{1}{r}\right)v_\theta$, $u_\theta = -rv_r$ $u_r = 2r\cos 2\theta,\ u_\theta = -2r^2 \sin 2\theta$ $v_r = 2r \sin p\theta,\ u_\theta = pr^2 \cos p\theta$ $\Rightarrow p = 2$	
29	**Examine whether the function $u = xy^2$ can be real part of an analytic function (MAY/JUNE 2018 R-17)**BTL5 Here $u_{xx} + u_{yy} = 0 - 2x = -2x \neq 0$ It couldn't satisfies harmonic condition. Hence $u = xy^2$ cannot be real part of an analytic function	
	PART-B	
1.	**If $f(z)$ is an analytic function, Prove that $\left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}\right)\lvert f(z)\rvert^2 = 4\lvert f'(z)\rvert^2$** **(NOV/DEC 2014) (8 M)**BTL5 **Answer : Refer Page No.3.31-Dr.M.CHANDRASEKAR** • C-R Equations are $u_x = v_y$, $u_y = -v_x$ **(2M)** • $\left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}\right)\lvert f(z)\rvert^2 = 2\left[\left(\frac{\partial u}{\partial x}\right)^2 + \left(\frac{\partial v}{\partial x}\right)^2 + \left(\frac{\partial u}{\partial y}\right)^2 + \left(\frac{\partial v}{\partial y}\right)^2\right]$ **(4M)** • $\left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}\right)\lvert f(z)\rvert^2 = 4\left[\left(\frac{\partial u}{\partial x}\right)^2 + \left(\frac{\partial v}{\partial x}\right)^2\right] = 4\lvert f'(z)\rvert^2$ **(2M)**	

2.	**If** $f(z)=u+iv$ **is analytic, Prove that** $\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}\right)\log\lvert f(z)\rvert=0$ **.(MAY/JUNE 2002) (8M)**BTL5 **Answer : Refer Page No.3.33-Dr.M.CHANDRASEKAR** • C-R Equations are $u_x=v_y$, $u_y=-v_x$ **(2M)** • $\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}\right)\log\lvert f(z)\rvert=\frac{(u^2+v^2)[u_x^2+v_x^2+u_y^2+v_y^2+u(u_{xx}+u_{yy})+\mathrm{v}(\mathrm{v}_{xx}+v_{yy})-2[(\mathrm{uu}_x+vv_x)^2+(\mathrm{uu}_y+vv_y)^2]}{(u^2+v^2)^2}$ **(4M)** • Since the function f(z) is analytic, it satisfies C-R equations and hence the function is harmonic. **(2 M)** $\therefore\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}\right)\log\lvert f(z)\rvert=0$
3.	**Prove that** $u=x^2-y^2, v=\frac{-y}{x^2+y^2}$ are harmonic but $u+iv$ **is not regular function. (NOV/DEC 2013) (8 M)**BTL5 **Answer : Refer Page No.3.44-Dr.M.CHANDRASEKAR** • For Proving u is harmonic $u_{xx}+u_{yy}=2-2=0$ **(2M)** • For Proving v is harmonic $v_{xx}+v_{yy}=\left(\frac{2y^3-6x^2y}{(x^2+y^2)^3}\right)+\left(-\frac{(2y^3-6x^2y)}{(x^2+y^2)^3}\right)=0$ **(2 M)** • But $u_x\neq v_y$, $u_y\neq -v_x \Rightarrow f(z)=u+iv$ is not a regular function . **(2 M)**
4.	**If** $f(z)=u+iv$ **is analytic, Prove that** $\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}\right)\lvert u\rvert^p=p(p-1)(u^{p-2})\lvert f'(z)\rvert^2$ **(MAY/JUNE 2002) (MAY/JUNE 2018 R-17) (8 M)** BTL5 **Answer : Refer Page No.3.36-Dr.M.CHANDRASEKAR** • C-R Equations are $u_x=v_y$, $u_y=-v_x$ **(2M)** • $\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}\right)\lvert u\rvert^p=pu^{p-1}\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}\right)+(p-1)pu^{p-2}\left(\left(\frac{\partial u}{\partial x}\right)^2+\left(\frac{\partial u}{\partial y}\right)^2\right)$ **(4M)** • $\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}\right)\lvert u\rvert^p=p(p-1)(u^{p-2})\lvert f'(z)\rvert^2$ **(2M)**

5.	**In a two dimensional flow, the stream function is** $\psi = \tan^{-1}\left(\frac{y}{x}\right)$ **Find the velocityPotential** ϕ **. (NOV/DEC 2016) (8 M)**BTL1 **Answer : Refer Page No.3.50-Dr.M.CHANDRASEKAR** • $\frac{\partial \psi}{\partial x} = \frac{-y}{x^2+y^2}$; $\frac{\partial \psi}{\partial y} = \frac{x}{x^2+y^2}$ **(2M)** • $\phi = \int\left(\frac{\partial \psi}{\partial y}dx - \frac{\partial \psi}{\partial x}dy\right)$ **(2 M)** • $\phi = \log(x^2+y^2)+\mathrm{c}$ **(4M)**	
6.	**Show that the function** $u = \frac{1}{2}\log(x^2+y^2)$ **is harmonic and find its harmonic conjugate (MAY/JUNE 2016) (8 M)** BTL2 **Answer : Refer Page No.3.52-Dr.M.CHANDRASEKAR** • $\frac{\partial u}{\partial x} = \frac{x}{x^2+y^2}$; $\frac{\partial u}{\partial y} = \frac{y}{x^2+y^2}$ **(2M)** • For Proving u is harmonic $u_{xx}+u_{yy} = \left(\frac{y^2-x^2}{(x^2+y^2)^2}\right)+\left(-\frac{y^2-x^2}{(x^2+y^2)^2}\right)=0$ **(2 M)** • $\mathrm{v} = \tan^{-1}\left(\frac{y}{x}\right)+c$ **(4M)**	
7.	**Prove that** $e^x[x\cos y - y\sin y]$ **can be the real part of an analytic function and determineits harmonic conjugate (NOV/DEC 2013) (8 M)** BTL5 **Answer : Refer Page No.3.55-Dr.M.CHANDRASEKAR** • $\frac{\partial u}{\partial x} = e^x x\cos y + e^x \cos y - e^x y\sin y$ $\frac{\partial u}{\partial y} = -e^x x\sin y - e^x \mathrm{y}\cos y - e^x \sin y$ **(2M)** • For Proving u is harmonic $u_{xx}+u_{yy} = \left(e^x x\cos y + 2e^x\cos y - e^x y\sin y\right)+\left(-e^x x\cos y - 2e^x\cos y + e^x y\sin y\right)=0$ **(2 M)** • $\mathrm{v} = e^x x\sin y + e^x \mathrm{y}\cos y + c$ **(4M)**	
8.	**Find an analytic function** $f(z) = u+iv$ **whose real part is** $e^x[x\cos y - y\sin y]$ **(8 M)** BTL1	

	Answer : Refer Page No.3.64-Dr.M.CHANDRASEKAR • $\frac{\partial u}{\partial x} = e^x x\cos y + e^x \cos y - e^x y\sin y$ $\frac{\partial u}{\partial y} = -e^x x\sin y - e^x y\cos y - e^x \sin y$ **(2M)** • $\frac{\partial u}{\partial x}(z,0) = e^z + ze^z$ $\frac{\partial u}{\partial y}(z,0) = 0$ **(2 M)** $f(z) = ze^z + c$ **(4M)**
9.	**Find an analytic function** $f(z) = u + iv$ **whose real part is** $e^{2x}[x\cos 2y - y\sin 2y]$ **(8 M)** BTL1 **Answer : Refer Page No.3.66-Dr.M.CHANDRASEKAR** • $\frac{\partial u}{\partial x} = 2e^{2x}x\cos 2y + e^{2x}\cos 2y - 2e^{2x}y\sin 2y$ $\frac{\partial u}{\partial y} = -2e^{2x}x\sin 2y - 2e^{2x}y\cos 2y - e^{2x}\sin 2y$ **(2M)** • $\frac{\partial u}{\partial x}(z,0) = e^{2z} + 2ze^{2z}$ $\frac{\partial u}{\partial y}(z,0) = 0$ **(2 M)** • $f(z) = ze^{2z} + c$ **(4M)**
10.	**Find an analytic function** $f(z) = u + iv$ **if** $u - v = e^x[\cos y - \sin y]$ **(MAY/JUNE 2018 R-17)(8 M)**BTL1 **Answer : Refer Page No.3.76-Dr.M.CHANDRASEKAR** • $\frac{\partial U}{\partial x} = e^x\cos y - e^x\sin y$ $\frac{\partial U}{\partial y} = -e^x\cos y - e^x\sin y$ **(2M)**

	• $\frac{\partial U}{\partial x}(z,0)=e^{z}$, $\frac{\partial V}{\partial y}(z,0)=-e^{z}$ **(2 M)** • $F(z)=(1+i)f(z)$, $f(z)=e^{z}+c$ **(4M)**	
11.	**Prove that the function** $v=e^{-x}[x\cos y+y\sin y]$ **is harmonic and determine the corresponding analytic function** $f(z)=u+iv$ **(8 M)** BTL5 **Answer : Refer Page No.3.69-Dr.M.CHANDRASEKAR** • $\frac{\partial v}{\partial x}=-e^{-x}x\cos y+e^{-x}\cos y-e^{-x}y\sin y$, $\frac{\partial v}{\partial y}=-e^{-x}x\sin y+e^{-x}\,\mathrm{y}\cos y+e^{-x}\sin y$ **(2M)** • For Proving u is harmonic $v_{xx}+v_{yy}=\left(e^{-x}[(x-2)\cos y+y\sin y]\right)+\left(e^{-x}[(2-x)\cos y-y\sin y]\right)=0$ **(2 M)** • $\frac{\partial v}{\partial x}(z,0)=e^{-z}(1-z)$, $\frac{\partial v}{\partial y}(z,0)=0$ **(2 M)** • $f(z)=ize^{-z}+c$ **(2M)**	
12.	**Given that** $u=\frac{\sin 2x}{\cosh 2y-\cos 2x}$ **find the analytic function whose real part is u.** **(NOV/DEC 2014)(MAY/JUNE 2006) (8 M)** BTL1 **Answer : Refer Page No.3.71-Dr.M.CHANDRASEKAR** • $\frac{\partial u}{\partial x}(z,0)=-\mathrm{cosec}^{2}z$, $\frac{\partial u}{\partial y}(z,0)=0$ **(4M)** • $f(z)=\cot z+c$ **(4M)**	
13.	**If** $f(z)=u+iv$ **is analytic, find** $f(z)$ **given that** $u+v=\frac{\sin 2x}{\cosh 2y-\cos 2x}$ **(NOV/DEC 2015) (8 M)**BTL1 **Answer : Refer Page No.3.74-Dr.M.CHANDRASEKAR**	

	• $\frac{\partial V}{\partial x}(z,0) = -\text{cosec}^2 z$ $\frac{\partial V}{\partial y}(z,0) = 0$ **(4M)** • $f(z) = \left(\frac{1+i}{2}\right)\cot z + c$ **(4M)**
14.	**Find the image of** $\lvert z-3\rvert = 3$ **under the mapping** $w = \frac{1}{z}$ **(NOV/DEC 2010) (8 M)** BTL1 **Answer : Refer Page No.3.108-Dr.M.CHANDRASEKAR** • $x = \frac{u}{u^2+v^2}$ & $y = \frac{-v}{u^2+v^2}$ **(4M)** • The image of the circle $\lvert z-3\rvert = 3$ is the straight line $u = \frac{1}{6}$ **(4M)**
15.	**Find the image of** $\lvert z+i\rvert = 1$ **under the mapping** $w = \frac{1}{z}$ **(NOV/DEC 2013) (8 M)**BTL1 **Answer : Refer Page No.3.109-Dr.M.CHANDRASEKAR** • $x = \frac{u}{u^2+v^2}$ & $y = \frac{-v}{u^2+v^2}$ **(4M)** • The image of the circle $\lvert z+i\rvert = 1$ is the straight line $v = \frac{1}{2}$ **(4M)**
16.	**Find the image of** $1 < y < 2$ **under the mapping** $w = \frac{1}{z}$ **(MAY/JUNE 2014) (8 M)**BTL1 **Answer : Refer Page No.3.110-Dr.M.CHANDRASEKAR** • $x = \frac{u}{u^2+v^2}$ & $y = \frac{-v}{u^2+v^2}$ **(4M)** • $1 < y < 2$ is mapped onto the region between the circles $u^2+v^2+v=0$ and $2(u^2+v^2)+v=0$ **(4M)**
17.	**Find the image of** $\lvert z-2i\rvert = 2$ **under the mapping** $w = \frac{1}{z}$ **(NOV/DEC 2007) (MAY/JUNE 2018 R-17) (8 M)** BTL1

	Answer : Refer Page No.3.112-Dr.M.CHANDRASEKAR • $x=\frac{u}{u^2+v^2}$ & $y=\frac{-v}{u^2+v^2}$ **(4M)** • The image of the circle $\lvert z-2i\rvert=2$ is the straight line $v=-\frac{1}{4}$ **(4M)**
18.	**Find the bilinear transformation which maps $-1,-i,1$ in the z-plane $\infty,i,0$ in the w-planerespectively. (8 M)**BTL1 **Answer : Refer Page No.3.132-Dr.M.CHANDRASEKAR** • $\frac{(w-w_1)(w_2-w_3)}{(w-w_3)(w_2-w_1)}=\frac{(z-z_1)(z_2-z_3)}{(z-z_3)(z_2-z_1)}$ **(2M)** • $w=\frac{(1-z)}{(1+z)}$ **(6M)**
19.	**Find the bilinear transformation which maps $\infty,i,0$ onto $0,i,\infty$ respectively. (8 M)** BTL1 **Answer : Refer Page No.3.133-Dr.M.CHANDRASEKAR** • $\frac{(w-w_1)(w_2-w_3)}{(w-w_3)(w_2-w_1)}=\frac{(z-z_1)(z_2-z_3)}{(z-z_3)(z_2-z_1)}$ **(2M)** • $w=\frac{-1}{z}$ **(6M)**
20.	**Find the bilinear transformation which maps $z=1,0,-1$ onto $w=\infty,-1,0$ respectively. (8 M)** BTL1 **Answer : Refer Page No.3.133-Dr.M.CHANDRASEKAR** • $\frac{(w-w_1)(w_2-w_3)}{(w-w_3)(w_2-w_1)}=\frac{(z-z_1)(z_2-z_3)}{(z-z_3)(z_2-z_1)}$ **(2M)** • $w=\frac{z+1}{z-1}$ **(6M)**
21.	**Find the bilinear transformation which maps $-1,0,1$ onto $-1,-i,1$ respectively. Show that under this transformation the upper half of the z-plane maps onto the interior of the unit circle $\lvert w\rvert=1$ (MAY/JUNE 2018 R-17) (8 M)** BTL1 **Answer : Refer Page No.3.134-Dr.M.CHANDRASEKAR** • $\frac{(w-w_1)(w_2-w_3)}{(w-w_3)(w_2-w_1)}=\frac{(z-z_1)(z_2-z_3)}{(z-z_3)(z_2-z_1)}$ **(2M)**

	• $w = \frac{1-iz}{z-i}$ **(2M)** • $x = \frac{2u}{u^2+(v-1)^2}$ & $y = \frac{-(u^2+v^2-1)}{u^2+(v-1)^2}$ **(2M)** • For provingthe upper half of the z-plane maps onto the interior of the unit circle $\lvert w \rvert \le 1$ **(2M)**	
	UNIT IV- COMPLEX INTEGRATION	
	Line integral – Cauchy's integral theorem – Cauchy's integral formula – Taylor's and Laurent's series – Singularities – Residues – Residue theorem – Application of residue theorem for evaluation of real integrals – Use of circular contour and semicircular contour.	
Q.No.	**PART-A**	
1	**State Cauchy integral theorem. (NOV/DEC 2014)(MAY/JUNE 2016)** BTL1 If a function $f(z)$ is analytic and its derivative $f'(z)$ is continuous at all points inside and on a simple closed curve C, then $\int_C f(z)dz = 0$.	
2	**State Cauchy integral formula.** BTL1 If $f(z)$ is analytic inside and on a simple closed curve C in the region R and if 'a' is any point in R then $\int_C \frac{f(z)}{z-a}dz = 2\pi i f(a)$ where the integration around C taken in the positive direction.	
3	**State Cauchy integral formula for derivatives. (NOV/DEC 2010)**BTL1 If a function f(z) is analytic within and on a simple closed curve c and 'a' is any point lying in it, then $\int_C \frac{f(z)}{(z-a)^{n+1}}dz = \begin{cases} \frac{2\pi i}{n!} f^n(a) \text{ ; a lies inside c} \\ 0 \quad \text{ ;a lies outside c} \end{cases}$	
4	**State Cauchy Residue Theorem (NOV/DEC 2012)**BTL1 If f (z) is analytic at all points inside and on a simple closed curve C except at a Finite number of points $z_1, z_2, z_3, ..., z_n$ inside C then $\int_C f(z)dz = 2\pi i\left[\text{sum of residues of } f(z)\right]$	
5	**Evaluate $\int_C \frac{dz}{z-2}$ where C is the square with vertices (0,0), (1,0), (1,1), (0,1).**BTL5 Given C is the square with vertices (0,0), (1,0), (1,1), (0,1). ie) x=1,y=1.Since $\int_C \frac{dz}{z-2}$. Equating the denominator to zero. $z-2=0, \Rightarrow z=2$. Which lies outside C.	

6	**Evaluate** $\int_C \frac{3z^2+7z+1}{z-3}dz$ **where C is** $\|z\|=2$. BTL5 Given $\|z\|=2$ that is, $x^2+y^2=2^2$ with center (0,0) and radius 2. Given $\int_C \frac{3z^2+7z+1}{z-3}dz$. Equating the denominator to zero. $(z-3)^2=0 \Rightarrow z=3$ which lies outside C. $\therefore$ By Cauchy's integral formula $\int_C \frac{3z^2+7z+1}{z-3}dz=0$.	
7	**Evaluate** $\int_C \frac{\cos \pi z}{z-1}dz$ **where C is** $\|z\|=2$.BTL5 Given $\|z\|=2$ that is, $x^2+y^2=2^2$ with center (0,0) and radius 2. Given $\int_C \frac{\cos \pi z}{z-1}dz$. Equating the denominator to zero. $z-1=0, \Rightarrow z=1$. Which lies inside C. $\therefore$ By Cauchy's integral formula $\int_C \frac{dz}{z-a}=2\pi i\, f(a)$. *Here* $a=1, f(z)=\cos \pi z \Rightarrow f(a)=f(1)=\cos \pi=-1$. $\therefore \int_C \frac{\cos \pi z}{z-1}dz=2\pi i(-1)=-2\pi i$.	
8	**Evaluate** $\int_C \tan z\, dz$ **where C is** $\|z\|=2$ **(NOV/DEC 2015)**BTL5 Given $\|z\|=2$ that is, $x^2+y^2=2^2$ with center (0,0) and radius 2. Given $\int_C \tan z\, dz=\int_C \frac{\sin z}{\cos z}dz$. Equating the denominator to zero. Cos z = 0 = $\cos\frac{\pi}{2} \Rightarrow z=\frac{\pi}{2}$ =1.732 . Which lies inside C. $\therefore$ By Cauchy's integral formula $\int_C \frac{dz}{z-a}=2\pi i\, f(a)$. *Here* $a=\frac{\pi}{2}, f(z)=\sin z \Rightarrow f(a)=f(\frac{\pi}{2})=\sin\frac{\pi}{2}=1$. $\therefore \int_C \tan z\, dz=2\pi i(1)=2\pi i$	
9	**Evaluate the integral** $\int_C (z^2+2z)dz$ **where C is** $\|z\|=1$.BTL5 Given $\|z\|=1$. that is, $x^2+y^2=1$ with centre (0,0)and radius 1. $f(z)=z^2+2z$ is a function which is analytic in the region bounded by C	

	Hence by Cauchy's theorem $\int_C \left(z^2+2z\right)dz = 0$.	
10	**Find the contour C:** $\lvert z\rvert<1$ **for which** $\int_C \frac{e^Z}{\left(z+1\right)^2(z+1)}dz$ **=0.** BTL1 $\int_C \frac{e^Z}{\left(z+1\right)^2(z+1)}dz$ **=0** when $\lvert z\rvert<1$. [since the points lies outside the contour, then the integral value is 0.]	
11	**Evaluate** $\int_C \frac{dz}{\left(z-3\right)^2}$ **where C is** $\lvert z\rvert=1$ BTL5 Given $\lvert z\rvert=1$. that is,) $x^2+y^2=1$ with center (0,0) and radius 1. $\int_C \frac{dz}{\left(z-3\right)^2}$. Equating the denominator to zero. $\left(z-3\right)^2=0 \Rightarrow z=3$ which lies outside C. $\therefore$ By Cauchy's integral formula for derivatives $\int_C \frac{dz}{(z-3)^2}=0$.	
12	**Evaluate** $\int_c \frac{e^z dz}{z-2}$ **, where C is the unit circle with centre as origin.** BTL5 **(MAY/JUNE 2009)** $f(z)=\frac{e^z}{z-2}$ z=2 lies outside C. $f(z)$ is analytic inside and on C. $f'(z)$ is continuous in C, By Cauchy's integral theorem $\int_c f(z)dz=0$	
13	**Define Taylor's series.** BTL1 If $f(z)$ is analytic inside a circle C with its centre at z = a then, For all z inside c, $f(z)=f(a)+\frac{f'(a)}{1!}(z-a)+\frac{f''(a)}{2!}(z-a)^2+............+\frac{f^n(a)}{n!}(z-a)^n+.......+\infty$.	
14	**Define Laurent's series.** BTL1 If C_1 and C_2 are two concentric circles with centre "a" and radii r_1 and r_2 ($r_1<r_2$) and if $f(z)$ is analyticon C_1 and C_2 and in the annulus region between them, then at any point z in R $f(z)=\sum_{n=0}^{\infty}a_n(z-a)^n+\sum_{n=1}^{\infty}\frac{b_n}{(z-a)^n}$, where $a_n=\frac{1}{2\pi i}\int_{C_1}\frac{f(z)}{\left(z-a\right)^{n+1}}dz$ *and* $b_n=\frac{1}{2\pi i}\int_{C_2}\frac{f(z)}{\left(z-a\right)^{1-n}}dz$ The integrals being taken in the anticlockwise direction.	
15	**Define Essential singularity.** BTL1	

	A singular point z =a is called an essential singular point of $f(z)$ if the Laurent's series of $f(z)$ containing negative powers of z.	
16	**Discuss the nature of singularities** $f(z)=e^{\frac{1}{z}}$ **.(NOV/DEC 2015)(MAY/JUNE 2012)** BTL6 $f(z)=e^{\frac{1}{z}}=1+\frac{\left(\frac{1}{z}\right)}{1!}+\frac{\left(\frac{1}{z}\right)^2}{2!}+\frac{\left(\frac{1}{z}\right)^3}{3!}+....$ $=1+z^{-1}+\frac{z^{-2}}{2!}+\frac{z^{-3}}{3!}+...$ Thereforez =0 is an essential singularity, since the principal part contains negative powers of z.	
17	**Define removable singularity.** BTL1 A singular point z=a is called a removable singular point of $f(z)$, if the Laurent's series of $f(z)$ containing positive powers of z.	
18	**Find the nature of the singularity** $f(z)=\frac{\sin z}{z}$ .BTL1 $f(z)=\frac{\sin z}{z}=\frac{1}{z}\left(z-\frac{z^3}{3!}+\frac{z^5}{5!}+......\right)=1-\frac{z^2}{3!}+\frac{z^4}{5!}$ **-....** There is no negative power of z. Therefore $z=0$ is a removable singularity.	
19	**Define isolated singularity with an example.**BTL1 A point $z=z_0$ is said to be isolated singularity of $f(z)$ i) If $f(z)$ is not analytic at $z=z_0$, ii)There exist neighborhoods of $z=z_0$ containing no other singularity Example: $f(z)=\frac{1}{(z-1)(z-2)}$ has two isolated singularity namely z =1 and z =2.	
20	**Find the singularities of** $f(z)=\frac{z^2+4}{z^2+2z+2}$ **.**BTL1 Given $f(z)=\frac{z^2+4}{z^2+2z+2}$**.** [The singularities are poles] The poles of $f(z)$ are given by equating the denominator to zero. $z^2+2z+2=0, \quad z=\frac{-2\pm\sqrt{4-8}}{2}=-1\pm i$. Which is a pole of order 1.	
21	**Find the singularities of the function** $f(z)=\frac{\cot \pi z}{(z-a)^3}$ **.**BTL1 Given $f(z)=\frac{\cot \pi z}{(z-a)^3}=\frac{\cos \pi z}{\sin \pi z(z-a)^3}$ $i.e. \sin \pi z(z-a)^3=0 \quad \Rightarrow \quad \sin \pi z=0 \quad (or)(z-a)^3=0$ Now $(z-a)^3=0$	

	$z=a$ is a pole of order 3 and then $\sin \pi z=0$ $\pi z=n\pi \Rightarrow \quad z=\pm n, \quad n=0,1,2,3.......$ $z=\pm n$ are simple poles.	
22	**State nature of the singularities of** $f(z)=\sin\left(\frac{1}{z+1}\right)$**.**BTL1 Given $f(z)=\sin\left(\frac{1}{z+1}\right)$ $\sin\left(\frac{1}{z+1}\right)=\left(\frac{1}{z+1}\right)-\frac{\left(\frac{1}{z+1}\right)^3}{3!}+\frac{\left(\frac{1}{z+1}\right)^5}{5!}+.......=\left(\frac{1}{z+1}\right)-\frac{1}{3!}\left(\frac{1}{z+1}\right)^3+\frac{1}{5!}\left(\frac{1}{z+1}\right)^5-........$ Z=-1 is an essential singularity.	
23	**Find the zeros of the function** $f(z)=\tan z$ **and its pole. (NOV/DEC 2016)**BTL1 Given $f(z)=\tan z=\frac{\sin z}{\cos z}=\frac{P(z)}{Q(z)}$ The poles are given by $\cos z=0$ $z=(2n+1)\frac{\pi}{2} \quad where \quad n=0, \pm 1, \pm 2, \pm 3,....$ $\text{Res}\left[f(z),a\right]=\frac{P(a)}{Q'(a)}$ Now $\frac{P(z)}{Q'(z)}=\frac{\sin z}{-\sin z}=-1$ $\text{Res}\left[f(z),(2n+1)\frac{\pi}{2}\right]=-1 \quad where \quad n=0, \pm 1, \pm 2, \pm 3,....$ Hence the residue of each pole is -1	
24	**Find the zeros of the function** $f(z)=\cot z$ **and it's pole .**BTL1 Given $f(z)=\cot z=\frac{\cos z}{\sin z}=\frac{P(z)}{Q(z)}$ The poles are given by $\sin z=0$ $z=n\pi \quad where \quad n=0, \pm 1, \pm 2, \pm 3,....$ Residue of f(z) at $z=n\pi$ is $\frac{P[n\pi]}{Q'[n\pi]}$ $\frac{P(z)}{Q'(z)}=\frac{\cos z}{\cos z}$ $\frac{P(z)}{Q'(z)}=\frac{\cos(2n+1)\frac{\pi}{2}}{\cos(2n+1)\frac{\pi}{2}}=1 \quad where \quad n=0, \pm 1, \pm 2, \pm 3,....$	
25	**Find residue of** $f(z)=\frac{z^2}{(z-1)^2(z+2)}$ **and at its simple pole.** BTL1	

Given $f(z)=\dfrac{z^2}{(z-1)^2(z+2)}$

The poles of f(z) are given by $(z-1)^2(z+2)=0$

$z=1$ is a pole of order 2 and $z=-2$ is a pole order 1[Simple pole]

Residue of f(z) at z=-2: [simple Pole] $\text{Res}\left[f(z)\right]_{z=a}=\lim\limits_{z\to a}(z-a)f(z)$

$$\text{Res}\left[f(z)\right]_{z=-2}=\lim_{z\to -2}(z+2)\frac{z^2}{(z-1)^2(z+2)}=\lim_{z\to -2}\frac{z^2}{(z-1)^2}=\frac{4}{9}$$

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Evaluate $\displaystyle\int_C \frac{3z^2+7z+1}{(z+1)}dz$ **where C is the circle** $|z|=\dfrac{1}{2}$ **(MAY/JUNE 2018 R-17)** BTL3

Here z=-1 lies outside C. Therefore $\begin{cases} f(z) \text{ is analytic inside and on C.} \\ \text{And } f'(z) \text{ is Continuous inside C} \end{cases}$

$$\therefore \int_C f(z)dz=0$$

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If C is the circle $|z|=3$ and if $g(z_0)=\displaystyle\int_C \frac{2z^2-z-2}{(z-z_0)}dz$ then find g(2) **(MAY/JUNE 2018 R-17)** BTL3

$$\int_C f(z)dz=2\pi i\ [\text{sum of the residues}]$$

Here $z=2$ is a pole order 1[Simple pole]

$$\left\{\text{Res } f(z)_{at\,z=2}\right\}=\lim_{z\to 2}(z-2)\left[\frac{2z^2-z-2}{(z-2)}\right]=4$$

$$\int_C \frac{2z^2-z-2}{(z-2)}dz=8\pi i$$

PART-B

1.

Use Cauchy's integral formula to evaluate $\displaystyle\int_C \frac{\sin\pi z^2+\cos\pi z^2}{(z-1)(z-2)}dz$ **where C is the circle** $|z|=3$ **(MAY/JUNE 2016) (8 M)**BTL3

Answer : Refer Page No.4.10-Dr.M.CHANDRASEKAR

- $\dfrac{\sin\pi z^2+\cos\pi z^2}{(z-1)(z-2)}=\dfrac{1}{(z-2)}-\dfrac{1}{(z-1)}$ **(2M)**

	• $\int_C \frac{f(z)}{(z-a)}dz = 2\pi i\ f(a)$ **(2M)** • $\int_C \frac{\sin \pi z^2 + \cos \pi z^2}{(z-1)(z-2)}dz = 4\pi i$ **(4M)**	
2.	**Use Cauchy's integral formula to evaluate** $\int_C \frac{z+4}{(z^2+2z+5)}dz$ **where C is the circle** $\lvert z+1-i \rvert = 3$ **(NOV/DEC 2006) (NOV/DEC 2014) (8 M)**BTL3 **Answer : Refer Page No.4.16-Dr.M.CHANDRASEKAR** • $\frac{z+4}{(z^2+2z+5)} = \frac{\left(\frac{3+2i}{4i}\right)}{z-(-1+2\mathrm{i})} + \frac{\left(\frac{3-2i}{-4i}\right)}{z-(-1-2\mathrm{i})}$ **(2M)** • $\int_C \frac{f(z)}{(z-a)}dz = 2\pi i\ f(a)$ **(2M)** • $\int_C \frac{z+4}{(z^2+2z+5)}dz = \frac{\pi(3+2i)}{2}$ **(4M)**	
3.	**Use Cauchy's integral formula to evaluate** $\int_C \frac{z}{(z-1)(z-2)}dz$ **where C is the circle** $\lvert z-2 \rvert = \frac{1}{2}$ **(MAY/JUNE 2015) (8 M)**BTL3 **Answer : Refer Page No.4.24-Dr.M.CHANDRASEKAR** • $\int_C \frac{f(z)}{(z-a)}dz = 2\pi i\ f(a)$ **(2M)** • $\int_C \frac{z}{(z-1)(z-2)}dz = 4\pi i$ **(6M)**	
4.	**Use Cauchy's integral formula to evaluate** $\int_C \frac{z+1}{(z-3)(z-1)}dz$ **where C is the circle** $\lvert z \rvert = 2$ **(MAY/JUNE 2016) (8 M)** BTL3 **Answer : Refer Page No.4.29-Dr.M.CHANDRASEKAR** • $\int_C \frac{f(z)}{(z-a)}dz = 2\pi i\ f(a)$ **(2M)** • $\int_C \frac{z+1}{(z-3)(z-1)}dz = -2\pi i$ **(6M)**	

5.	**Use Cauchy's integral formula to evaluate** $\int_C \frac{z-1}{(z-2)(z+1)^2}dz$ **where C is the circle** $\lvert z-i\rvert = 2$ **(8 M)** BTL3 **Answer : Refer Page No.4.31-Dr.M.CHANDRASEKAR** • $\int_C \frac{f(z)}{(z-a)^{n+1}}dz = \begin{cases} \frac{2\pi i}{n!} f^n(a) \text{ ; a lies inside c} \\ 0 \text{ ; a lies outside c} \end{cases}$ **(2M)** • $\int_C \frac{z-1}{(z-2)(z+1)^2}dz = -\frac{2\pi i}{9}$ **(6M)**
6.	**Use Cauchy's integral formula to evaluate** $\int_C \frac{z^2}{(z^2+1)^2}dz$ **where C is the circle** $\lvert z-i\rvert = 1$ **(MAY/JUNE 2018 R-17)(8 M)**BTL3 **Answer : Refer Page No.4.30-Dr.M.CHANDRASEKAR** • $\int_C \frac{f(z)}{(z-a)^{n+1}}dz = \begin{cases} \frac{2\pi i}{n!} f^n(a) \text{ ; a lies inside c} \\ 0 \text{ ; a lies outside c} \end{cases}$ **(2M)** • $\int_C \frac{z^2}{(z^2+1)^2}dz = \frac{\pi}{2}$ **(6M)**
7.	**Use Cauchy's integral formula to evaluate** $\int_C \frac{z+1}{(z^2+2z+4)}dz$ **where C is the circle** $\lvert z+1+i\rvert = 2$. **(8 M)** BTL3 **Answer : Refer Page No.4.39-Dr.M.CHANDRASEKAR** • $\int_C \frac{f(z)}{(z-a)}dz = 2\pi i\, f(a)$ **.(2M)** • $\int_C \frac{z+1}{(z^2+2z+4)}dz = \pi i$ **(6M)**
8.	**Expand** $\frac{z^2-1}{(z+2)(z+3)}$ **in the appropriate series in the regions** $(i)\ 2<\lvert z\rvert<3 \quad (ii)\ \lvert z\rvert>3$ **using Laurent's series. (8 M)**BTL2 **Answer : Refer Page No.4.51-Dr.M.CHANDRASEKAR**

	• $f(z)=1+\frac{3}{z+2}-\frac{8}{z+3}$ **(2M)** (i) In $2<\|z\|<3$, • $f(z)=1+\frac{3}{z}\sum_{n=0}^{\infty}(-1)^n\left(\frac{2}{z}\right)^n-\frac{8}{3}\sum_{n=0}^{\infty}(-1)^n\left(\frac{z}{3}\right)^n$ **(3M)** (ii) In $\|z\|>3$, • $f(z)=1+\frac{3}{z}\sum_{n=0}^{\infty}(-1)^n\left(\frac{2}{z}\right)^n-\frac{8}{z}\sum_{n=0}^{\infty}(-1)^n\left(\frac{3}{z}\right)^n$ **(3M)**	
9.	**Expand** $f(z)=\frac{7z-2}{z(z-2)(z+1)}$ **in Laurent's series in the regions** $(i)\,2<\|z\|<3 \quad (ii)\,\|z\|>3$ **(8 M)**BTL2 **Answer : Refer Page No.4.52-Dr.M.CHANDRASEKAR** • $f(z)=\frac{1}{z}+\frac{2}{z-2}-\frac{3}{z+1}$ **(2M)** (i) In $2<\|z\|<3$, • $f(z)=\frac{1}{z}+\sum_{n=0}^{\infty}\left(\frac{2}{z}\right)^{n+1}+3\sum_{n=0}^{\infty}(-1)^{n+1}\left(\frac{1}{z}\right)^{n+1}$ **(3M)** (ii) In $\|z\|>3$, • $f(z)=\frac{1}{z}+\sum_{n=0}^{\infty}\left(\frac{2}{z}\right)^{n+1}+3\sum_{n=0}^{\infty}(-1)^{n+1}\left(\frac{1}{z}\right)^{n+1}$ **(3M)**	
10.	**Expand** $f(z)=\frac{7z-2}{z(z-2)(z+1)}$ **in Laurent's series in the region** $(i)\,\|z\|<2 \quad (ii)\,1<\|z+1\|<3$ **(MAY/JUNE 2014) (8 M)**BTL2 **Answer : Refer Page No.4.52-Dr.M.CHANDRASEKAR** • $f(z)=\frac{1}{z}+\frac{2}{z-2}-\frac{3}{z+1}$ **(2M)** (i) In $\|z\|<2$, • $f(z)=\frac{1}{z}-\sum_{n=0}^{\infty}\left(\frac{z}{2}\right)^n-3\sum_{n=0}^{\infty}(z)^n$ **(3M)** (ii) In $1<\|z+1\|<3$, • $f(z)=\frac{-3}{z+1}+\sum_{n=1}^{\infty}\left(\frac{1}{z+1}\right)^n-\frac{2}{3}\sum_{n=0}^{\infty}\left(\frac{z+1}{3}\right)^n$ **(3M)**	

11.	**Expand** $f(z)=\dfrac{6z+5}{z(z-2)(z+1)}$ **in Laurent's series in the region** $1<\|z+1\|<3$ **(MAY/JUNE 2018 R-17) (8 M)**BTL2 **Answer : Refer Page No.4.56-Dr.M.CHANDRASEKAR** • $f(z)=\dfrac{-5}{2z}+\dfrac{17}{6(z-2)}-\dfrac{1}{3(z+1)}$ **(2M)** In $1<\|z+1\|<3,$ • $f(z)=\dfrac{-1}{3(z+1)}-\dfrac{5}{2(z+1)}\sum_{n=0}^{\infty}\left(\dfrac{1}{z+1}\right)^n-\dfrac{17}{8}\sum_{n=0}^{\infty}\left(\dfrac{z+1}{3}\right)^n$ **(6M)**	
12.	**Expand** $f(z)=\dfrac{1}{(z-1)(z-2)}$ **in Laurent's series in the region** $(i)\|z\|>2 \quad (ii)\ 0<\|z-1\|<1$ **(NOV/DEC 2014) (8 M)**BTL2 **Answer : Refer Page No.4.57-Dr.M.CHANDRASEKAR** • $f(z)=\dfrac{-1}{z-1}+\dfrac{1}{z-2}$ **(2M)** (i) In $\|z\|>2,$ • $f(z)=-\sum_{n=0}^{\infty}\left(\dfrac{1}{z}\right)^n+\dfrac{1}{z}\sum_{n=0}^{\infty}\left(\dfrac{2}{z}\right)^n$ **(3M)** (ii) In $0<\|z-1\|<1,$ • $f(z)=\dfrac{-1}{z-1}+\sum_{n=0}^{\infty}(z-1)^n$ **(3M)**	
13.	**Use Cauchy's Residue theorem to evaluate** $\int_C \dfrac{\sin \pi z^2+\cos \pi z^2}{(z-1)^2(z-2)}dz$ **where C is the circle** $\|z\|=3$ **(NOV/DEC 2015) (8 M)**BTL3 **Answer : Refer Page No.4.96-Dr.M.CHANDRASEKAR** • $\int_C f(z)dz=2\pi i$ [sum of the residues] **(2M)** • $\left\{\text{Res } f(z)_{at\,z=2}\right\}=1$ $\left\{\text{Res } f(z)_{at\,z=1}\right\}=-2\pi+1$ **(4M)** • $\int_C \dfrac{\sin \pi z^2+\cos \pi z^2}{(z-1)^2(z-2)}dz=4\pi i(1-\pi)$ **(2M)**	

14.	**Use Cauchy's Residue theorem to evaluate** $\int_C \frac{12z-7}{(z-1)^2(2z+3)}dz$ **where C is the circle** $\lvert z\rvert = 2$ **(8 M)**BTL3 **Answer : Refer Page No.4.92-Dr.M.CHANDRASEKAR** • $\int_C f(z)dz = 2\pi i$ [sum of the residues] **(2M)** • $\left\{\text{Res } f(z)_{at\, z=-3/2}\right\} = -4$ **(4M)** $\left\{\text{Res } f(z)_{at\, z=1}\right\} = 4$ • $\int_C \frac{12z-7}{(z-1)^2(2z+3)}dz = 0$ **(2M)**	
15.	**Use Cauchy's Residue theorem to evaluate** $\int_C \frac{z^2}{(z+1)^2(z^2+4)}dz$ **where C is the circle** $\lvert z\rvert = 3$ **(8 M)** BTL3 **Answer : Refer Page No.4.99-Dr.M.CHANDRASEKAR** • $\int_C f(z)dz = 2\pi i$ [sum of the residues] **(2M)** $\left\{\text{Res } f(z)_{at\, z=-1}\right\} = -\frac{8}{25}$ • $\left\{\text{Res } f(z)_{at\, z=2i}\right\} = \frac{-4}{(1+2i)^2(4i)}$ **(4M)** $\left\{\text{Res } f(z)_{at\, z=-2i}\right\} = \frac{-4}{(1-2i)^2(-4i)}$ • $\int_C \frac{z^2}{(z+1)^2(z^2+4)}dz = 0$ **(2M)**	
16.	**Use Cauchy's Residue theorem to evaluate** $\int_C \frac{dz}{(z^2+4)^2}$ **where C is the circle** $\lvert z-i\rvert = 2$ **(8 M)**BTL3 **Answer : Refer Page No.4.100-Dr.M.CHANDRASEKAR** • $\int_C f(z)dz = 2\pi i$ [sum of the residues] **(2M)**	

	• $\left\{\text{Res } f(z)_{at\, z=2i}\right\} = \frac{1}{32i}$ **(4M)** $\left\{\text{Res } f(z)_{at\, z=-2i}\right\} = 0$ • $\int_C \frac{dz}{(z^2+4)^2} = \frac{\pi}{16}$ **(2M)**	
17.	**Evaluate** $\int_0^{2\pi} \frac{\cos 2\theta}{5+4\cos\theta} d\theta$ **by using Contour integration (MAY/JUNE 2018 R-17) (16M)**BTL5 **Answer : Refer Page No.4.105-Dr.M.CHANDRASEKAR** • $\int_0^{2\pi} \frac{\cos 2\theta}{5+4\cos\theta} d\theta = \frac{1}{4i} \int_C \frac{(z^2+1)dz}{z^2(z+1/2)(z+2)}$ **(4M)** • $\int_C f(z)dz = 2\pi i$ [sum of the residues] **(2M)** $\left\{\text{Res } f(z)_{at\, z=0}\right\} = \frac{-5}{2}$ • $\left\{\text{Res } f(z)_{at\, z=-1/2}\right\} = \frac{17}{6}$ **(8M)** $\left\{\text{Res } f(z)_{at\, z=-2}\right\} = 0$ • $\int_0^{2\pi} \frac{\cos 2\theta}{5+4\cos\theta} d\theta = \frac{\pi}{6}$ **(2M)**	
18.	**Prove that** $\int_0^{2\pi} \frac{d\theta}{5+4\sin\theta} = \frac{2\pi}{3}$ **by using Contour integration. (NOV/DEC 2006) (8 M)** BTL5 **Answer : Refer Page No.4.120-Dr.M.CHANDRASEKAR** • $\int_0^{2\pi} \frac{d\theta}{5+4\sin\theta} = \int_C \frac{dz}{(z+2i)(2z+i)}$ **(3M)** • $\int_C f(z)dz = 2\pi i$ [sum of the residues] **(1M)** • $\left\{\text{Res } f(z)_{at\, z=-i/2}\right\} = \frac{1}{3i}$ **(3M)** $\left\{\text{Res } f(z)_{at\, z=-2i}\right\} = 0$	

	• $\int_0^{2\pi} \frac{d\theta}{5+4\sin\theta} = \frac{2\pi}{3}$ **(1M)**	
19.	**Evaluate** $\int_0^{2\pi} \frac{d\theta}{13+5\sin\theta}$ **by using Contour integration. (NOV/DEC 2014) (8 M)**BTL5 **Answer : Refer Page No.4.123-Dr.M.CHANDRASEKAR** • $\int_0^{2\pi} \frac{d\theta}{13+5\sin\theta} = \int_C \frac{2dz}{(5z+i)(2+5i)}$ **(3M)** • $\int_C f(z)dz = 2\pi i\ [\text{sum of the residues}]$ **(1M)** • $\left\{\text{Res } f(z)_{at\, z=5i}\right\} = 0$ $\left\{\text{Res } f(z)_{at\, z=-\frac{i}{5}}\right\} = \frac{1}{12i}$ **(3M)** • $\int_0^{2\pi} \frac{d\theta}{13+5\sin\theta} = \frac{\pi}{6}$ **(1M)**	
20.	**Evaluate** $\int_{-\infty}^{\infty} \frac{x^2dx}{(x^2+1)(x^2+4)}$ **by using Contour integration. (NOV/DEC 2008) (8 M)** BTL5 **Answer : Refer Page No.4.92-Dr.G.BALAJI** • $\int_{-\infty}^{\infty} \frac{x^2dx}{(x^2+1)(x^2+4)} = \int_C \frac{z^2}{(z^2+1)(z^2+4)}dz$ **(1M)** • $\int_C f(z)dz = 2\pi i\ [\text{sum of the residues}]$ **(1M)** • $\left\{\text{Res } f(z)_{at\, z=i}\right\} = \frac{i}{6}$ $\left\{\text{Res } f(z)_{at\, z=2i}\right\} = -\frac{i}{3}$ **(3M)** • $\int_{-\infty}^{\infty} \frac{x^2dx}{(x^2+1)(x^2+4)} = \frac{\pi}{3}$ **(3M)**	
21.	**Evaluate** $\int_0^{\infty} \frac{\cos mx}{(x^2+a^2)}dx$ **by using Contour integration. (NOV/DEC 2016) (8 M)**BTL5 **Answer : Refer Page No.4.101-Dr.G.BALAJI**	

	• $\int_0^\infty \frac{\cos mx\,dx}{(x^2+a^2)} = R.P\ of\ \int_C \frac{e^{mz}}{(z^2+a^2)}dz$ **(1M)** • $\int_C f(z)dz = 2\pi i$ [sum of the residues] **(1M)** • $\{\text{Res } f(z)_{at\, z=ai}\} = \frac{e^{-ma}}{2ai}$ **(3M)** • $\int_0^\infty \frac{\cos mx}{(x^2+a^2)}dx = \frac{\pi e^{-ma}}{2a}$ **(3M)**	

	UNIT V LAPLACETRANSFORMS
	Existence conditions – Transforms of elementary functions – Transform of unit step function and unit impulse function – Basic properties – Shifting theorems -Transforms of derivatives and integrals – Initial and final value theorems – Inverse transforms – Convolution theorem – Transform of periodic functions – Application to solution of linear second order ordinary differential equations with constantcoefficients.
	PART * A
Q.No.	**Questions**
1.	**State the sufficient condition for the existence of Laplace transforms.** **(OR) State the conditions under which the Laplace Transform of $f(t)$ exisits.** **(APR/MAY 2015, 2017 R-13)**BTL1 The Laplace transform of $f(t)$ exists if a) $f(t)$ is piecewise continuous in $[a,b]$ where $a > 0$. b) $f(t)$is of exponential order.
2.	**Is the linearity property applicable to $L\left[\frac{1-cost}{t}\right]$?Reason out?**BTL5 Given, $L\left[\frac{1-cost}{t}\right] = L\left[\frac{1}{t}\right] - L\left[\frac{cos\,t}{t}\right]$by linearity property, provided the result exists. $L\left[\frac{1}{t}\right]$does not exist. Since $\lim_{t\to 0}\frac{1}{t} = \frac{1}{0} = \infty$. $L\left[\frac{cos\,t}{t}\right]$does not exist. Since, $\lim_{t\to 0}\frac{\cos t}{t} = \frac{1}{0} = \infty$. $\therefore$ Linearity property is not applicable to $L\left[\frac{1-cost}{t}\right]$.
3.	**If L[F(t)]=$F(s)$, Prove that $L\left[f\left(\frac{t}{5}\right)\right] = 5F(5s)$.**BTL5

	$L[f(t)]=\int_0^\infty e^{-st}f(t)dt$ $put \quad \frac{t}{5}=u \Rightarrow 5du=dt$ $L\left[f\left(\frac{t}{5}\right)\right]=\int_0^\infty e^{-(5s)u}f(u)5du$ $=5\int_0^\infty e^{-(5s)u}f(u)du=5F(5s)$
4	**Find the Laplace transform of unit step function.**BTL1 The unit step function is $u_a(t)=\begin{cases}0 & t<a \\ 1 & t>a,\end{cases} \quad a\ge 0$ The Laplace transform $L[f(t)]=\int_0^\infty e^{-st}f(t)dt=\int_a^\infty e^{-st}(1)dt=\left[\frac{e^{-st}}{-s}\right]_a^\infty=-\frac{1}{s}\left[e^{-\infty}-e^{-as}\right]=\frac{e^{-as}}{s}.$
5	**Prove that $L\left(\int_0^t f(t)dt\right)=\frac{F(s)}{s}$ where $L[f(t)]=F(s)$. [DEC 2016 R-13]**BTL5 Let $F(t)=\int_0^t f(t)dt$ $F'(t)=f(t)$ $L[F'(t)]=sL[F(t)]-F(0)=sL[F(t)]-0$ $L[f(t)]=sL[F(t)]=sL[\int_0^t f(t)dt]$ $\therefore L\left(\int_0^t f(t)dt\right)=\frac{F(s)}{s}$
6	**Does $L\left[\frac{\cos at}{t}\right]$ exist?** BTL4 $\underset{t\to 0}{Lt}\frac{f(t)}{t}=\underset{t\to 0}{Lt}\frac{\cos at}{t}=\frac{1}{0}=\infty$ $\therefore L\left[\frac{\cos at}{t}\right] does \quad not \quad exist.$
7	**Obtain the Laplace transform of $sin2t-2tcos2t$.**BTL3 $L[\sin 2t-2t\cos 2t]=L[\sin 2t]-2L[t\cos 2t]=L[\sin 2t]-2\left(-\frac{d}{ds}L[\cos 2t]\right)$ $=\frac{2}{s^2+4}+2\frac{d}{ds}\left(\frac{s}{s^2+4}\right)=\frac{2}{s^2+4}+2\left(\frac{(s^2+4)(1)-s(2s)}{(s^2+4)^2}\right)$ $=\frac{2(s^2+4)+2(4-s^2)}{(s^2+4)^2}=\frac{16}{(s^2+4)^2}.$

8	**Find** $L^{-1}\left[\frac{s+2}{s^2+2s+2}\right]$**.**BTL4 $L^{-1}\left[\frac{s+2}{s^2+2s+2}\right]=L^{-1}\left[\frac{(s+1)+1}{(s+1)^2+1}\right]\{\because L^{-1}[F(s+a)]=e^{-at}L^{-1}[F(s)]\}$ $=L^{-1}\left[\frac{(s+1)}{(s+1)^2+1}\right]+L^{-1}\left[\frac{1}{(s+1)^2+1}\right]$ $=e^{-t}\left(L^{-1}\left[\frac{s}{s^2+1}\right]+L^{-1}\left[\frac{1}{s^2+1}\right]\right)$ $=e^{-t}(\cos t+\sin t).$
9	**What is the Laplace transform of** $\boldsymbol{f(t)}, \mathbf{0}<t<10$ **with** $\boldsymbol{f(t)}=\boldsymbol{f(t+10)}$?BTL3 Given $\boldsymbol{f(t)}$ is a periodic function with period $\boldsymbol{p}$. $L[f(t)]=\frac{1}{1-e^{-ps}}\int_0^p e^{-st}f(t)dt$ $put \quad p=10, \quad L[f(t)]=\frac{1}{1-e^{-10s}}\int_0^{10} e^{-st}f(t)dt$
10	**State and Prove Linearity property. [MAY/JUNE 2016]**BTL1 $Statement: \quad L[af(t)\pm bg(t)]=aL[f(t)]\pm bL[g(t)]$ $proof: \quad L[f(t)]=\int_0^\infty e^{-st}f(t)dt$ $L[af(t)\pm bg(t)]=\int_0^\infty e^{-st}L[af(t)\pm bg(t)]dt$ $=\int_0^\infty e^{-st}af(t)dt\pm\int_0^\infty e^{-st}bg(t)dt$ $=a\int_0^\infty e^{-st}f(t)dt\pm b\int_0^\infty e^{-st}g(t)dt$ $=aL[f(t)]\pm bL[g(t)].$
11	**Find** $L^{-1}\left(\frac{S}{S^2+4S+5}\right)$**. [MAY/JUNE 2016]**BTL3 $L^{-1}\left(\frac{S}{S^2+4S+5}\right)=L^{-1}\left(\frac{(S+2)-2}{(S+2)^2+1}\right)=e^{-2t}L^{-1}\left(\frac{S-2}{S^2+1}\right)$ $=e^{-2t}\left[L^{-1}\left(\frac{S-2}{S^2+1}\right)-2L^{-1}\left(\frac{1}{S^2+1}\right)\right]=e^{-2t}[\cos t-2\sin t].$

12	**Find** $L[te^{-3t}\cos 2t]$**.**BTL3 We know that $L[t\cos at]=\dfrac{s^2-a^2}{(s^2+a^2)^2}$, $L[te^{-3t}\cos 2t]=\left[\dfrac{s^2-2^2}{(s^2+2^2)^2}\right]_{s\to s+3}=\dfrac{(s+3)^2-2^2}{((s+3)^2+2^2)^2}$
13	**Find**$\boldsymbol{L^{-1}}\left[\tan^{-1}\left(\dfrac{1}{s}\right)\right]$**.** BTL3 $Let \quad F(s)=\tan^{-1}\left(\dfrac{1}{s}\right)$ $F'(s)=\dfrac{1}{1+\left(\cancel{1}/s\right)^2}\left(\dfrac{-1}{s^2}\right)=\dfrac{-1}{s^2+1}$ $By \quad property \quad L^{-1}\left[F'(s)\right]=-L^{-1}\left[\dfrac{1}{s^2+1}\right]=-\sin t$ $\therefore L^{-1}\left[F'(s)\right]=-\sin t;$ $L^{-1}\left[F(s)\right]=\dfrac{-1}{t}L^{-1}\left[F'(s)\right]$ $\mathrm{L}^{-1}\left[\tan^{-1}\left(\dfrac{1}{s}\right)\right]=\dfrac{\sin \mathrm{t}}{\mathrm{t}}.$
14	**Solve using Laplace transform** $\dfrac{dy}{dt}+y=e^{-t}$ **given that** $\boldsymbol{y(0)=0}$.BTL3 Taking Laplace transform on both sides, we get $L[y'(t)]+L[y(t)]=L[e^{-t}]$ $sL[y(t)]-y(0)+L[y(t)]=L[e^{-t}]$ $sL[y(t)]-0+L[y(t)]=\dfrac{1}{s+1}$ $(s+1)L[y(t)]=\dfrac{1}{s+1}$ $L[y(t)]=\left(\dfrac{1}{(s+1)^2}\right)$ $\therefore y(t)=L^{-1}\left(\dfrac{1}{(s+1)^2}\right)=e^{-t}L\left(\dfrac{1}{s^{2]gh[\,]}}\right)=e^{-t}t.$ $\{\because L[e^{-at}f(t)]=F(s+a)\}$
15	**Given an example for a function that do not have Laplace transform.**BTL5 Consider $\boldsymbol{f(t)=e^{t^2}}$, since $\underset{t\to\infty}{Lt}\, e^{-st}e^{t^2}=\infty$, hence $\boldsymbol{e^{t^2}}$ is not exponential order. Hence $\boldsymbol{f(t)=e^{t^2}}$ does not have Laplace transform.

16	**Can $F(s) = \frac{s^3}{(s+1)^2}$ be the Laplace transform of some $f(t)$?**BTL5 $\underset{s\to\infty}{Lt} F(s) = \underset{s\to\infty}{Lt} \frac{s^3}{(s+1)^2} \neq 0$ Hence $F(s)$ cannot be Laplace transform of $f(t)$.
17	**Evaluate $\int_0^t \sin u \cos(t-u)du$ using Laplace Transform.**BTL3 $Let \quad L\left[\int_0^t \sin u\cos(t-u)du\right] = L[\sin t * \cos t]$ $= L[\sin t]L[\cos t] \qquad (by \quad convolution \quad theorem)$ $= \frac{1}{(s^2+1)}\frac{s}{(s^2+1)} = \frac{s}{(s^2+1)^2}.$ $\int_0^t \sin u\cos(t-u)du = L^{-1}\left[\frac{s}{(s^2+1)^2}\right] = \frac{1}{2}L^{-1}\left[\frac{2s}{(s^2+1)^2}\right] = \frac{t}{2}\sin t.$ $\left[\because L^{-1}\left(\frac{2s}{(s^2+1)^2}\right) = t\sin at\right].$
18	**Given an example for a function having Laplace transform but not satisfying the continuity condition.**BTL1 $f(t) = t^{\frac{-1}{2}}$ has Laplace transform even though it does not satisfy the continuity condition. (i.e.) It is not piecewise continuous in $(0,\infty)$ $\quad as \underset{t\to 0}{Lt} f(t) = \infty.$
19	**Define a Periodic function with example.**BTL1 $f(t)$ for all t. The least value of $p > 0$ is called the period of $f(t)$. For example, $\sin t$ and $\cos t$ are periodic functions with period 2π.
20	**If $L[f(t)] = F(s)$, find $L[f(at)]$. [APR/MAY 2018 R-17]**BTL5 $L[f(at)] = \int_0^\infty e^{-st} f(at)dt$ $put \qquad u = at$ $L[f(at)] = \int_0^\infty e^{-\left(\frac{s}{a}\right)u} f(u)\frac{du}{a} = \frac{1}{a}\int_0^\infty e^{-\left(\frac{s}{a}\right)u} f(u)du = \frac{1}{a}F\left(\frac{s}{a}\right).$
21	**Find the Laplace transform of $\frac{t}{e^t}$. [APR/MAY 2018 R-17]**BTL3 $L\left[\frac{t}{e^t}\right] = L[e^{-t}t] = \left[\frac{1}{s^2}\right]_{s\to s+1} = \frac{1}{(s+1)^2}.$
22	**State Convolution theorem on Laplace Transform. [MAY/JUNE 2017 R-13]**BTL1 The Laplace transform of convolution of two functions is equal to the product of their Laplace transform. (i.e) $L[f(t)*g(t)] = L[f(t)]L[g(t)]$.

23	**Find** $L\left[\frac{1}{\sqrt{t}}\right]$. **[APR/MAY 2017 R-13]**BTL3 We know that, $L[t^n] = \frac{\Gamma(n+1)}{s^{n+1}}$ $L\left[\frac{1}{\sqrt{t}}\right] = L[t^{-1/2}]$ $= \frac{\Gamma(-1/2+1)}{s^{-1/2+1}}$ $= \frac{\Gamma(1/2)}{s^{1/2}} = \sqrt{\frac{\pi}{s}}.$
24	**Find the Laplace transform** $\boldsymbol{sin^3(2t)}$.BTL3 $L[\sin^3(2t)] = \frac{1}{4}L[3\sin 2t - \sin 6t]$ $= \frac{3}{4}L[\sin 2t] - \frac{1}{4}L[\sin 6t]$ $\{\because \sin^3 t = \frac{1}{4}[3\sin t - \sin 3t]\}$ $= \frac{3}{4}\left(\frac{2}{s^2+4}\right) - \frac{1}{4}\left(\frac{6}{s^2+36}\right)$ $= \frac{6}{4}\left\{\left(\frac{1}{s^2+4}\right) - \left(\frac{1}{s^2+36}\right)\right\}$
25	**Find the Laplace transform of** $\boldsymbol{e^{-2t}t^{1/2}}$.BTL3 $L(e^{-2t}t^{1/2}) = L[t^{1/2}]_{s \to s+2}$ $\because if \quad L[f(t)] = F(s), \quad then \quad l[e^{-at}f(t)] = F(s)/_{s \to s+2}$ $\left[\frac{\Gamma\left(\frac{1}{2}+1\right)}{s^{\frac{3}{2}}}\right]_{s \to s+2} = \left[\frac{\frac{1}{2}\Gamma\left(\frac{1}{2}\right)}{s^{\frac{3}{2}}}\right]_{s \to s+2}$ $= \frac{\frac{1}{2}\sqrt{\pi}}{(s+2)^{\frac{3}{2}}} \qquad \left(\because \Gamma\left(\frac{1}{2}\right) = \sqrt{\pi}, \quad \Gamma n+1 = n\Gamma n\right).$
26	**Does** $L\left[\frac{\cos at}{t}\right]$ **exist?** BTL5

	$\underset{t\to 0}{Lt}\dfrac{f(t)}{t}=\underset{t\to 0}{Lt}\dfrac{\cos at}{t}=\dfrac{1}{0}=\infty$ $\therefore L\left[\dfrac{\cos at}{t}\right]$ *does not exist.*
27	**Using Laplace transform, Evaluate** $\int_0^\infty te^{-2t}\sin t\,dt$**. [APR/MAY 2015 R-13]**BTL3 $\int_0^\infty e^{-2t}f(t)dt=\left[\int_0^\infty e^{-st}f(t)dt\right]_{s=2}=[L[t\sin t]]_{s=2}=\left[-\dfrac{d}{ds}L[\sin t]\right]_{s=2}=-\dfrac{d}{ds}\left(\dfrac{1}{s^2+1}\right)=\dfrac{4}{25}$
	Part*B
1	**Find** **1)** $L[\frac{\sinh 2t}{t}]$**.** **2)** $L[\frac{e^{-t}\sin t}{t}]$ **3)** $L[\frac{\cos at-\cos bt}{t}]$**. [APR/MAY 2011,2015, NOV/DEC 2012,2016 R-13] (12M)**BTL3 **Answer: Refer Page No:5.35-Dr. G. Balaji.** 1) $L\left[\dfrac{\sinh 2t}{t}\right]=\int_s^\infty L[\sinh 2t]ds=\int_s^\infty\dfrac{2}{s^2-4}ds=2\left[\dfrac{1}{2(2)}\log\left(\dfrac{s-2}{s+2}\right)\right]_s^\infty$ $=\dfrac{1}{2}\left[\log\dfrac{s+2}{s-2}\right]=\log\sqrt{s+2/s-2}$ $(4M)$ 2) $L\left[\dfrac{e^{-t}\sin t}{t}\right]=\left[L\left[\sin t/t\right]\right]_{s\to s+1}$ $=\left[\cot^{-1}s\right]_{s\to(s+1)}=\cot^{-1}(s+1).$ $(3M)$ 3) $L\left[\dfrac{\cos at-\cos bt}{t}\right]=\int_s^\infty L[\cos at-\cos bt]ds$ $=\int_s^\infty\left[\dfrac{s}{s^2+a^2}-\dfrac{s}{s^2+b^2}\right]ds=\dfrac{1}{2}\left[\log(s^2+a^2)-\log(s^2+b^2)\right]_s^\infty=\dfrac{1}{2}\log\dfrac{s^2+b^2}{s^2+a^2}.$ $(5M)$
2	**1) State and prove Initial Value and Final value theorem. [APR/MAY 2017 R-13]** **2) Verify the initial and Final value theorem for** $f(t)=1+e^t(\sin t+\cos t)$**. [NOV/DEC 2009, MAY/JUNE 2012R-13]** **3) Using the initial value theorem, find** $\underset{s\to\infty}{Lt}\,sL[f(t)]$ **for the function** $f(t)=e^{-t}\cos t$**. [NOV/DEC 2016 R-13] (16M)**BTL3 **Answer: Refer Page No:5.40-Dr. G. Balaji.** 1) <u>Initial Value theorem Statement:</u> $L[f(t)]=F(s)$, *then* $\underset{t\to 0}{Lt}f(t)=\underset{s\to\infty}{Lt}sF(s).$

$\Pr oof : We \quad know \quad that \quad L[f'(t)] = sL[f(t)] - f(0) = sF(s) - f(0)$

$= \int_0^\infty e^{-st} f'(t)dt$

$\underset{s\to\infty}{Lt}[sF(s) - f(0)] = \underset{s\to\infty}{Lt}\int_0^\infty e^{-st} f'(t)dt = \underset{s\to\infty}{Lt}\, sF(s) - f(0) = 0$

$hence \quad \underset{t\to 0}{Lt}\, f(t) = \underset{s\to\infty}{Lt}\, sF(s). \qquad (2M)$

Final Value theorem Statement: $L[f(t)] = F(s), \quad then \quad \underset{t\to\infty}{Lt}\, f(t) = \underset{s\to 0}{Lt}\, sF(s).$

$\Pr oof : We \quad know \quad that \quad l[f'(t)] = sL[f(t)] - f(0) = sF(s) - f(0)$

$= \int_0^\infty e^{-st} f'(t)dt$

$\underset{s\to 0}{Lt}[sF(s) - f(0)] = \underset{s\to 0}{Lt}\int_0^\infty e^{-st} f'(t)dt = \underset{s\to 0}{Lt}\, sF(s) - f(0) = f(\infty) - f(0)$

$hence \quad \underset{t\to\infty}{Lt}\, f(t) = \underset{s\to 0}{Lt}\, sF(s). \qquad (2M)$

2) $f(t) = 1 + e^t(\sin t + \cos t)$

Initial Value theorem state that $L[f(t)] = F(s), \quad then \quad \underset{t\to 0}{Lt}\, f(t) = \underset{s\to\infty}{Lt}\, sF(s).$

$L[f(t)] = L[1 + e^t(\sin t + \cos t)]$

$= \frac{1}{s} + \frac{1}{(s+1)^2+1} + \frac{s+1}{(s+1)^2+1}$

$LHS \quad = \lim_{t\to 0} f(t) = 2.$

$RHS = \underset{s\to\infty}{Lim}\left[1 + \frac{s(s+2)}{(s+1)^2+1}\right] = 2 \qquad (4M)$

$LHS \quad = \quad RHS$

Hence, Initial Value theorem verified.

Final Value theorem state that $L[f(t)] = F(s), \quad then \quad \underset{t\to\infty}{Lt}\, f(t) = \underset{s\to 0}{Lt}\, sF(s).$

$LHS \quad = \lim_{t\to\infty} f(t) = 1.$

$RHS = \underset{s\to 0}{Lim}\left[1 + \frac{s(s+2)}{(s+1)^2+1}\right] = 1 \qquad (4M)$

$LHS \quad = \quad RHS$

3) Initial Value theorem Statement: $L[f(t)] = F(s), \quad then \quad \underset{t\to 0}{Lt}\, f(t) = \underset{s\to\infty}{Lt}\, sF(s).$

$f(t) = e^{-t}\cos t$

$\lim_{t\to 0} f(t) = 1$

$\lim_{s\to\infty} sF(s) = 1 \qquad (4M)$

	Hence proved.
3	**Using convolution theorem find** $L^{-1}\left[\frac{1}{(s+a)(s+b)}\right]$**. [APR/MAY 2011 R-13] (8M)**BTL3 **Answer: Refer Page No:5.77-Dr. G. Balaji.** $L^{-1}\left[\frac{1}{(s+a)(s+b)}\right]=L^{-1}\left[\left(\frac{1}{(s+a)}\right)\left(\frac{1}{(s+b)}\right)\right]$ $=L^{-1}\left(\frac{1}{(s+a)}\right)*L^{-1}\left(\frac{1}{(s+b)}\right)$ $=e^{-at}*e^{-bt} \qquad (3M)$ $=\int_0^t e^{-at}e^{-b(t-u)}du$ $=e^{-bt}\left[\frac{e^{-(a-b)u}}{-(a-b)}\right]_{u=0}^{u=t} \qquad (3M)$ $=\frac{e^{-bt}-e^{-at}}{a-b}. \qquad (2M)$ <u>Note:</u> **Using convolution theorem find** $L^{-1}\left[\frac{1}{(s+1)(s+2)}\right]$**. [NOV/DEC 2007,2012 R-13] (8M)** **Hint:** In the above problem put $a=2, b=1$.
4	**Find the Laplace inverse of** $\left[\frac{s^2}{(s^2+a^2)^2}\right]$ **using convolution theorem. [NOV/DEC 2011R-13] (8M)**BTL3 **Answer: Refer Page No:5.84-Dr. G. Balaji.** $L^{-1}\left[\frac{s^2}{(s^2+a^2)^2}\right]=L^{-1}\left[\left(\frac{s}{(s^2+a^2)}\right)\left(\frac{s}{(s^2+a^2)}\right)\right]$ $=L^{-1}\left(\frac{s}{(s^2+a^2)}\right)*L^{-1}\left(\frac{s}{(s^2+a^2)}\right)$ $=\cos at*\cos at \qquad (3M)$ $=\int_0^t \cos au\cos a(t-u)du$

	$=\frac{1}{2}\int_0^t [\cos(au+at-au)+\cos(au-at+au)]du \qquad (2M)$ $=\frac{1}{2}\left[[(\cos at)u]+\left[\frac{\sin[2au-at]}{2a}\right]\right]_{u=0}^{u=t}$ $=\frac{1}{2}\left[t\cos at+\frac{\sin at}{a}\right]$ $L^{-1}\left[\frac{s^2}{(s^2+a^2)^2}\right]=\frac{1}{2a}[\sin at+at\cos at]. \qquad (3M)$ Note: **Using Convolution theorem, find** $L^{-1}\left[\frac{s^2}{(s^2+4)^2}\right]$**. [NOV/DEC 2012 R-13] (8M)** **Hint:** In the problem put $a=2$.
5	**Using convolution theorem find** $L^{-1}\left[\frac{s}{(s^2+a^2)^2}\right]$**. [NOV/DEC 2013, APR/MAY 2017 R-13] (8M)**BTL3 **Answer: Refer Page No:5.83-Dr. G. Balaji.**

	$L^{-1}\left[\dfrac{s}{(s^2+a^2)^2}\right]=L^{-1}\left[\left(\dfrac{s}{(s^2+a^2)}\right)\left(\dfrac{1}{(s^2+a^2)}\right)\right]$ $=L^{-1}\left(\dfrac{s}{(s^2+a^2)}\right)*\dfrac{1}{a}L^{-1}\left(\dfrac{a}{(s^2+a^2)}\right)$ $=\cos at*\dfrac{1}{a}\sin at \qquad (3M)$ $=\dfrac{1}{a}\int_0^t \cos au \sin a(t-u)du$ $=\dfrac{1}{2a}\int_0^t [\sin(at-au+au)+\sin(at-au-au)]du \qquad (2M)$ $=\dfrac{1}{2a}\left[[(\sin at)u]+\left[\dfrac{-\cos[a(t-2u)]}{-2a}\right]\right]_0^t$ $=\dfrac{1}{2a}\left[t\sin at+\dfrac{\cos at}{2a}-\dfrac{\cos at}{2a}\right]$ $L^{-1}\left[\dfrac{s}{(s^2+a^2)^2}\right]=\dfrac{1}{2a}t\sin at. \qquad (3M)$
6	**Using convolution theorem find** $L^{-1}\left[\dfrac{s}{(s^2+a^2)(s^2+b^2)}\right]$**. [MAY/JUNE 2016 R-13] (8M)**BTL3 **Answer: Refer Page No:5.81-Dr. G. Balaji.** $L^{-1}\left[\dfrac{s}{(s^2+a^2)(s^2+b^2)}\right]=L^{-1}\left[\left(\dfrac{s}{(s^2+a^2)}\right)\left(\dfrac{1}{(s^2+b^2)}\right)\right]$ $=L^{-1}\left(\dfrac{s}{(s^2+a^2)}\right)*L^{-1}\left(\dfrac{1}{(s^2+b^2)}\right)$ $=\cos at*\dfrac{1}{b}\sin bt \qquad (3M)$ $=\dfrac{1}{b}\int_0^t \cos au \sin b(t-u)du$ $=\dfrac{1}{2b}\int_0^t [\sin(au+bt-bu)+\sin(bt-bu-au)]du \qquad (2M)$

	$=\frac{1}{2b}\left[\left[\frac{-\cos[(a-b)u+bt}{a-b}\right]+\left[\frac{-\cos[bt-(a+b)u]}{-(a+b)}\right]\right]_0^t$ $=\frac{1}{2b}\left[\cos at\left(\frac{1}{a+b}-\frac{1}{a-b}\right)-\cos bt\left(\frac{1}{a+b}-\frac{1}{a-b}\right)\right]$ $L^{-1}\left[\frac{s}{(s^2+a^2)(s^2+b^2)}\right]=\frac{\cos at-\cos bt}{b^2-a^2}.$ $(3M)$ <u>Note:</u> **Using convolution theorem find** $L^{-1}\left[\frac{s}{(s^2+1)(s^2+4)}\right]$**.** **[MAY/JUNE 2015,2016 R-13] (8M)** **Hint:** In the above problem put $a=1, b=2$, **Using convolution theorem find** $L^{-1}\left[\frac{s}{(s^2+4)(s^2+9)}\right]$**.** **[MAY/JUNE 2015,2016 R-13] (8M)** **Hint:** In the above problem put $=2, b=3$.
7	**Find** $L^{-1}\left[\frac{s^2}{(s^2+a^2)(s^2+b^2)}\right]$ **using convolution theorem. [APR/MAY 2014, 2015,2016, NOV/DEC 2014, 2016 R-13] (8M)**BTL3 **Answer: Refer Page No:5.86-Dr. G. Balaji.** $L^{-1}\left[\frac{s^2}{(s^2+a^2)(s^2+b^2)}\right]=L^{-1}\left[\left(\frac{s}{(s^2+a^2)}\right)\left(\frac{s}{(s^2+b^2)}\right)\right]$ $=L^{-1}\left(\frac{s}{(s^2+a^2)}\right)*L^{-1}\left(\frac{s}{(s^2+b^2)}\right)$ $=\cos at*\cos bt$ $(3M)$ $=\int_0^t \cos au\cos b(t-u)du$

	$= \frac{1}{2}\int_0^t [\cos(au+bt-bu)+\cos(au-bt+bu)]du \qquad (2M)$ $= \frac{1}{2}\left[\left[\frac{\sin[(a-b)u+bt}{a-b}\right]+\left[\frac{\sin[(a+b)u-bt}{a+b}\right]\right]_0^t$ $= \frac{1}{2}\left[\sin at\left(\frac{1}{a-b}+\frac{1}{a+b}\right)+\sin bt\left(\frac{1}{a+b}-\frac{1}{a-b}\right)\right]$ $L^{-1}\left[\frac{s^2}{(s^2+a^2)(s^2+b^2)}\right] = \frac{a\sin at - b\sin bt}{a^2-b^2}. \qquad (3M)$ Note: **Find** $L^{-1}\left[\frac{s^2}{(s^2+1)(s^2+4)}\right]$ **using convolution theorem. [APR/MAY 2017 R-13] (8M)** **Hint:** In the above problem put $a = 1$ & $b = 2$.
8	**Find the Laplace transform of the rectangular wave given by** $f(t)=\begin{cases} k & ,0<t<b \\ -k & ,b<t<2b \end{cases}$. **[APR/MAY 2008, 2015 R-13] (8M)**BTL5 **Answer: Refer Page No:5.92-Dr. G. Balaji.** Given, $f(t)=\begin{cases} k & ,0<t<b \\ -k & ,b<t<2b \end{cases}$. This function is periodic in the interval $(0,2b)$ with period $2b$. $L[f(t)] = \frac{1}{1-e^{-ps}}\int_0^p e^{-st} f(t)dt$ $L[f(t)] = \frac{1}{1-e^{-2bs}}\int_0^{2b} e^{-st} f(t)dt$ $= \frac{1}{1-e^{-2bs}}\left[\int_0^b e^{-st}(k)dt + \int_b^{2b} e^{-st}(-k)dt\right] \qquad (2M)$ $= \frac{k}{1-e^{-2bs}}\left[\left[\frac{e^{-st}}{-s}\right]_0^b - \left[\frac{e^{-st}}{-s}\right]_b^{2b}\right] \qquad (2M)$ $= \frac{k}{s}\frac{1}{1-e^{-2bs}}\left[1-2e^{-bs}+e^{-2bs}\right]$ $= \frac{k}{s}\frac{\left[1-e^{-bs}\right]^2}{\left(1-e^{-bs}\right)\left(1+e^{-bs}\right)} \qquad (2M)$ $= \frac{k}{s}\tanh\left[\frac{bs}{2}\right] \qquad (2M)$

	Note: **Find the Laplace transform of the rectangular wave given by** $f(t)=\begin{cases}1 & ,0<t<b\\ -1 & ,b<t<2b\end{cases}$. **[APR/MAY 2013, 2014 R-13] (8M)** **Hint:** In the above problem put $k=1$. **Find the Laplace transform of the rectangular wave given by** $f(t)=\begin{cases}E & ,0<t<a\\ -E & ,a<t<2a\end{cases}$ **for all** $\boldsymbol{f(t+2a)=f(t)}$ **[NOV/DEC 2010 R-13] (8M)** **Hint:** In that above solved problem put $k=E$ and $b=a$.
9	**Find the Laplace transform of a square wave function given by** $f(t)=\begin{cases}E & for \quad 0\le t\le a/2\\ -E & for \quad a/2\le t\le a\end{cases}$ **and** $\boldsymbol{f(t+a)=f(t)}$. **[NOV/DEC 2011, 2016, MAY/JUNE 2016 R-13] (8M)** BTL5 **Answer: Refer Page No:5.95-Dr. G. Balaji.** $L[f(t)]=\dfrac{1}{1-e^{-ps}}\displaystyle\int_0^p e^{-st}f(t)dt$ $L[f(t)]=\dfrac{1}{1-e^{-as}}\displaystyle\int_0^a e^{-st}f(t)dt$ $=\dfrac{1}{1-e^{-as}}\left[\displaystyle\int_0^{a/2} e^{-st}(E)dt+\int_{a/2}^{a} e^{-st}(-E)dt\right] \qquad (2M)$ $=\dfrac{E}{1-e^{-as}}\left[\left[\dfrac{e^{-st}}{-s}\right]_0^{a/2}-\left[\dfrac{e^{-st}}{-s}\right]_{a/2}^{a}\right] \qquad (2M)$ $=\dfrac{E}{s}\dfrac{1}{1-e^{-as}}\left[1-2e^{-as/2}+e^{-sa}\right]$ $=\dfrac{E}{s}\dfrac{\left[1-e^{-as/2}\right]^2}{\left(1-e^{-as/2}\right)\left(1+e^{-as/2}\right)} \qquad (2M)$ $=\dfrac{E}{s}\tanh\left[\dfrac{as}{4}\right] \qquad (2M)$
10	**Find the Laplace Transform of triangular wave function** $\begin{cases}t & , \quad 0<t<a\\ 2a-t & , \quad a<t<2a\end{cases}$ **with** $\boldsymbol{f(t+2a)=f(t)}$. **[APR/MAY 2000, 2008, 2015, 2016, MAY/JUNE 2006, 2009, 2012, NOV/DEC 2005, 2009, 2014 R-13] (8M)** BTL5

	Answer: Refer Page No:5.94-Dr. G. Balaji. $L[f(t)]=\frac{1}{1-e^{-2as}}\int_0^{2a}e^{-st}f(t)dt$ $=\frac{1}{1-e^{-2as}}\left[\int_0^a e^{-st}tdt+\int_a^{2a}e^{-st}(2a-t)dt\right]\qquad(2M)$ $L[f(t)]=\frac{1}{1-e^{-2as}}\left[\frac{-ae^{-as}}{s}-\frac{e^{-as}}{s^2}+\frac{1}{s^2}+\frac{ae^{-as}}{s}+\frac{e^{-2as}}{s^2}-\frac{e^{-as}}{s^2}\right]\qquad(3M)$ $L[f(t)]=\frac{1}{1-e^{-2as}}\left[\frac{1-2e^{-as}+e^{-2as}}{s^2}\right]$ $=\frac{1}{s^2}\frac{(1-e^{-as})^2}{(1-e^{-as})(1+e^{-as})}$ $=\frac{1}{s^2}\frac{(1-e^{-as})}{(1+e^{-as})}.$ $=\frac{1}{s^2}\tanh\left[\frac{as}{2}\right].\qquad(3M)$
11	**Using Laplace transform technique, solve $y''+y'=t^2+2t$, given $y=4, y'=-2$ when $t=0$. [NOV/DEC 2013, MAY/JUNE 2016 R-13] (8M)**BTL 3 **Answer: Refer Page No:5.109-Dr. G. Balaji.** Given: $y''+y'=t^2+2t,\ y=4, y'=-2$ when $t=0$, $L[y''(t)]+L[y'(t)]=L[t^2]+2L[t]$ $s^2L[y(t)]-sy(0)-y'(0)+sL[y(t)]-y(0)=\frac{2}{s^3}+2\frac{1}{s^2}\qquad(2M)$ $(s^2+s)L[y(t)]=4s+2+\frac{2+2s}{s^3}=\frac{4s^4+2s^3+2+2s}{s^3}$ $L[y(t)]=\frac{4s^4+2s^3+2+2s}{s^3(s^2+s)}$ $L[y(t)]=\frac{4}{s+1}+\frac{2}{s(s+1)}+\frac{2}{s^4}\qquad(3M)$ $L[y(t)]=\frac{2}{s}+\frac{2}{s+1}+\frac{2}{s^4}$ $y(t)=2L^{-1}\left[\frac{1}{s}\right]+2L^{-1}\left[\frac{1}{s+1}\right]+2L^{-1}\left[\frac{1}{s^4}\right]$ $y(t)=2+2e^{-t}+\frac{1}{3}t^3.\qquad(3M)$
12	**Solve** $\frac{d^2y}{dt^2}+4y=\sin 2t$, **given $y(0)=3$, and $y'(0)=4$. [MAY/JUNE 2014 R-13] (8M)**BTL 3

	Answer: Refer Page No:5.106-Dr. G. Balaji. Given: $\frac{d^2y}{dt^2}+4y=\sin 2t, y(0)=3,$ and $y'(0)=4.$ $L[y''(t)]+4L[y(t)]=L[\sin 2t]$ $[s^2L[y(t)]-sy(0)-y'(0)]+4L[y(t)]=\frac{2}{s^2+4}$ $[s^2+4]L[y(t)]=\frac{2}{s^2+4}+3s+4 \qquad (3M)$ $L[y(t)]=\frac{2}{(s^2+4)^2}+\frac{3s}{s^2+4}+\frac{4}{s^2+4}$ $y(t)=\frac{2}{8}L^{-1}\left[\frac{(s^2+2^2)-(s^2-2^2)}{(s^2+2^2)^2}\right]+3\cos 2t+\frac{4}{2}\sin 2t. \qquad (3M)$ $y(t)=\frac{1}{8}\sin 2t-\frac{1}{4}t\cos 2t+3\cos 2t+2\sin 2t. \qquad (2M)$
13	**Solve** $\frac{d^2x}{dt^2}-3\frac{dx}{dt}+2x=2$ **given** $x=0$ **and** $\frac{dx}{dt}=5$ **for** $t=0$ **using Laplace transform method. [APR/MAY 2011, NOV/ DEC 2012 R-13] (8M)**BTL 3 **Answer: Refer Page No:5.100-Dr. G. Balaji.** Given: $\frac{d^2x}{dt^2}-3\frac{dx}{dt}+2x=2$ given $x=0$ and $\frac{dx}{dt}=5$for $t=0$. $L[x''(t)]-3L[x'(t)]+2L[x(t)]=L[2]$ $[s^2L[x(t)]-sx(0)-x'(0)]-3[sL[x(t)]-x(0)]+2L[x(t)]=2L[1]$ $[s^2-3s+2]L[x(t)]=\frac{2}{s}+5$ $L[x(t)]=\frac{2+5s}{s(s^2-3s+2)} \qquad (2M)$ $L[x(t)]=\frac{1}{s}+\frac{(-7)}{s-1}+\frac{6}{(s-2)}$ $x(t)=L^{-1}\left[\frac{1}{s}\right]-7L^{-1}\left[\frac{1}{s-1}\right]+6L^{-1}\left[\frac{1}{(s-2)}\right] \qquad (3M)$ $x(t)=1-7e^t+6e^{2t} \qquad (3M)$
14	**Solve using Laplace transform,** $x''-2x'+x=e^t$ **when** $x(0)=2, x'(0)=-1$**. [NOV/DEC 2015, APRIL 2017 R-13] (8M).**BTL 3 **Answer: Refer Page No:5.103-Dr. G. Balaji.** Given:

	$x''(t)-2x'(t)+x(t)=e^{t}$ $x(0)=2; x'(0)=-1$ $[s^2L[x(t)]-sx(0)-x'(0)]-2[sL[x(t)]-x(0)]+L[x(t)]=L(e^t)$ $L[x(t)](s-1)^2=\frac{1}{s-1}+2s-2-3. \quad (3M)$ $L[x(t)]=\frac{1}{(s-1)^3}+\frac{2(s-1)}{(s-1)^2}-\frac{3}{(s-1)^2}$ $x(t)=L^{-1}\left[\frac{1}{(s-1)^3}\right]+2L^{-1}\left[\frac{1}{(s-1)}\right]-3L^{-1}\left[\frac{1}{(s-1)^2}\right]$ $=e^t\frac{t^2}{2}+2e^t-3e^tt \quad (5M)$
15	**Solve by using L.T$(D^2+9)y=\cos 2t$, given that if $y(0)=1, y\left(\frac{\pi}{2}\right)=-1$. [NOV/DEC 2004, MAY/JUNE 2009, APR/MAY 2015, DEC/JAN 2016 R-13] (8M)**BTL 3 **Answer: Refer Page No: 5.99-Dr. G. Balaji.** Given: $(D^2+9)y=\cos 2t.$ $y''(t)+9y(t)=\cos 2t.$ $L(y''(t))+9L(y(t))=L(\cos 2t).$ $[s^2L[y(t)]-sy(0)-y'(0)]+9L[y(t)]=\frac{s}{s^2+4}. \quad (2M)$ $(s^2+9)L[y(t)]=\frac{s}{s^2+4}+s+k.$ $L[y(t)]=\frac{s}{(s^2+4)((s^2+9)}+\frac{s+k}{(s^2+9)}.$ $L[y(t)]=\frac{1}{5}\frac{s}{s^2+4}+\frac{4}{5}\frac{s}{s^2+9}+\frac{k}{s^2+9} \quad (2M)$ $y(t)=\frac{1}{5}\cos 2t+\frac{4}{5}\cos 3t+\frac{k}{3}\sin 3t. \quad (2M)$ $\because y\left(\frac{\pi}{2}\right)=-1$ $\therefore y\left(\frac{\pi}{2}\right)=\frac{1}{5}\cos 2\left(\frac{\pi}{2}\right)+\frac{4}{5}\cos 3\left(\frac{\pi}{2}\right)+\frac{k}{3}\sin 3\left(\frac{\pi}{2}\right)=-1$ $k=\frac{12}{5}.$ $y(t)=\frac{1}{5}\cos 2t+\frac{4}{5}\cos 3t+\frac{4}{5}\sin 3t. \quad (2M)$
16	**Find the Laplace transform of theHalf-sine wave rectifier function given by** $f(t)=\begin{cases}\sin\omega t & for \quad 0\le t\le \pi/\omega \\ 0 & for \quad \pi/\omega \le t\le 2\pi/\omega\end{cases}$ **. [NOV/DEC 2012, 2016,2019 MAY/JUNE 2017, 2019**

	R-13] (8M)BTL5 **Answer: Refer Page No:5.95-Dr. G. Balaji.** $L[f(t)] = \frac{1}{1-e^{-ps}}\int_0^p e^{-st} f(t)dt$ $L[f(t)] = \frac{1}{1-e^{-as}}\int_0^{2\pi/\omega} e^{-st} f(t)dt$ $= \frac{1}{1-e^{-2\pi/\omega s}}\left[\int_0^{\pi/\omega} e^{-st}(\sin\omega t)dt + \int_{\pi/\omega}^{2\pi/\omega} e^{-st}(0)dt\right] \quad (2M)$ $= \frac{1}{1-e^{-2\pi/\omega s}}\left[\frac{e^{-st}}{s^2+\omega^2}[-s\sin\omega t - \omega\cos\omega t\right]_0^{\pi/\omega} \quad (2M)$ $= \frac{1}{1-e^{-2\pi/\omega s}}\left[\frac{e^{-st}\omega+\omega}{s^2+\omega^2}\right]$ $= \frac{\omega}{[1-e^{-\pi/\omega s}][[s^2+\omega^2]]} \quad (2M)$

MATERIALS SCIENCE–PH8252

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OBJECTIVES

***To introduce the essential principles of materials science for mechanical and related engineering applications.

UNIT I PHASE DIAGRAMS 9

Solid solutions-Hume Rothery's rules-the phase rule-single component system-one-component system of iron-binary phase diagrams-isomorphous systems-the tie-line rule-the lever rule-application to isomorphous system-eutectic phase diagram-peritectic phase diagram-other invariant reactions-free energy composition curves for binary systems-microstructural change during cooling.

9

UNIT II FERROUS ALLOYS

The iron- carbon equilibrium diagram-phases, invariant reactions-microstructures of slowly cooled steels-eutectoid steel, hypo and hypereutectoid steels –effect of alloying elements on the Fe-C system – diffusion in solids – Fick's laws – phase transformations – T-T-T- diagram for eutectoid steel – pearlitic, baintic and martensitic transformations – tempering of martensite – steels – stainless steels –cast irons.

UNIT III MECHANICAL PROPERTIES 9

Tensile test- plastic deformation mechanisms –slip and twinning –role of dislocations in slip – strengthening methods-strain hardening – refinement of the grain size – solid solution strengthening –precipitation hardening – creep resistance –creep curves – mechanisms of creep-creep-resistant materials – fracture – the Griffith criterion-critical stress intensity factor and its determination –fatigue failure-fatigue tests- methods of increasing fatigue life –hardness – Rockwell and Brinell hardness-Knoop and Vickers microhardness.

UNIT IV MAGNETIC DIELECTRIC AND SUPERCONDUCTING MATERIALS 9

Ferromagnetism-domain theory-types of energy-hysteresis-hard and soft magnetic materials-ferrites-dielectric materials-types of polarization-Langevin –Debye equation-frequency effects on polarization –dielectric breakdown-insulating materials-Ferroelectric materials-superconducting materials and their properties.

UNIT V NEW MATERIALS 9

Ceramics-types and applications – composites: classification, role of matrix and reinforcement, processing of fiber reinforced plastics – metallic glasses: types, glass forming abilityof alloys, melt spinning process, applications-shape memory alloys: phases, shape memory effect, pseudo elastic effect, NiTi alloy, applications –nanomaterial: preparation(bottom up and top down approaches), properties and applications – carbon nanotubes: types.

TOTAL: 45 PERIODS

OUTCOMES:

Upon completion of this course,

✓ The students will have knowledge on the thermal performance of buildings,
✓ The students will acquire knowledge on the acoustic properties of buildings,

- ✓ The students will get knowledge on various lighting designs for buildings,
- ✓ The students will gain knowledge on the properties and performance of engineering materials, and
- ✓ The students will understand the hazards of buildings.
- ✓ **TEXT BOOKS:**

1. Bhattacharya, D.K. & Poonam, T. ―Materials science‖. Oxford University Press, 2015.
2. Gaur, R.K. & Gupta, S.L. ―Materials science‖. Dhanpat Rai Publishers, 2012.
3. Pandey, B.K. & Chaturvedi, S. ―Materials Science‖. Cengage Learning India, 2012.

REFERENCES:

1. Halliday, D., Resnick, R. & Walker, J. ―Principles of Physics‖. Wiley, 2015.
2. Serway, R.A. & Jewett, J.W. ―Physics for Scientists and Engineers‖. Cengage Learning, 2010.

UNIT I –PHASE DIAGRAMS

Solid solutions-Hume Rothery's rules-the phase rule-single component system-one-component system of iron-binary phase diagrams-Isomorphous systems-the tie-line rule-the lever rule-application to isomorphous system-eutectic phase diagram-peritectic phase diagram-other invariant reactions-free energy composition curves for binary systems-microstructural change during cooling.

PART * A

Q.No.	Questions
1.	**What is Solid solution?**BTL1 A solid solution is formed when two metals are completely soluble in liquid state and also completely soluble in solid state.
2	**Differentiate substitutional and interstitial solid solution with examples.**BTL5 In the substitutional solid solution, the atoms of the solvent metal are replaced in the crystal lattice atoms of the solute.Eg: In Au – Cu, the Cu atoms replace the Au atoms. In an Interstitial solid solution, the atoms of the solute fit into the interstitial, soaces of the solvent.Eg: The carbon atoms fit into the interstitial spaces of iron.
3	**Define the term phase.**BTL1 A homogeneous portion of a system that has uniform physical and chemical characteristics is called phase.
4	**What is a phase diagram?**BTL1 A graphical representation of the relationships between environmental constrains (Eg: temperature and sometimes pressure), composition, and regions of phase stability. Ordinarily under conditions of equilibrium is called phase diagram.
5	**Write the equation for Gibbs phase rule and define each of the term. (or) State Gibb's phase rule. (Anna University April/May 2014)**BTL2 The construction of phase diagrams and some of the principles governing the conditions for phase equilibriums are given by laws of thermodynamics. One of these is phase rule, proposed by J. Willard Gibbs. This rule represents a criterion for the number of phase that will co-exist within a system at equilibrium and is given by simple equation $F = C - P + N$ P – No.of phases present F – No.of degrees of freedom of the system N – No.of non-compositional variables, Say for EX. If we have 2 variables such as

	temperature and pressure.Then N = 2 Equation (1) becomes $F = C – P + 2$
6	**Define tie – line rule and lever rule.(Anna University April/May 2014)**BTL1 Tie Line rule: A Horizontal line drawn in a two phase region of a phase diagram to assist in determining the composition of two phases. Lever rule: A technique for determining the amount of each phase in a two phase system.
7	**What is meant by binary phase diagram?**BTL1 A phase diagram for a system with two components is known as binary phase diagram.
8	**Define isomorphism system. (May 2019)**BTL1 A binary phase diagram in which the two components display complete solid solubility is known as isomorphous phase diagram or isomorphous system.
9	**What is meant by eutectic phase diagram? (Anna University April/May 2014)**BTL3 When solid solubility is limited and melting points of the components are not vastly different, and eutectic phase diagram usually results.
10	**What is meant by peritectic phase diagram?**BTL1 When the melting point of the components is vastly different from each other, a peritecticphase diagram may be formed.
11	**Define eutectic and peritectic reactions.**BTL1 A reaction wherein, upon cooling, a liquid phase transforms isothermally and reversibly into tow intimated mixed solid phases. $\text{Liquid} \underset{\text{Heating}}{\overset{\text{cooling}}{\rightleftharpoons}} \underset{\text{Eutectic mixture}}{\text{Solid 1 + Solid 2}}$ A reaction wherein, upon cooling, a solid and a liquid phase transform isothermally and reversibly to a solid phase having a different composition. $\text{Liquid 1 + solid 1} \underset{\text{Heating}}{\overset{\text{cooling}}{\rightleftharpoons}} \text{New solid 2}$
12	**Distinguish eutectic and eutectoid transformations.**BTL5 In eutectic transformation, the liquid is transformed into solid solutions or intermediated phases

	Cooling Liquid $\rightleftarrows$ Solid 1 + Solid 2 Heating In eutectoid transformation, the phase involved is solids Cooling Solid 1 $\rightleftarrows$ Solid 2 + Solid 3 Heating
13	**What do you mean by Hume – Rothery rules? Define Hume Rothery's Empirical rules for the substitutional solid solutions. (Anna University April/May 2014/MAY 2018/19)**BTL3 The Hume – Rothery rules are a set of basic rules that describe the conditions under which an element could dissolve in a metal, forming a solid solution. ➢ **Size factor:** Atoms must be in similar size, with less than a 15% difference in atomic radius (to minimize lattice strain) ➢ **Crystal structure:** The materials must have similar crystal structure. ➢ **Valence**: The valence number must be similar. ➢ **Electronegativity**: Atoms must have approximately same electronegativity
14	**What are the effects of crystal structure and atomic ratio on formation of solid between two metallic elements?**BTL4 It two metals are of same crystal lattice; it is possible for complete solubility to occur over the whole composition range. It the atomic ration of solute and solvent differ by less 15%, conditions are favorable for the formation of solid solution. If the difference exceeds 15%, solid solution formation is extremely limited.
15	**What is phase diagram? (Anna University April/May 2014)**BTL1 A phase diagram in which there is only one component is called unary phase diagram.
16	**Distinguish between hypo eutectoid and hypereutectoid alloy.**BTL5

Hypo eutectoid alloy	Hypereutectoid alloy
For an alloy system displaying a eutectoid, an alloy for which the concentration of solute is less than the eutectoid composition.	For an alloy system displaying a eutectoid, an alloy for which the concentration of solute is greater than the eutectoid composition.

17	**What is meant by hypoeutectic alloy and hypereutectic alloy?**BTL3 An alloy composition between the left hand side end of the tie – line defining the eutectic reaction and eutectic composition is called hypoeutectic alloy. An alloy composition between that of the right hand side end of the tie – line defining the eutectic composition is called hypereutectic alloy.
18	**What is micro constituent?**BTL3 A phase or mixture of phases in an alloy that has a distinct appearance. Frequently, we describe a microstructure in terms of the micro- constituents rather than the actual phases.
19	**What is meant by eutectic structure?**BTL3 A two – phase microstructure resulting from solidification of a liquid having be eutectic composition; the phases exist as lamellae that alternate with one another.
20	**What is meant by eutectic reaction?**BTL3 A three phases, invariant reaction in which one liquid phase solidifies to produce two solid phases is called eutectic reaction. $$\text{Liquid} \underset{\text{Heating}}{\overset{\text{Cooling}}{\rightleftharpoons}} \text{Solid 1 + Solid 2}$$
21	**What is meant by peritectic reaction?**BTL3 A three - phase reaction in which a solid and a liquid combine to produce a second solid on cooling. $$\text{Liquid 1 + Solid 1} \underset{\text{Heating}}{\overset{\text{Cooling}}{\rightleftharpoons}} \text{New Solid 2}$$
22	**What is meant by peritectoid?**BTL1 A three-phase reaction in which, a two solids combine to produce a third solid on cooling.
23	**What useful information does a phase diagram provide?**BTL1 ➢ Prediction of number of phases ➢ Prediction of chemical composition of phases ➢ Prediction of relative amount of phases
	PART * B
1	**Explain the following invariant reaction with reference to a phase diagram: (a) Eutectic**

reaction, (b) peritectic reaction (or) Explain with a phase diagram of Eutectic &Peritectic reaction. (or) Explain with neat sketch of the eutectic systems? Give examples for this system. (or) What is a eutectic Phase diagram? Draw a typical equilibrium diagram for a eutectic type of system with limited solid solubility and explain its important. (April/May 2017), (Nov/Dec 2014), (Nov/Dec 2013), (May/June 2013) (May 2019/18) (16M)BTL2

Answer: Page :1.11 -Dr.P.MANI

EUTECTIC REACTION(6M)

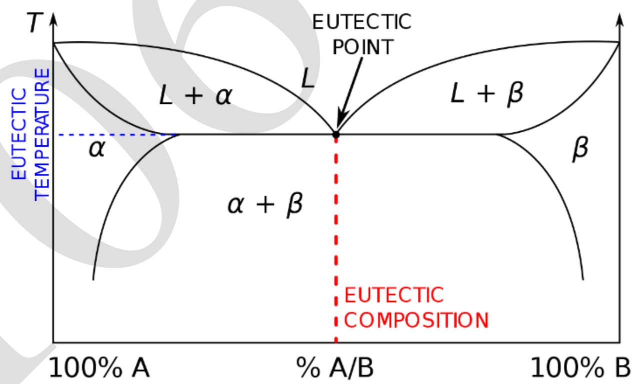
- Reversible, isothermal reaction of a liquid which transforms two different solid phases upon cooling.

  Liquid ⇌ Solid 1 + Solid 2
- Found in many metallic and ceramic systems.
- Liquid phase on cooling results formation of mixture of two solid namely

  Austenite or γ iron (solid solution of carbon in iron), and

  Cementite (Fe_3C)
- Eutectic reaction in iron-carbon (Fe-C) system

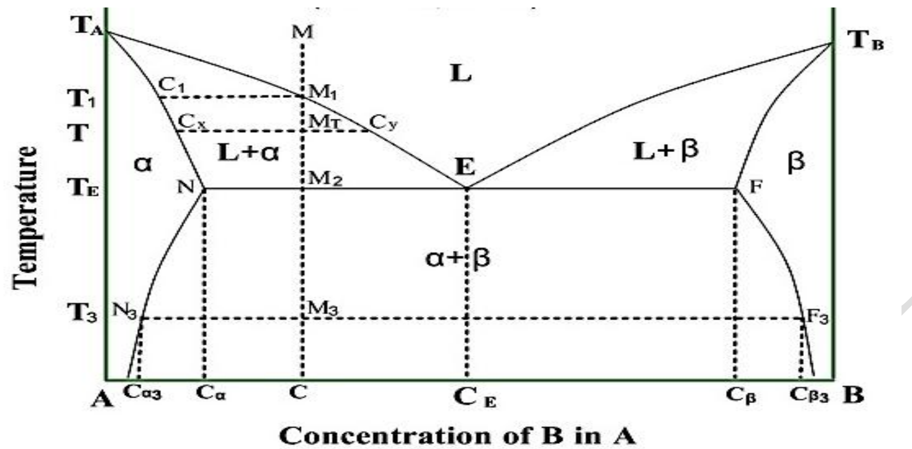
  Liquid ⇌ γ iron (Austenite) + Fe_3 C (Cementite)



EUTECTOID REACTION(6M)

- Eutectoid involves a solid-solid transformation.
- An isothermal reversible reaction one solid phase transforms into two intimately mixed new solid phases, upon cooling.

  Solid 1 ⇌ Solid 2 + Solid 3
- Found in many systems such as Cu-Al, Cu-Zr, Cu-Sn, Al-Mn, Cu-Be,so on.
- This reaction is the basis for much of the heat treating of steel and its variety of applications.

	➢ In Fe-C system, Here when austenite (γ iron) is cooled below a temperature of 723^o C, it transforms itself into a mixture of ferrite (solid solution of carbon in α iron) and Cementite (Fe_3C). γ iron (Austenite) ⇌ α iron (Ferrite) + Fe_3 C (Cementite)  PERITECTIC REACTION (4M) ➢ Upon cooling, a solid and a liquid phase transform isothermally and reversibly to a solid phase having a different composition. Liquid + Solid 1 ⇌ Solid 2 ➢ Found in Sb-Sn and Pt-Ag systems. ➢ In the eutectic, the liquid transform into two solid phases. In the Peritectic, solid and liquid phases combine to form another solid phase, looks**"upside-down eutectic".** ➢ Observed in iron-carbon system at 1450^o C and at 0.18% carbon. ➢ In iron-carbon (Fe-C) system, Liquid + δ iron ⇌ γ iron (Austenite).
2	**Discuss about (i) types of solid solutions (ii) Hume Rothery's rules and (iii) What is mean by phases. (Nov/ Dec 2013)(16M)**BTL2 **Answer: Page :1.3 -Dr.P.MANI** **SOLID SOLUTIONS** (4M) Homogeneous mixture, atoms or molecule of one substanceinto another. There are two types of solid solution, ➢ **Substitutional Solid solution,** The mixture of the two elements,Substitutional solid solution. ➢ **Interstitial solid solution,**

Solute atoms fit into space betweensolvent or parent atoms, space/voids, called ***"interstices".***

Hume Rothery's Rules(4M)

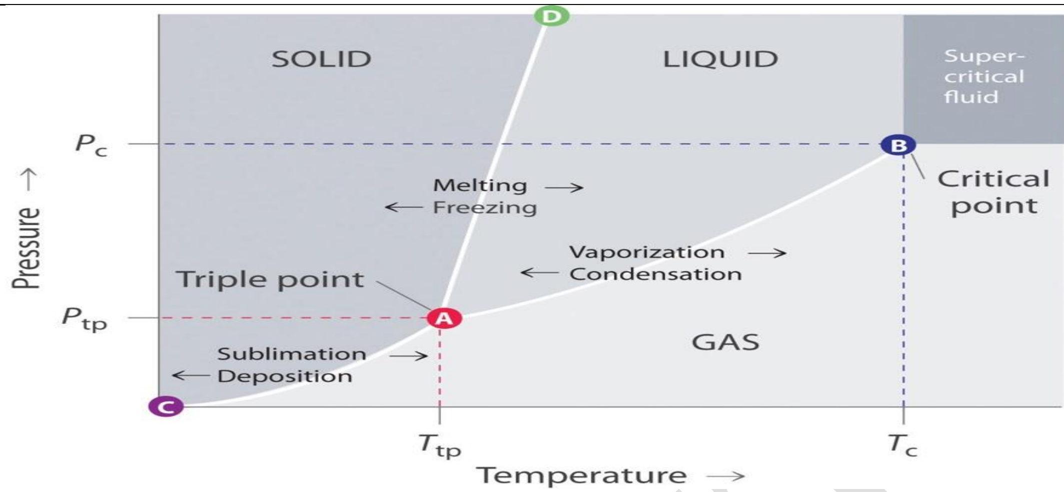
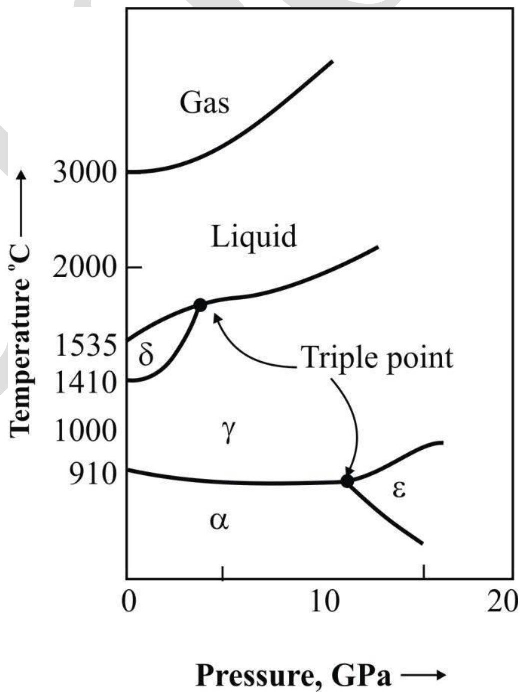
- **Size factor:** Atoms must be in similar size, with less than a 15% difference in atomic radius (to minimize lattice strain)
- **Crystal structure:** The materials must have similar crystal structure.
- **Valence**: The valence number must be similar.
- **Electronegativity**: Atoms must have approximately same electronegativity

Phase:(4M)

- A phase is defined as *"any physically distinct, homogeneous and mechanically separable portion of a substance".*
- In layman's term, a phase requires a unique structure, uniform composition, and well-defined boundaries or interfaces.
- **Examples:** A pure substance such as water is a single phase.
- Oil and water tends to form isolated regions and are considered as two distinct phases.
- A single-phase system is also termed as ***"homogeneous system".***
- System composed of two or more phases are termed as ***"mixtures"*** or ***"heterogeneous system".***

Phase diagram of pure substance (4M)

- The phases relationship may be represented on a pressure-temperature (PT) diagram. Such a pressure-temperature phase diagram, known as a ***one-component*** (or unary) ***phase diagram,*** for H_2O system.

	 ➢ ***Two-phase equilibrium line.*** ➢ ***Triple point:*** Three phases (solid, liquid and vapour phases) of a single material coexist at 0.0098^{o} C and at pressure 4.58 mm of Hg. ➢ If pressure and temperature are known, the equilibrium of the system can be found.
3	**With a neat diagram, explain one component system of iron.(ii) Discuss the free energy composition curves for binary system.(16M)**BTL2 **Answer: Page :1.16 -Dr.P.MANI** **One Component system of Iron:** In graph, X-axis pressure, Y- Axis temperature 

Single phase region (4M)

- The Gibb's phase rule for single phase diagram is,
- $F = C – P + N$
- Substituting $C = 1$, $P = 2$ and $N = 2$ in equation (1) $F = 2$.
- Therefore, both temperature and pressure can be changed independently within the limits.

Two phase regions(3M)

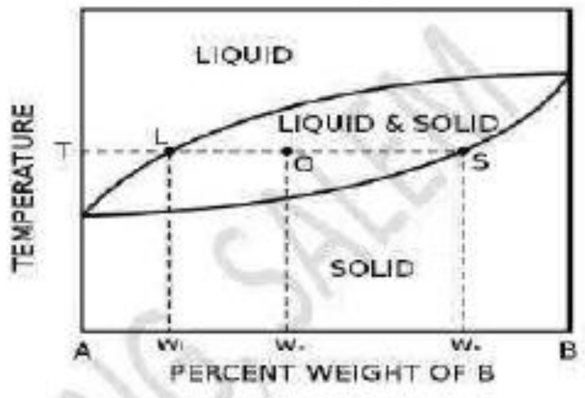
- $F = C – P + N$, $= 1-2+2$, $F = 1$
- Therefore, either temperature or pressure can be changed independently, but not both.
- Now, in order to protect the two phase equilibrium, it is essential to change the pressure by such an amount, so that we return to a point on the phase boundary.

Three phase region(3M)

- The points where 3 phase boundaries meet are called triple points.
- 2 such points (Fig.), Here $F = 0$ (pressure or temperature) can be varied arbitrarily.
- 3 phases will co-exist at particular combination of pressure and temperature.
- If we change pressure or temperature from the fixed triple – point value, one or two of the phases will disappear.

Binary Phase diagrams(6M)

- A tie line is drawn on the phase diagram to determine the percent weight of each element. On the diagram to the right it is line segment. LS.
- The percent weight of element B at the solidus is given by W_s.
- X – Axis, Percent weight of elements A and B, Y – Axis, Temperature
- The percent weight of solid liquid can then be calculated using the following lever rule equations.
- Percent weight of the solid phase = $X_s = W_o – W_L / W_s – W_L$
- Percent weight of the solid phase = $X_s = W_o – W_L / W_s – W_L$
- W_0 is the percent weight of element B for the given composition.



4

Discuss the micro structural changes for any alloy that occur on cooling in the binary isomorphous system.(16M)BTL2

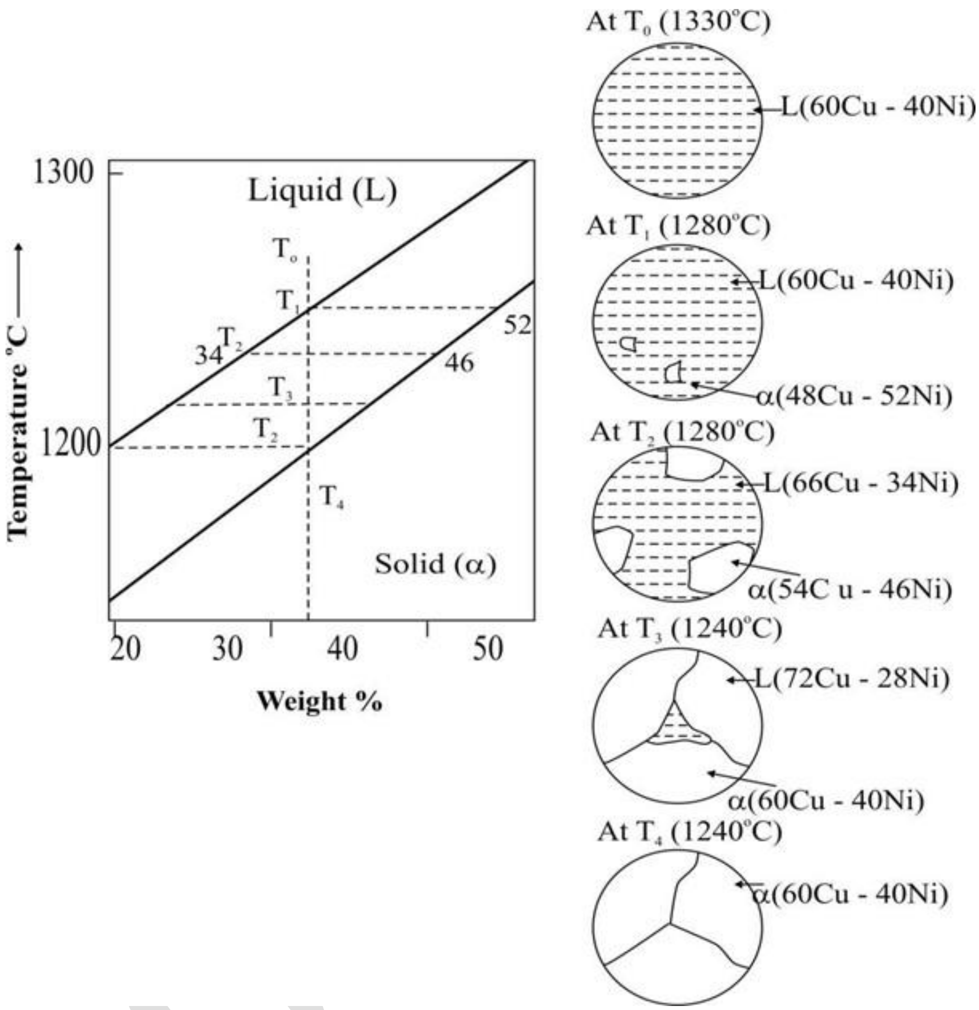
Answer: Page :1.60 -Dr.P.MANI

Binary isomorphous system

Eutectic system

BINARY ISOMORPHOUS SYSTEM(8M)

- The microstructural changes on cooling for an overall composition C_o in the Cu-Ni diagram are sketched
- The copper-nickel system, usually an alloy consists of composition 35 Wt% Ni-65 Wt% Cu when it is cooled from 1300˚C.
- Cooling of an alloycorresponds to moving down the vertical dashed line.
- At 1300˚ C, point α, the alloy is completely represented by the circle inset in the fig.
- As cooling begins and reaches the point b at 1260°C which is called liquidus line.
- At point b, the first solid α begins to form, composition of 46 Wt% Ni-54 Wt% Cu found by using tie-line.
- The composition of liquid still at 35 Wt% Ni-65 Wt% Cu which is different from solid α.
- With continued cooling, both components and relative amounts of each of the phases will change.
- The compositions of the liquid and α-phases will follow the liquidus and solid lines, respectively.
- Alloy composition (35 Wt% Ni-65 Wt% Cu) remains unchanged during cooling.
- At 1250°C, point C, compositions of the liquid and α phases are 31.5 Wt% Ni-68.5 Wt% Cu[L(31.5 Ni)] and 42.5 Wt% Ni-57.5 Wt%, Cu [α(42.5 Ni)], respectively.



- The solidification complete at about 1220 ^{o} C, point d; composition of solid α is approximately 35 Wt% Ni-76 Wt% Cu while that of the last remaining liquid is 24 Wt% Ni-76 Wt% Cu
- Upon crossing the solidus line, the final product then is a polycrystalline α-phase solid solution that has a uniform 35 Wt% Ni-65 Wt% Cu composition (point e).

MICROSTRUCTURAL CHANGE DURING COOLING FOR A EUTECTIC SYSTEM(8M)

- Let us consider the cooling of an overall composition $C_{o,}$ at Temperature T_1
- Solidification starts with β crystals of composition $C\beta_1$ coming out of the liquid.
- At a lower temperature T_2 , amount of β phase has increased.
- In composition is now different and is given by Tie-line drawn at this temperature.
- Above eutectic temperature,quantity of β crystals has further increased, their composition now being $C_{\beta E}$.

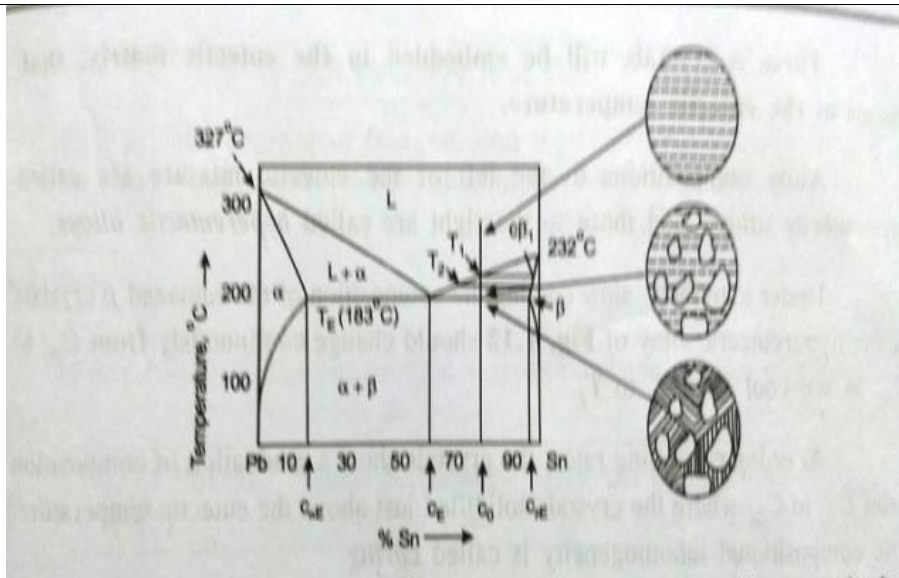


Fig. 1.12. The lead-tin phase diagram. Microstructural changes for composition c_0 are sketched

- Below the eutectic temperature, the liquid transforms according to the eutectic reaction

$$L \longrightarrow \alpha + \beta$$

  - To yield a fine mixture of thin plate-like crystals of α and β.
- The microstructure below the eutectic temperature is re-sketched.
- Large equiaxed crystals of pro-eutectic β formed before the eutectic reaction.
- The matrix in which eutectic mixture consisting of thin parallel plates of alternate α and β crystals.

Fig. 1.13
Microstructure of a hypereutectic Pb-Sn alloy, showing the proeutectic β crystals in a matrix of the eutectic mixture (schematic)

- α crystals embedded in the eutectic matrix, that forms at the eutectic temperature.
- Alloy compositions to the left of the eutectic mixture are called hypoeutectic alloys, and those to the right are called hypereutectic alloys.
- Under extremely slow cooling the composition of the equiaxed β crystals of the

hypereutectic alloy should change continuously from $C_{\beta 1}$ to $C_{\beta E}$ as we cool from T_1 to T_E.

- At ordinary cooling rates, the crystals show a graduation of composition from $C_{\beta 1}$ to $C_{\beta E}$
- The crystals solidified just above the eutectic temperature.
- The compositional inhomogeneity is called coring.

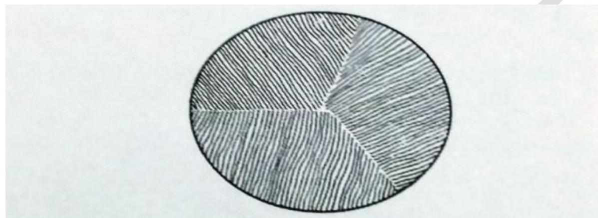


Fig. 1.14
Microstructure of a Pb-Sn alloy of eutectic composition (schematic)

5

Free energy composition curves for binary systems.(16M)BTL4

Answer: Page : 1.60 -Dr.P.MANI

<u>Construction of binary phase diagram from Gibbs free energy curves</u><u>(8M)</u>

- The two phases, liquid and solid α, are in stable equilibrium in two-phase field between liquidus and solidus lines.
- The Gibbs free energies are calculated as a function of composition for ideal liquid solutions and for ideal solid solutions of the two components A and B.

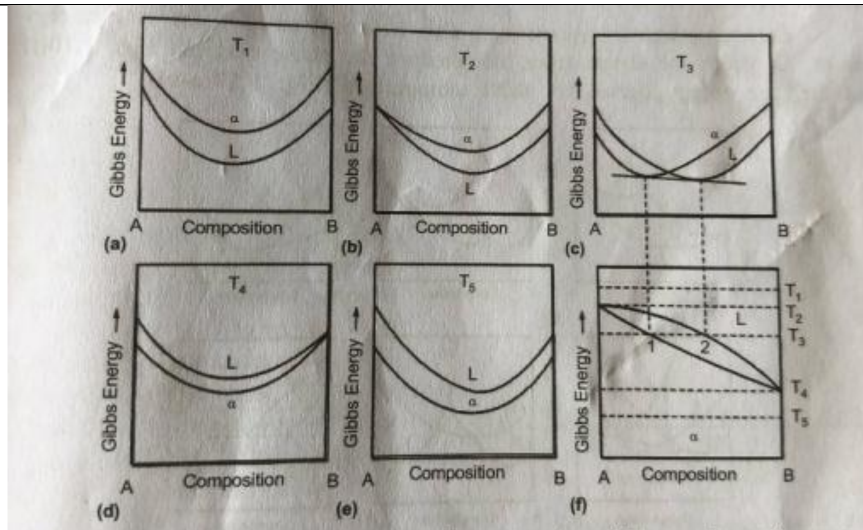


Fig. 1.9 Gibbs free energy curves and construction of binary phase diagram

- At temperature T_1, liquid solution has lower Gibbs free energy and therefore is more stable phase.
- At T_2 melting temperature of A, liquid and solid are equally stable only at a composition of pure A.
- At T_3, between the melting temperatures of A and B, free energy curves cross.
- Temperature T_4 is melting temperature of B, while T_5 is below it.

Construction of eutectic phase diagram from Gibbs free energy curves(8M)

- Eutectic phase diagrams can also be constructed from free energy curves.
- Consider the temperature indicated on phase diagram Fig. (F) and free energy curves for these temperature .

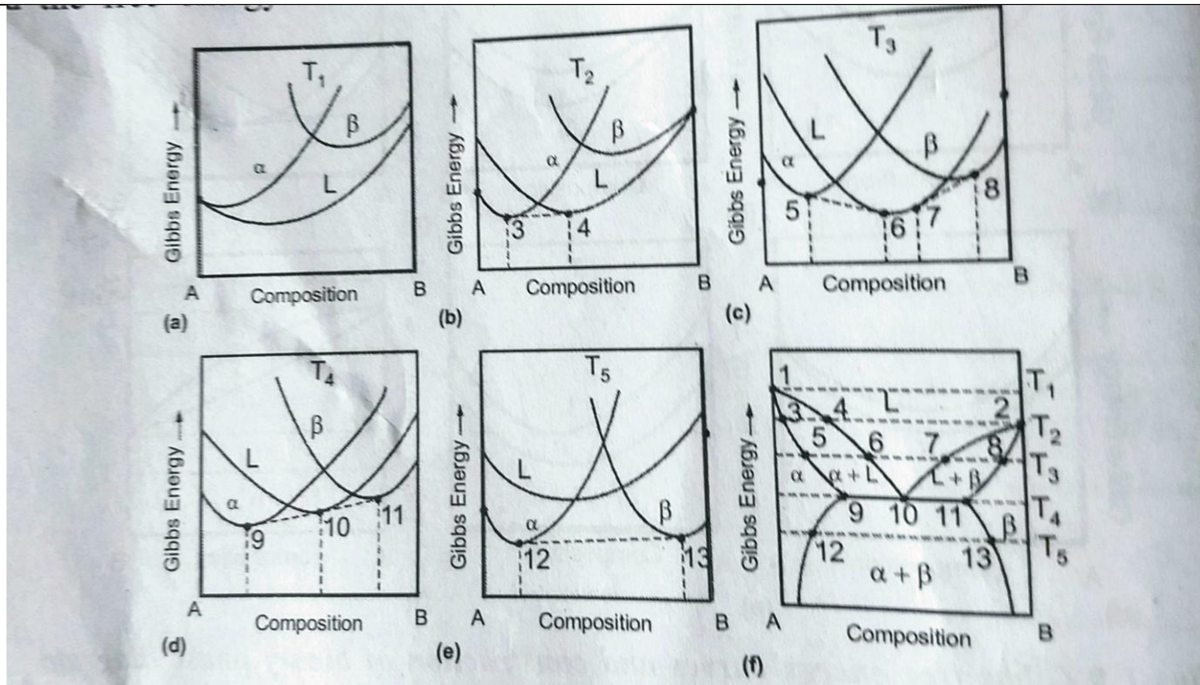
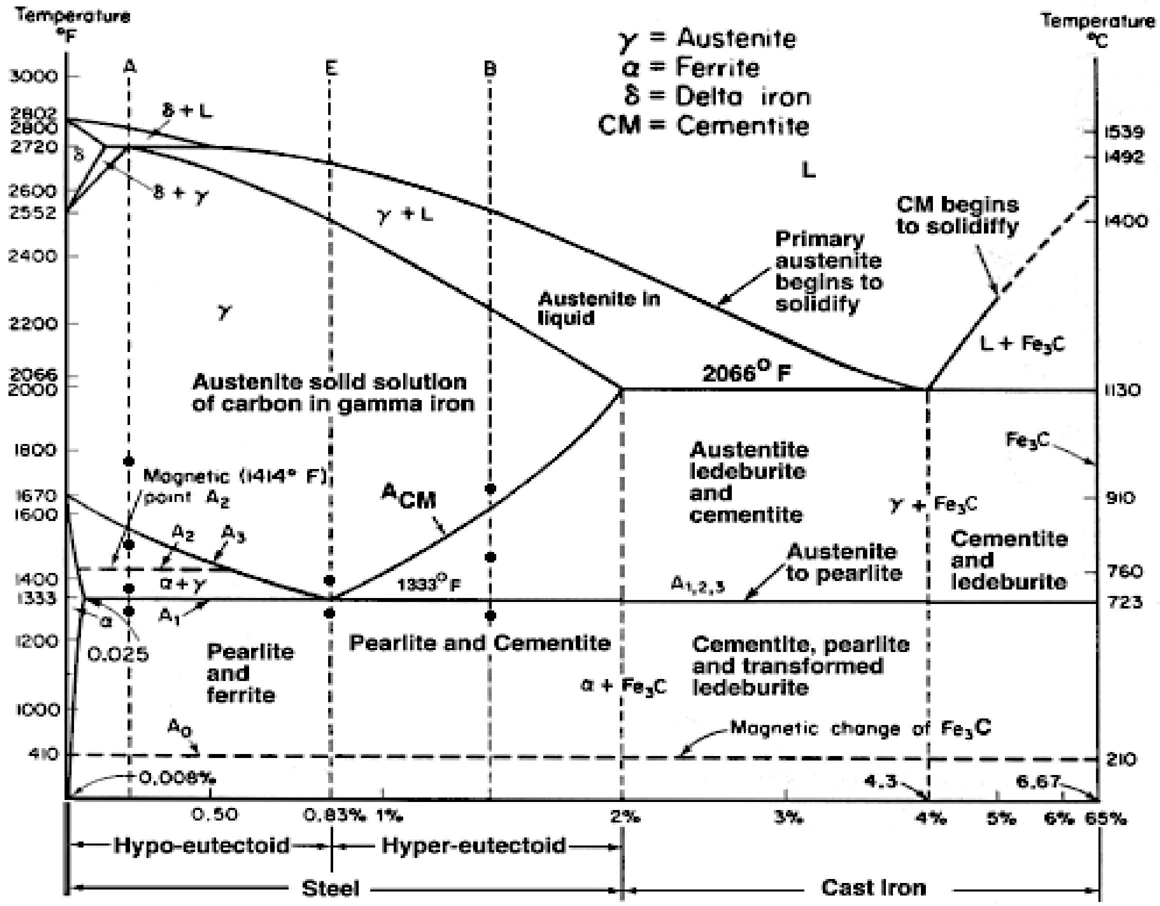


Fig. 1.10 Gibbs free energy curves and construction of eutectic phase diagra

	➢ When pints of tangency on energy curves are transferred to the phase diagram, resulting shape forms typical eutectic system.
6.	**What is binary phase diagram? Explain in detail about binary isomorphous system and the region present in it. (May 2019)** BTL2
7.	**What is peritectic reaction? Explain in detail the different phases in a peritectic phase diagram. (May 2018)** BTL2
	UNIT-II FERROUS ALLOYS
	The iron- carbon equilibrium diagram-phases, invariant reactions-microstructures of slowly cooled steels-eutectoid steel, hypo and hypereutectoid steels –effect of alloying elements on the Fe-C system – diffusion in solids – Fick's laws – phase transformations – T-T-T- diagram for eutectoid steel – pearlitic, baintic and martensitic transformations – tempering of martensite – steels – stainless steels –cast irons.
	PART * A
Q.No.	**Questions**
1.	**What is meant by ferrous alloy?**BTL2 A metal alloy for which iron is the prime constituent is called ferrous alloy.

2	**Define austenite.**BTL1 Austenite is an interstitial solid solution of carbon in gamma iron(Fe) and has FCC structure. The maximum solubility of carbon is 2.14wt% at 1147^{0}C which decreases to 0.77wt% at 727^{0}C.
3	**Define cementite.** BTL1 The inter metallic compound iron carbide is called cementite. This compound has a fixed carbon content of 6.67%C. It is an extremely hard and brittle compound.
5	**What feature in the iron-carbide diagram is used to distinguish between steels and cast iron?** BTL4 The carbon content is used to distinguish between steels and cast irons in iron-iron carbide diagram. The alloys containing solid phases with less than 2.14% carbon are known as steels and those containing more tha 2.14% carbon are known as cast irons.
6	**Distinguish between hypoeutectoid steel and hypereutectoid steels.** BTL5 Cast irons that contain less than 4.3wt% C are termed as hypoeutectic. Cast irons that contain more than 4.3wt% C are termed as hypereutectic.
7	**Give the composition of low, medium and high carbon steel.** BTL2 ➢ Low carbon steel –Chain, wires, nails, screws, structural steels like plates, rods ➢ Medium carbon steel- Connenting rods, shafts, axles, gears, laminated springs. ➢ High carbon steel-Screw drivers, saws, chisels, files, reamers, wood working tools.
8	**State Fick's law of diffusion.** BTL1 Fick's first law states that "the diffusion flux is proportional to the concentration gradient. This relationship is employed for steady- state diffusion situations $J= -D\, dc/dx$
9	**Define phase transformation and TTT diagram.** BTL1 The Time-Temperature –Transformation diagram describes the time required at any temperature for a phase transformation to begin
10	**Is it possible to harden austenitic steels by heat treatment? Why?**BTL3 It is not possible to harden austenitic steels by heat treatment as austenitic stainless steels contain 9% nickel along with 17% chromium. Since nickel is an austenite stabilizer and austenite is the stable structure even at room temperature, there is no phase transformation with temperature.
11	**What are stainless steel? Why are steels stainless?** BTL2 Stainless steels are high alloys steels containing more than 11% chromium. Chromium form a strongly adherent chromium oxide film on the surface of the steel. This film prevents corrosion and gives a pleasing appearance. So these steels are called stainless.
12	**What are tool steels? What are the general requirements of tool steels?** BTL3 The steels used especially for the shaping of metals y cutting, shearing, drawing, extruding, die-casting or rolling are called tool steels. The general requirements of tool steels are high strength, toughness, hardness, and wear resistance at room and elevated temperature.
13	**Why are steels alloyed?** BTL2 Steels are normally alloyed either to improve their corrosion resistance or to make them reactive to heat treatment.
14	**What is white and grey cast iron?** BTL1 White cast iron derives its name from the fact that is fracture surface has a white or silvery

	appearance. The microstructure of grey cast iron consists of graphite flakes, which resemble a number of potato crisps glued together at a single location.
15	**Mention the role played by diffusion.**BTL3 Diffusion plays an important role in many metallurgical process, such as phase transformations, annealing, precipitation hardening, diffusion bonding creep deformation.
16	**Cite two major differences between martensitic and pearlitic transformations.**BTL1 Two major differences are: ➢ Atomic diffusion is necessary for the pearlitic transformation, whereas the martensitic transformation is diffusionless ➢ Relative to transformation rate, the martensitic transformation is virtually instantaneous, while the pearlitic transformation is time-dependent.
17	**How is compacted graphite iron produced?**BTL4 Compacted graphite iron is produced when the molten iron is first desulphurised in the ladle and then treated at 1444 degree C with a single alloy containing appropriate amounts of Mg, Ti, Si, Carbon.
	PART * B
1	**Draw iron-iron carbide phase diagram and mark on it all silent temperature and composite fields and name the various field, line and reactions.(or) With a neat sketch, label the reaction of Fe_3 – Fe_3C.(or) Explain with a neat sketch of iron-iron carbide equilibrium diagram and indicate all phases. (or) With the help of the Fe-C equilibrium diagram describe completely the changes that take place during the show cooling of 0.5% carbon steel from liquid state. (April/May 2017), (Nov/Dec 2016),(May/June 2016), (Nov/Dec 2015), (April/May 2015), (Nov/Dec 2014), (May/June 2014), (Nov/Dec 2013)(16M)**BTL2 **The iron-iron carbide phase diagram**(12M) ➢ This phase diagram has carbon composition (weight per cent) along X-axis and temperature along the Y-axis. ➢ Phases present at various temperature for very slowly cooled iron-carbon alloy with carbon upto 6.67% carbon. ➢ At room temperature the stable form, called ferrite (or α iron), exists with BCC crystal structure. ➢ Upon heating, ferrite transform to FCC austenite (or γ iron) at 912^o C (1674 ^{o}F). ➢ This austenite continues till 1394^o C (2541 ^{o}F); at this temperature the FCC austenite transform back to a BCC phase known as δ ferrite.



(4M)

- Then finally the iron melts at 1538° C (2800 °F). All these changes are seen in the left vertical axis of the phase diagram.
- Carbon is an interstitial impurity in iron and forms a solid solution with each of α and δ ferrites, also with austenite.
- The important information that can be obtained from the Fe-Fe_3C can be studied under the following topics
- Solid phases in the phase diagram.
- Invariant reactions in the phase diagram.
- Eutectoid, hypo eutectoid and hyper eutectoid steels.
- Eutectic, hypo eutectic and hyper eutectic cast irons.

2

Discuss the classification of Cast Iron and its microstructure. (or)What are the properties and application of different types of cast iron? Explain in brief. (Nov/Dec 2016), (May/June 2016), (Nov/Dec 2015), (Nov/Dec 2013)BTL2 (16M)

Cast Iron (4M)

- Ferrous alloys with greater than 2% carbon with small amounts of silicon, phosphorus, manganese and sulphur.
- Cast iron are eutectic alloys of iron and carbon.

Features of Cast Iron

- Metallurgical substance.
- Good rigidity and good strength under compression.
- Easy castability,machinability and high durability.
- High-duty, example, spheroidal graphite irons - trong, malleable irons - tough.

Composition of Cast Iron

- Carbon 3.0 – 4.0 %
- Sulphur upto 0.1%
- Silicon 1.0 – 3.0 %
- Phosphorus upto 1.0%
- Manganese 0.5 – 1.0%

Effect of composition elements on Cast Iron(4M)

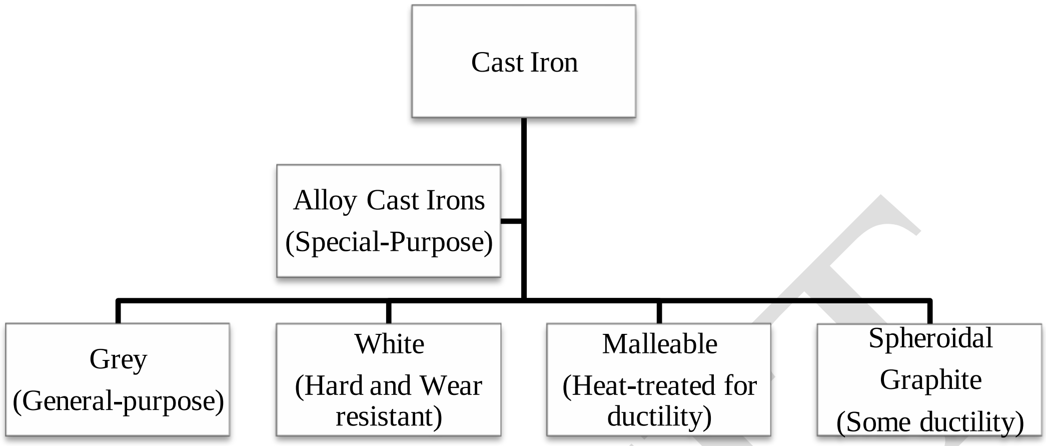
- **Carbon -** as flakes of graphite/network of hard, brittle iron carbide i.e., ***Cementite.***
- **Silicon -** It causes Cementite to unstable, decomposes and releasing free graphite.
- **Sulphur - S**tabilize Cementite, it helps to produce white iron. However,excessive sulphur causes brittleness in cast iron.
- **Manganese -** Toughens and strengthens an iron, controlling influence over harmful effects of sulphur.
- **Phosphorus -** Minimum amountgives fluidity in cast iron and brittleness.

Properties of Cast Iron (4M)

- Slow cooling rates graphite formation in iron resulting in grey irons.
- More rapid solidification will trend to give white iron structure.
- Higher silicon content for thin sections and slow cooling rate casting of thick sections.

Types of Cast Iron (4M)

There are five major types of cast irons are:



3

What is diffusion? Derive fick's first and second law of diffusion equation (Nov/ Dec 2013)BTL3 (16M)

Fick's first law of diffusion:(2M)

In a solution, concentration gradient of atoms from regions of high to low,net flux of solute is proportional to the concentration gradient.

Explanation (2M)

$$J = 1/A \times dn/dt$$

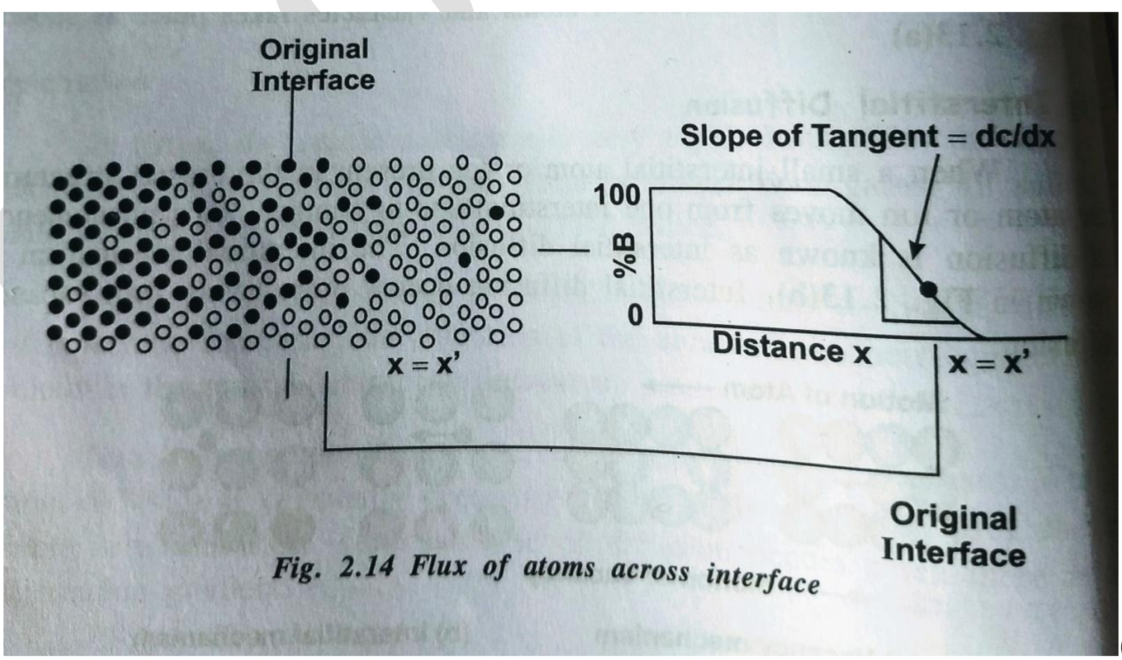


Fig. 2.14 Flux of atoms across interface

(2M)

$$J = -D \times dc/dX$$

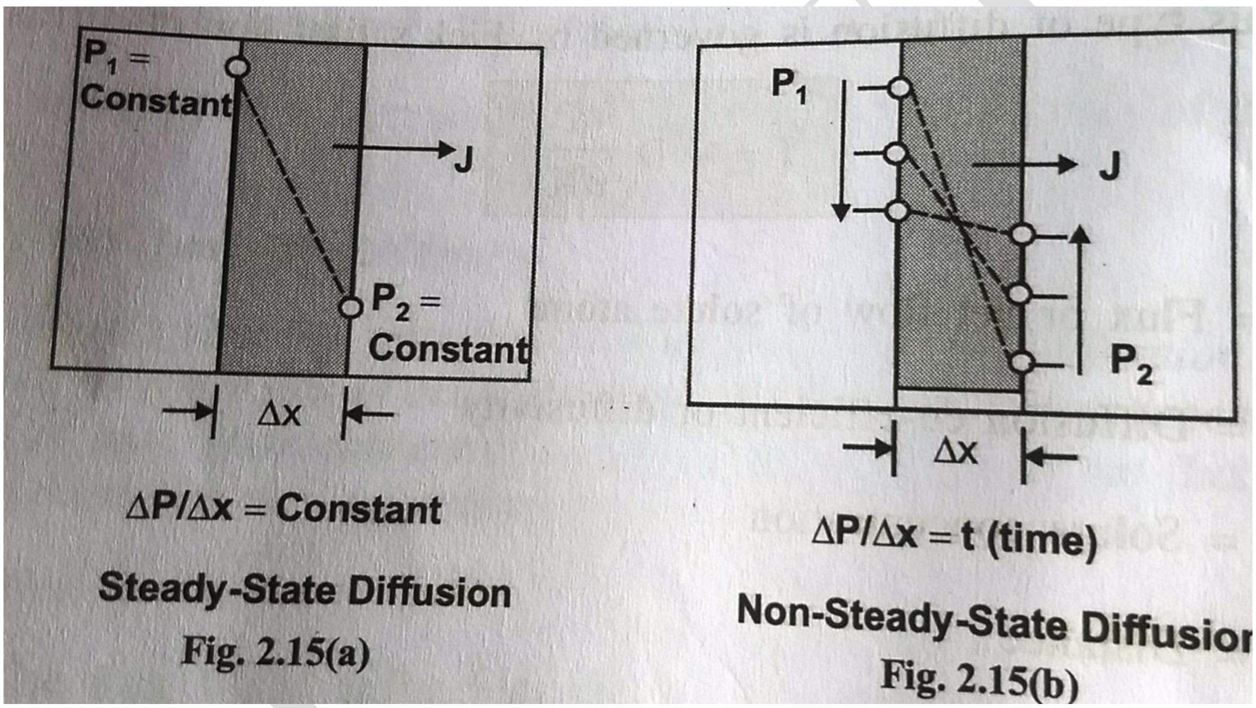
- The negative sign, diffusion from higher to lower concentration.

Fick's second law

Rate of change of concentration proportional to second derivative of concert ration gradient.

Explanation (2M)

- Non-steady-state diffusion takes place,concentration of solute atoms at any pointchanges with time
- Gas diffuses from finite volume through a membrane into another finite volume, pressures change with time, creating a pressure gradient across membrane.



(2M)

From fick's second law , rate of change of concentration gradient

$$\partial c / \partial t = -\partial j / \partial x$$

$$\partial c / \partial t = -\partial / \partial x \, [-D \, \partial c / \partial x]$$

If D - independent of concentration,

$$\partial c / \partial t = D \, \partial^2 c / \partial x^2$$

$C(x,t) = A - B \operatorname{erf}(x / 2\sqrt{Dt})$ (6M)

4	**Explain with a neat sketch the T-T-T diagram of eutectoid steel.** **Write a note on tempering of martensite? (Apr/May 2014)**BTL2(16M)

T-T-T- DIAGRAM:

- T-T-T diagram stands Time-Temperature-Transformation/isothermal-transformation diagram. It determines, constituents form as a function of temperature and time.

Definition:

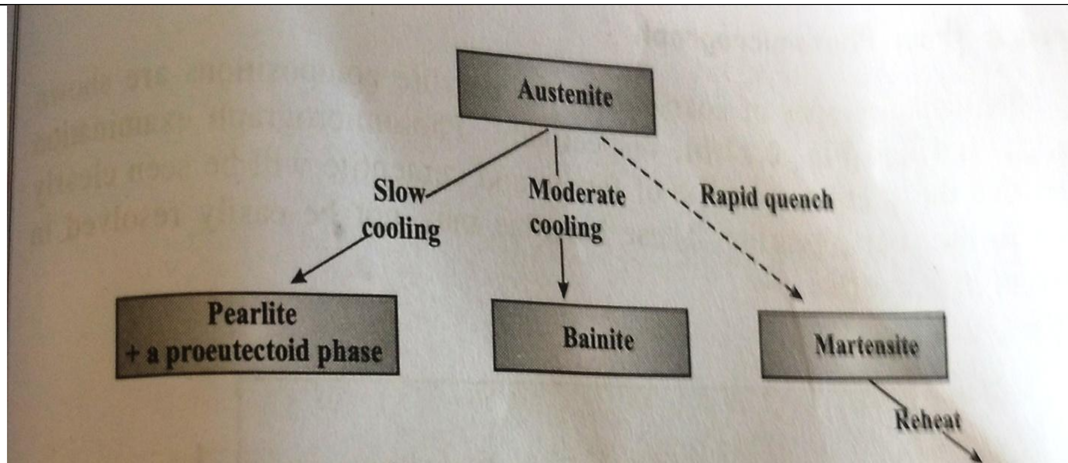
- TTT diagram, a plot of temperature versus the logarithmic of time for a steady alloy of definite composition.
- Heating / cooling of a series of samples, history of austenite transformation may be recorded.
- Indicatesstarting and ending point of a specific transformation/shows percentage of transformation of austenite when particular temperature achieved.

T-T-T- Diagram for Eutectoid steel

- When cooling rate extremely fast, iron-carbon phase diagram cannot be used, because quenching such a radical departure from equilibrium.
- At rapid cooling rates, necessary to use TTT diagram.
- After quenching, metallographic used to determine microstructure.
- Sample evaluated for other temperature such as 700, 600, 500,400.300°c and so on.
- The data are collected; they are used to plot the extent of transformation product in the microstructure.

Explanation:

- TTT diagram with transformation products on the diagram (Fig.)
- For eutectoid steel, which contains 0.76 Wt% C.
- Austenite is stable at temperature above eutectoid temp. 727°C but unstable below 727°C
- Left curve indicates start of transformation and right curve representsfinish of transformation.
- Area between the two curves indicates transformation of austenite to different types of crystal structures (Austenite to pearlite, Austenite to Bainite and Austenite to Martensite transformation).
- Nose of C-curve corresponds to a minimum time for a specified fraction of transformation.
- The nose temp. at which dX/dt is a maximum.



Possible transformations involving the decomposition of austenite. Solid arrows, transformations involving diffusion; dashed arrow, diffusion less transformation.

(8M)

TEMPERED MARTENSITE:

- Tempering:
- Martensite reheated to reduce its brittleness, without much loss of its hardness called tempering.
- (Temperatures between 250 and 650 °C).
- Formation of tempered martensite, according to reaction
- Martensite (BCT, single phase) ----------- Tempered Martensite (α + Fe_3C phases)

Fig. 2.20 Electron micrograph of tempered martensite. Tempering was carried out at 594°C (1100°F). The small particles are the cementite phase; the matrix phase is α-ferrite.

- Photomicrograph:
- Microstructure of tempered martensite consists of extremely small and uniformly dispersed

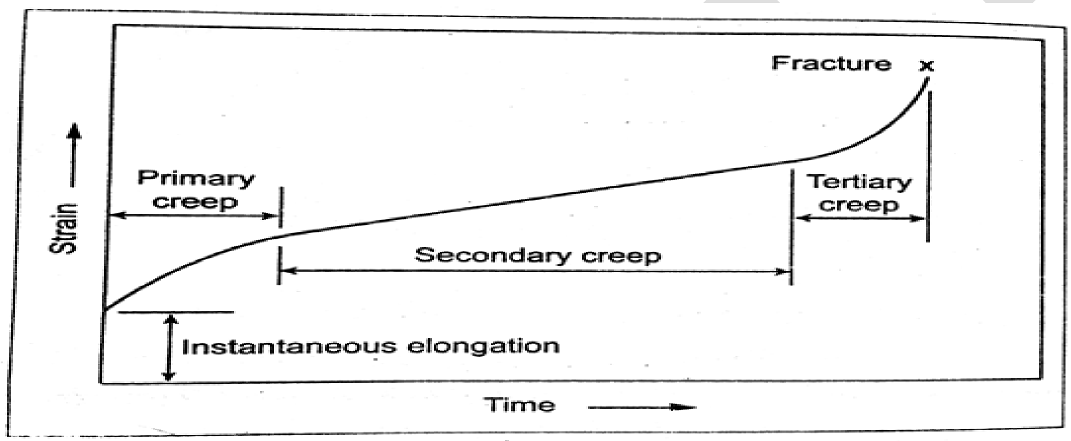
	cementite particles embedded within a continuous ferrite matrix. ➢ Tempered marensite nearly as hard and strong as martensite, but with substantially enhanced ductility and toughness. ➢ High speed steel contains very fine tungsten carbide particles after tempering, its strength at elevated temperatures. ➢ High cutting speed as compared to carbon steel. (8M)
5	**Compare Austempering and Martempering. (Nov/Dec 2015)**BTL4 (16M) **Martempering (marquenching)** ➢ Martempering / marquenching,an interrupted cooling procedure for steels, minimize stresses, distortion and cracking of steels that developed during rapid quenching. ***Martempering process*** ➢ Step1: Heating steel above its critical range to make it all austenite. ➢ Step2: Quenching steel in hot oil molten salt at a temperature just slightly above the martensite start temperature(M_s). ➢ Step3: Holding steel in quenching medium until temperature and stopping isothermal treatment before austenite-to-bainite transformation begins. ➢ Step4: Cooling at a moderate to room temperature (usually in air). ➢ Show cooling path for martempering process. ➢ Microstructure of martempered steel seems untemperedmartensite. ➢ Untemperedmartensite structuretransformed into tempered martensite structure byheat treatment processing. ***Application*** ➢ Martempering process mostly used in alloys steels. ***Advantages*** ➢ Minimized quenching stresses. ➢ Minimized change of deformation of quenching cracks. ➢ Less distortion or warping. (8M) **Austempering** ➢ Austempering / isothermal heat treatment process,used to reduce quenching distortion and to make a tough strong steels. ➢ An interrupted quenching that forms bainite structure.

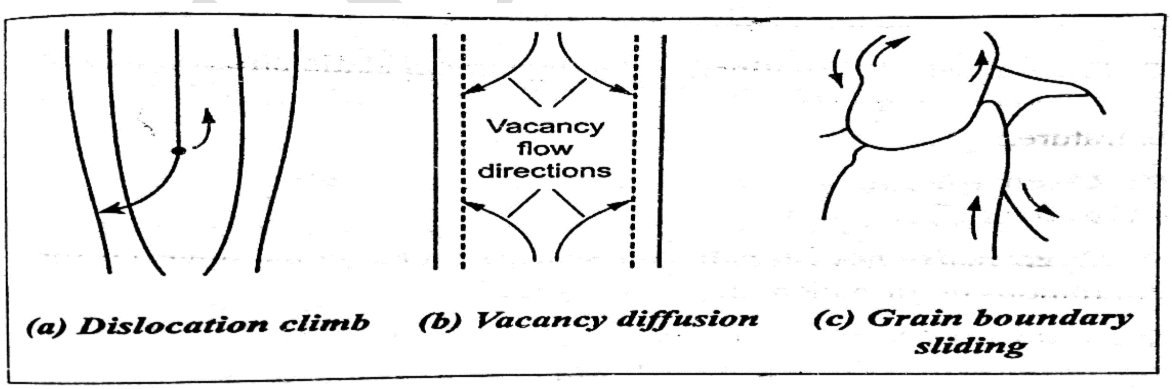
	Austempering process ➢ Consider a steel, ➢ Quenching to austenize steel in a molten salt bath at a temperature just above the martensite start temperature. ➢ Holdingisothermally to allow austenite-to-bainite transformation. ➢ Slow cooling to room temperature in air. ➢ Resulting microstructure to bainite. ➢ Unlike martempering, tempering rarely needed after Austempering. ***Application*** ➢ Austempering widely applied on small tools, springs, retainers. ➢ Automobile seat belt component, like chains, lawnmower blades and various machinery parts. ***Advantages*** ➢ Improved ductility. ➢ Increased impact strength and toughness. ➢ Decreased distortion. ➢ Less danger of quenching cracks. ***Disadvantages*** ➢ Need for a special molten salt bath. ➢ Used in limited number of steels. ➢ Small sections (upto 9 mm thick) are suitable for Austempering. ➢ Big sections cannot be cooled rapidly to avoid the formation of pearlite. (8M)
	UNIT-III- MECHANICAL PROPERTIES
	Tensile test- plastic deformation mechanisms –slip and twinning –role of disloacations in slip – strengthening methods-strain hardening – refinement of the grain size – solid solution strengthening –precipitation hardening – creep resistance –creep curves – mechanisms of creep-creep-resistant materials – fracture – the Griffith criterion-critical stress intensity factor and its determination –fatique failure-fatigue tests- methods of increasing fatigue life –hardness – Rockwell and Brinell hardness-Knoop and Vickers microhardness.
	PART * A
Q.No.	**Questions**
1.	**What is meant by Tensile Test? (Anna University Nov/Dec 2013)**BTL1 A tensile test is a fundamental type of mechanical test performed to determine their suitability for specific engineering or construction applications of ensures quality.

2	**Mention the uses of Tensile Test.** BTL3 The tensile test is used to determine ➢ Ultimate tensile strength (UTS) ➢ Ductility ➢ Toughness ➢ Yield strength ➢ Resilience and other mechanical properties.
3	**What is the principle of Tensile Test?**BTL1 If a metallic specimen is subjected to a gradually increasing uniaxial tensile load, it gets plastically deformed and finally fails [breaks]. During plastic deformation, changes in cross sectional area and length occur.
4	**What properties are determined from Tensile test of metallic products?**BTL1 ➢ Yielding properties - proportional limit, elastic limit, yield strength, proof stress ➢ Strength properties – ultimate tensile strength, breaking stress ➢ Elastic properties – modulus of elasticity, resilience ➢ Ductility - percent elongation, percent reduction ➢ Toughness
5	**Distinguish between proportional limit and elastic limit.**BTL4 Proportional limit is the highest stress up to which the stress is directly proportional to strain. Elastic limit is the highest stress upto which the deformation is elastic.
6	**Define proof stress.** BTL1 Proof stress may be defined as the stress at which the material s shows a specific amount of plastic deformation or permanent set (change).
7	**Define ultimate tensile strength and modulus of elasticity based on stress – strain curve.**BTL2 Ultimate tensile strength is the maximum stress on the engineering stress – strain curve. Modulus of elasticity is the slope of the stress – strain curve in the elastic region.
8	**What important information is obtained from the percent elongation?**BTL1 The ability of a material to undergo plastic deformation without fracture is known as ductility. This is measured by percent reduction or percent elongation.

9	**What is meant by resilience and toughness?**BTL1 Resilience is the strain energy absorbed by the material in the elastic region per unit volume. It is the area contained under the elastic portion of the stress –strain curve Toughness is the total energy absorbed by the material per volume prior to its fracture. It is the total area under the stress – strain curve.
10	**Define plastic deformation.** BTL2 Permanent deformation is a permanent deformation that remains even after the removal of load
11	**Name the mechanics of plastic deformation in metals.**BTL3 Plastic deformation in metals takes place by two mechanisms. They are slip and twinning.
12	**Define slip.**BTL1 During plastic deformation, the atoms on certain crystallographic plates glide over the other. This cause a permanent displacement of one part of crystal related to the other. This phenomenon is called slip.
13	**What are slip system?** BTL1 Slip occurs in some specific planes (high density planes) and specific directions (high density directions) The combination of the slip plane and the slip direction is called slip system. A_d – area after deformation
14	**What is Hall – Petchequation?**BTL2 Hall petch equation is $\sigma_y = \sigma_o + k_y / \sqrt{d}$ σ_y – yield strength d – Average grain diameter k_y – A locking parameter which is a measure of the relative hardening contribution as grain boundaries σ_0 - A friction stress which represents overall resistance of the lattice to dislocation motion.
15	**Define solid-solution strengthening.**BTL1 Increasing the strength of a metallic material through the formation or a solid solution is called solid – solution strengthening.
16	**What are the factors responsible for solid – solution strengthening?** BTL1 Concentration of solute atoms

	Shear modulus of solute atoms Atomic size difference.
17	**Define precipitation hardening?**BTL1 Precipitation hardening is a process which small particles of a new phase precipitate in matrix which harden material by forming impediments to dislocation motion.
18	**Why precipitation hardening is called Age hardening?**BTL5 Precipitation hardening is also called Age hardening because hardness often increases with time or as the alloy ages.
19	**What is meant by solution heat treatment?**BTL1 In solution heat treatment, all solute atoms are dissolved it form a single phase solid solution.
20	**What is meant by precipitation heat treatment?**BTL1 If the supersaturated α solid solution is heated to an intermediate temperature within the two phase region, then is called as precipitation heat treatment.
21	**Define creep.**BTL1 Slow and progressive deformation of a material with time under a constant stress at a temperature approximately above 0.4 T_m [T_m is melting temperature].
22	**Define Creep resistance?**BTL1 Creep resistance can be defined as a materials ability to resist any kind of distortion when under a load over an extended period of time.
23	**Name few mechanisms whereby creep deformation occurs.**BTL3 ➢ Dislocations climb ➢ Dislocation glide ➢ Diffusion creep ➢ Grain boundary sliding
24	**Suggest few methods to improve the creep resistance in alloys.**BTL3 Dispersion strengthening and reduction of grain boundaries by single grain solidification are few methods to improve the creep resistance in alloys.
25	**Vickers hardness number? (Anna University Nov / Dec 2013)**BTL2 HV = 1.854P / d^2 P- applied load in kg $d = d_1 + d_2 / 2$

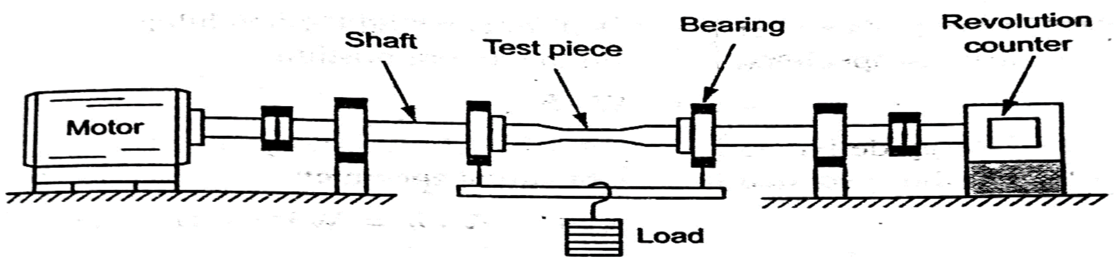
26	**Define fracture.** BTL1 Fracture is defined as the separation of a solid body into two or more pieces in response to the applied stress.
	PART * B
1	**Draw a typical creep curve and brief on the mechanism. (Nov/dec-2015)** BTL1(16M) Definition (2M) Material deforms continuously under a steady load. CREEP CURVE (2M) ➢ Creep curve showsvariation of extension of metal under different stresses. ➢ Typical creep curve under constant nominal stress and constant temperature.  *Typical creep curve for a long time, and high temperature creep test* (2M) Three distinct stages of creep curve PRIMARY CREEP ➢ In this stage creep mainly due to dislocation movement. ➢ Creep rate decreases with time. ➢ During this stage, recovery effect is less than work-hardening effect. Hence, creep rate decreses logarithmi-cally. (2M) Secondary Creep ➢ During this stage, rates of work hardening and recovery are equal, So, material creeps at steady rate. ➢ Steady rate creep may be viscous or plastic in character,depending uponstate level and temperature. ➢ Importans part of creep curve which is used to setimate service life of alloy. (2M)

	TERTIARY CREEP: ➢ This stage, creep rate increases wit time until fracture occurs. ➢ Generally tertiary creep occurs due to necking of specimen or boundary sliding. **IMPORTANT CREEP RELATED PROPERTIES** CREEP STRENTH:Constnt nominal stress will cause a specified creep extension in given time at constant temperature. CREEP LIMIT: Maximum static stress will result in creep at a rate lower than some assigned rate at a given temperature. CREEP LIFE: Time required for occurance of creep fracture under a given static load. CREEP RESISTANCE: Resistance offered by material for its continous deformation under steady load. FACTOR AFFECTING CREEP ➢ Grain size. ➢ Thermal stability of micro-structure. ➢ Chemical reaction. ➢ Prior strain. MECHANICAL OF CREEP FRACTURE: ➢ Dislocation ➢ vacancy diffusion,and ➢ grain boundary sliding. (4M)  *Mechanism of creep* (2M)
2	Draw the typical S-N curve of fatigue testing and brief on the mechanism. (Nov/Dec-2015) BTL1(16M)

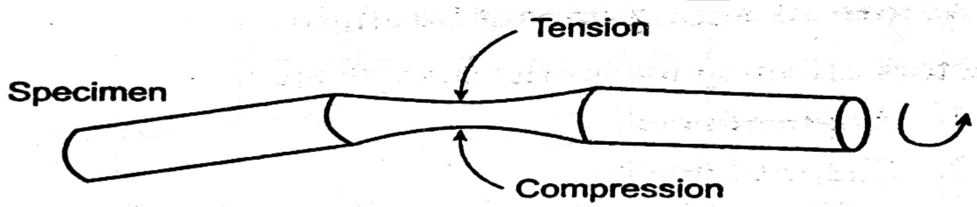
- Determines resistence of material to repeated pulsatingof flucatuating loades.
- FATIGUE DEFINED: Capacity to withstand repeatedly applied load.
- Fatigue failure is characteristed by its fatigue or endurance limit.
- Endurance limit or endurance strength: Maximum stress whichspeciman can endure without failure when this stress is repeated number of cycles. (4M)

ARRANGEMENT:

Schematic arrangement of most commenly used rotating beam fatigue.



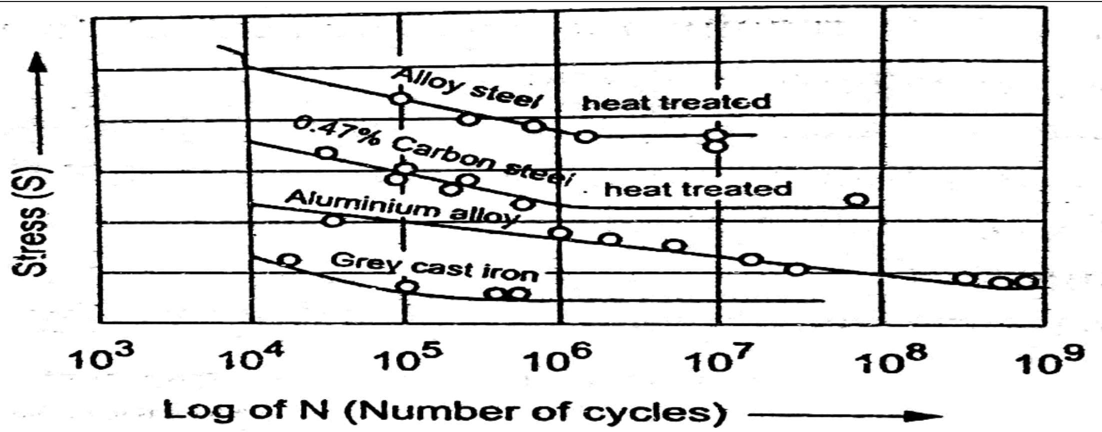
Rotating beam fatigue testing machine



(2M)

TESTING PROCEDURE:

- Specimen rotated using an electric motor.
- Upper surface specimansubjected to tension and its lower surface experiences compressive stress.
- As speciman rotates, sinusoidal variation of stress between state of maximum tensile stress and state of maximum compressive stress.
- Cycles of stress applied untill speciman to fracture. Reduction counter records number of stress cycles.
- At least six specimens are tested same manner under different stress levels
- Number of cycles (N) in X-axis and stress (S) inY-axis, S-N graph formed. (4M)



Fatigue test (S-N) curves

(2M)

RESULTS OF THE FATIGUE TEST

- Maximum allowable loades can be applied to prevent failure.
- Usefull in setting the design criterion with the use of endurance limit.
- Durability of a componant at a particular stress.
- Endurance ratio $= \frac{Endurancelimit}{Tensilestrength} = 0.5$.
- Endurance or fatigue ratio allows us to estimate fatigue properties from tensile test. (2M)

3

Sketch and describe the hardness tests Brinell, (Nov/Dec-2017, May 2018, May 2019)BTL1 (12M)

TYPES OF HARDNESS TESTS

- Brinell hardness test
- Vickers hardness test and
- Rockwell hardness test (2M)

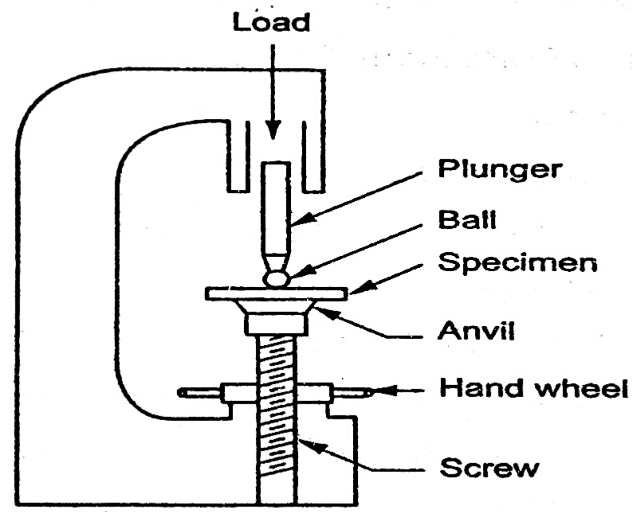
Basic Common Principle

Hardness measured from an indentation produced on surface by applying a constant load for a fixed time. (2M)

BRINELL HARDNESS TEST

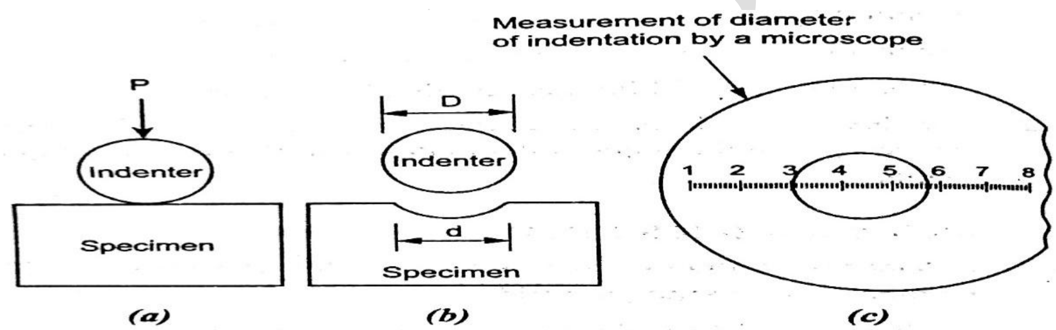
- A hardened steel ball indenter forced into surface of metal to be tested.
- Diameter of hardened steel (or tungsten carbide) indenter is 10mm.
- Standard loads range between 500kg to 3000kg increments.
- Load is maintained constant for 10 to 15 seconds. (2M)

Testing Arrangement and Procedure



A Brinell hardness testing machine **(2M)**

- Performed by pressing a steel ball /Indenter, into specimen.
- Diameter of an impression measured with help of calibrated microscope.



Brinell hardness test

$$\textbf{BHN} = \frac{\text{Load on the ball}}{\text{Area of identation of steel ball}}$$

$$= \frac{P}{\frac{\pi D}{2}[D - \sqrt{D^2 - d^2}}$$

Where P - Load applied on indenter in kg,

D - Diameter of steel ball indenter in mm,

d - Diameter of ball impression in mm.

✓ BHN - higher,material is harder. BHN - less, metal is soft (2M)

Limitation of Brinell Hardness Test

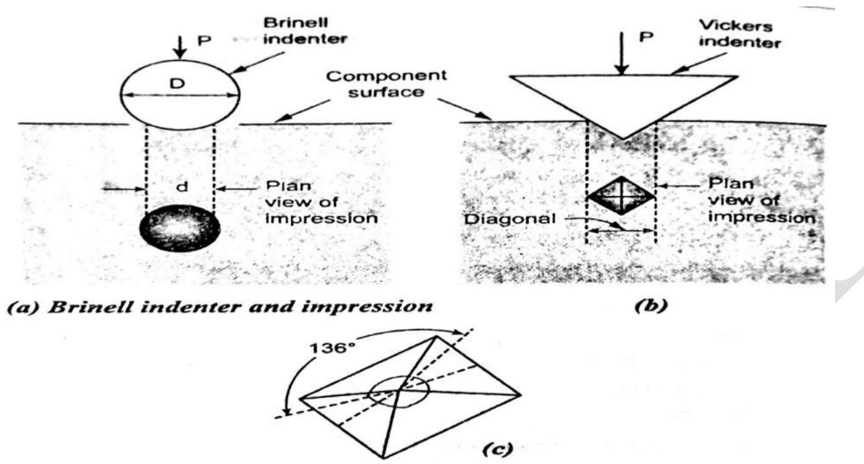
- It cannot be used on very hard or very soft materials.
- The test may not be valid for thin specimens.
- The test is not valid for case-hardened surfaces.

- The test should be conducted on a location of indentation edges only. (2M)

4

<u>Sketch and describe the hardness test :Vickers Hardness Test (Nov/Dec 2017)</u><u>BTL1(16M)</u>

- Vickers hardness test is similar to Brinell test, but, with square-based diamond pyramid as indenter.



(b) & (c) Vickers indenter and impression

Brinell hardness test

- Indenter forced into surface of material under action of a static load for 10 to 15 seconds
- Standard indenter a square pyramid shape with an angle of 136˚ between opposite faces
  - VHN $=\frac{Applied\ \ load}{Surface\ \ area\ \ of\ \ impression}$
    - $=\frac{2P\ Sin\ \frac{\theta}{2}}{D^2}$ (or) $=\frac{1.8544\ P}{D^2}$
- Where P = Applied load in kg,
  - θ = Angle between the opposite faces of diamond = 136 ˚
  - D = Mean diagonal length in mm. (8M)

ADVANTAGES OF VICKERS HARDNESS TEST

- Vicker test has following advantages over the brinell test.
- Diagonals of square indentation measured accuretly than diameters of circles.
- Suitable for hard materials and soft materials.
- Hardness number is independent of load applied . (4M)

LIMITATION OF VICKERS HARDNESS TEST:

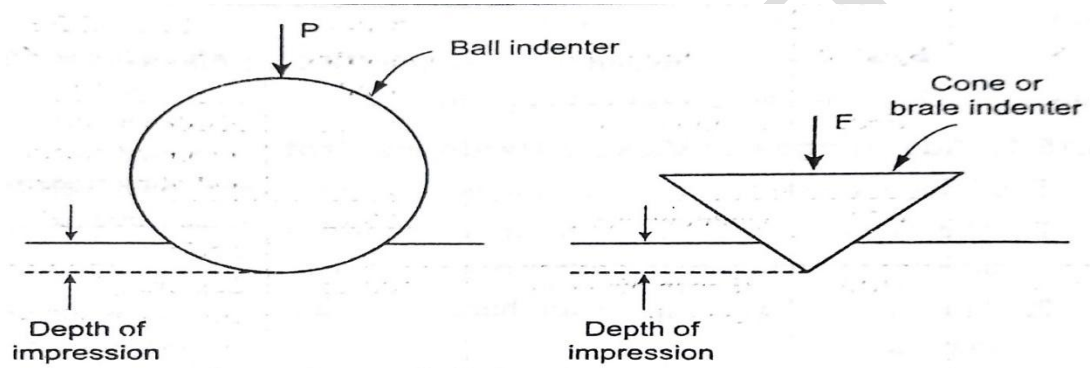
- Impression is very small.
- It requires careful surface preparration of specimen.

- It takes a relativly long time to perform a vickres hardness test. (4M)

5

Sketch and describe the hardness test :Rockwell Hardness Test (Nov/Dec 2017, May 2018, May 2019)BTL1(16M)

- Most widely used methods of hardness testing due to its accuracy and simplicity.
- Rockwell test principle is depth of impression is related to hardness rather than diameter or diagonal of impression.
- A dial that gives a direct reading of hardness; no need for measuring indentation diameter or diagonal length using microscope.



Rockwell indenter (4M)

Table. Rockwell hardness scales

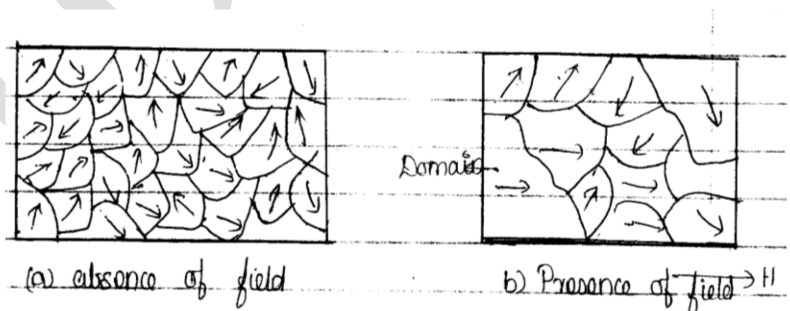
Scale	Symbol	Indenter	Total identing load	Material for which scale
A	HRA	Diamond cone	60 kg	Thin hardened steel strip
B	HRB	1/16 inch diameter steel ball	100 kg	Mild steel and non-heat treated medium carbon steels
C	HRC	Diamond cone	150 kg	Hardened and tempered steels and alloy steels
D	HRD	Diamond cone	100 kg	Case hardened steels
E	HRE	1/8 inch diameter steel ball	100 kg	Cast iron, aluminium alloys and magnesium alloys
F	HRF	1/16 inch diameter steel ball	60 kg	Copper and brass
G	HRG	1/16 inch diameter steel ball	150 kg	Bronzes, gun metal and beryllium copper
H	HRH	1/8 inch diameter steel ball	60 kg	Soft aluminium and thermoplastics
K	HRK	1/8 inch diameter steel ball	150 kg	Aluminium and magnesium alloys
L	HRL	1/4 inch diameter steel ball	100 kg	Thermoplastics
R	HRR	1/2 inch diameter	60 kg	Very soft thermoplastics

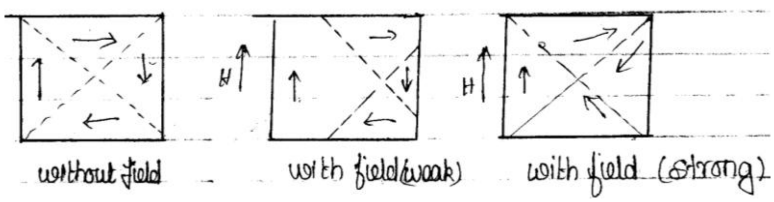
(4M)

	Testing Procedure ➢ Material held on the anvil of machine. ➢ Test piece raised by turning hand wheel, till it just touches indenter. ➢ A minor load of 10 kg is applied to seat specimen. Then, dial indictor is set at zero. ➢ Major load (100 kg for B-scale or 150 kg for C-scale) is applied to indenter to produce a deeper indentation. ➢ After indicating pointer has come to rest, major load is removed. ➢ Pointer now indicates Rockwell hardness number on dial. (4M) ➢ **Advantages of Rockwell Hardness Test** ➢ Very simple to use. ➢ Hardness can be read directly in a single step. ➢ Each measurement requires only a few seconds. ➢ Suitable for routine test of hardness in mass production. ➢ Used to test materials over a greater range of hardness. ➢ Used on metallic materials and plastics. ➢ **Limitations of Rockwell Hardness Test** ➢ Rockwell test not as accurate as Vickers testpreferred for research and development works. (4M)
	UNIT IV MAGNETIC,DIELECTRICAND SUPERCONDUCTING MATERIALS
	Ferromagnetism-domain theory-types of energy-hysteresis-hard and soft magnetic materials-ferrites-dielectric materials-types of polarization-Langevin –Debye equation-frequency effects on polarization –dielectric breakdown-insulating materials-Ferroelectric materials-superconducting materials and their properties.
	PART*A
Q.No.	**Questions**
1.	**What is meant by magnetic materials? Give example. (June 2009, June 2010)** BTL1 The materials which can be easily magnetized by keeping it in an external magnetic field are called magnetic materials. Eg: Iron, Ferrites, etc
2	**Define Magnetic dipole moment. (May 2003)**BTL1 A system having two opposite magnetic poles separated by a distance‘d’ is called as a magnetic dipole. If ‘m’ is the magnetic pole strength and ‘l’ is the length of the magnet, then its dipole moment is given by M = ml

3	**Define magnetic field intensity (H).(June 2010)**BTL1 It is defined as the force experienced by a unit North Pole placed at the given point in a magnetic field.
4	**Define magnetization (or) Intensity of magnetization (I).** BTL1 It is the process of converting a nonmagnetic material into a magnetic material. It is also defined as the magnetic moment per unit volume.
5	**Define magnetic flux density (or) magnetic induction.** BTL1 It is defined as the number of magnetic lines of force passing normally through unit area of cross section
6	**Define magnetic permeability.** BTL1 It is defined as the ratio between magnetic flux density (B) and the magnetic field intensity (H). it is the measure of degree at which the lines of force can penetrate through the material.
7	**Define magnetic susceptibility.(Nov. 2002, June 2010)**BTL1 It is the measure of the ease with which the specimen can be magnetized by the magnetizing force. It is the ratio between intensity of magnetization (I) and magnetic field strength (H).
8	**What do you understand by the term magnetic domains?**BTL2 Magnetic domains are small regions in a ferromagnetic material where all the dipoles are aligned in the same direction.
9	**What is Bohr magneton?(Nov. 2002, Nov. 2003, June 2009, June 2010)**BTL1 The orbital magnetic moment and spin magnetic moment of an electron in an atom can be expressed in terms of atomic unit of magnetic moment called Bohr magneton. 1 Bohr magneton=$eh/4\pi m=9.27x10^{-24}$ Am^2
10	**Define hysteresis.(May 2009, May 2011)** BTL1 When a ferromagnetic material is made to undergo a cycle of magnetization, the intensity of magnetization and the magnetic flux density lags behind the applied magnetic field.This process is known as hysteresis.
11	**What are the four types of energy involved in the growth of magnetic domains?**BTL1 The four types of energies involved in the growth of magnetic domains are ➢ Exchange energy ➢ Anisotropy energy ➢ Domain wall energy

	➢ Magneto-strictive energy.
12	**What is meant by reversible and irreversible domains?**BTL1 When the external magnetic field applied to a domain is increased, it starts expanding. Now when the external magnetic field is removed, if the domain returns to its original position it is called reversible domains and if the domain doesn't returns to its original position it is known as irreversible domains.
13	**What are soft and hard magnetic materials?(Nov. 2002, Nov. 2003, June 2009, June 2010)**BTL1 The materials which can be easily magnetized and demagnetized are called soft magnetic materials. The materials which are very difficult to magnetize and demagnetize are called hard magnetic materials.
14	**State the applications of ferrites.(June 2009, June 2010, May 2011)**BTL5 They are used in transformer cores for high frequencies up to microwaves. They are used in radio receivers to increase the sensitivity and selectivity of the receivers. Ferrites is used in data processing circuits as magnetic storage elements.
15	**Define retentivity(Nov 2003)**BTL1 Even when the applied field is zero(or)removed, the material still acquires some magnetic induction which is known as residual magnetism (or) retentivity.
16	**Define coercivity (Nov 2003)**BTL1 To remove the residual magnetism in a magnetic material, the magnetic field strength has to be reversed during a hysteresis cycle and this phenomenon is known as coercivity.
17	**Define hysteresis loss. (May 2009)**BTL1 It is the loss of energy in taking a ferromagnetic material through a complete cycle of magnetization and the area enclosed is called hysteresis loop.
18	**Define dielectric constant.(June 2009, May 2011)**BTL1 **I**t is the ratio between absolute permittivity of the medium (ε) and permittivity of the free space (ε_0) $$\text{Dielectric constant } (\varepsilon_r) = \frac{\text{absolute permittivity } (\varepsilon)}{\text{Permittivity of free space } (\varepsilon_0)}$$
19	**Define polarization of dielectric material**.BTL1 The process of producing electrical dipoles inside the dielectric by the application of external

	electric field is called polarization in dielectrics. Induced dipole moment (μ) = α E Where E - Applied electric field α - Polarisability
20	**Name the four polarization mechanisms.(Dec 2009)**BTL5 ➢ Electronic polarization ➢ Ionic polarization ➢ Orientational polarization ➢ Space-charge polarization
	PART-B
1	**What is meant Domain theory of Ferromagnetism and domain structure in ferro-magnetic material? (April/May 2016)(12M)**BTL2 **Answer: Page :4.12 -Dr.P.MANI** ***Domain Theory of Ferromagnetism:****(4M)* According to Weiss-Ferromagnetic material small regions - domains size vary from 10^{-6}m. ➢ Domain acts as single magnetic dipole ➢ Direction of spontaneous magnetization varies from domain to domain. ➢ In absence of magnetic field-net magnetization zero-In presence of magnetic field-spin of all domains rotated.  Fig:: Domain alignment ***Domain magnetization:*** Two types ➢ By motion of domain wall ➢ By rotation of domain wall



By the movement of domain walls:*(4M)*

Weak field applied -magnetic moment increases -domains displaced.

By the rotation of domain wall:*(4M)*

Strong external field applied-magnetization changes.

2

What are ferrites and mention its types. (A.U. May 2010, May 2019)(12M) (12M)BTL2

Answer: Page :4.26 -Dr.P.MAN

Ferrites:*(4M)*

Materials which exhibit ferromagnetism called ferrites.

General chemical formula is $M^{2+} Fe_2^{3+} O_4^{2-}$

Structure of Ferrites:

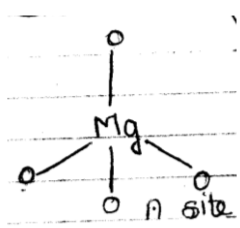
Two types of structures

Regular spinal

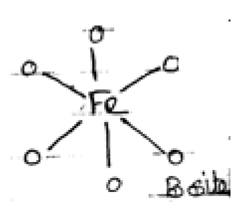
Inverse spinal

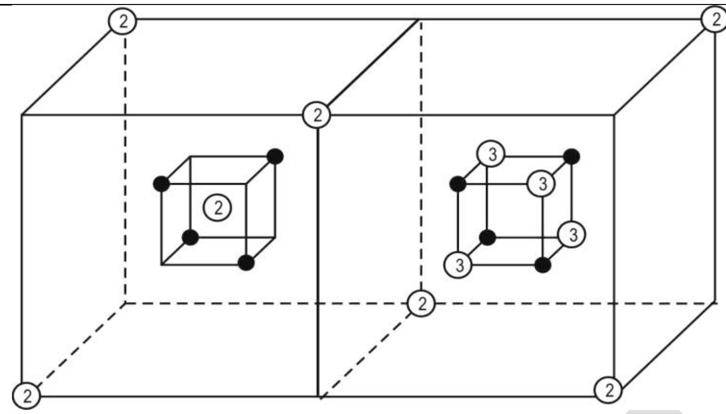
Regular Spinal: *(4M)*

Mg^{2+} ions -Tetragonal fashion- **'A'** site.

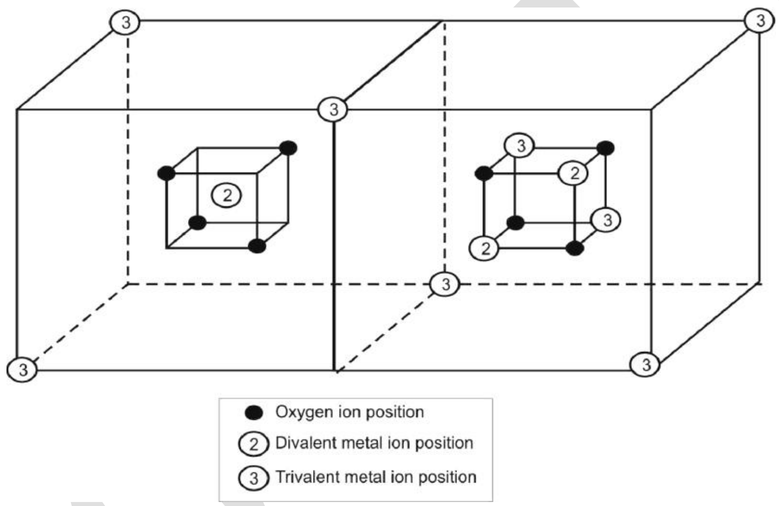


Octahedral fashion-16 octahedral site- B site.





Inverse Spinal: Fe^{3+} $[Fe^{2+}$ $Fe^{3+}]$ $O_{4(4M)}$



Properties of Ferrites

.Susceptibility very large –High permeability-Hysteresis loses low- Spin alignment antiparrallel.

Applications of ferrites:

Video transformers-Gyrator-Data processing unit-Storage devices.

3

Explain the different types of polarization mechanisms involved in a dielectric material. (April 2002, Dec 2005, May 2011, May 2018)(16M)*BTL2*

Answer: Page :5.7 -Dr.P.MANI

Various types of polarization mechanism:

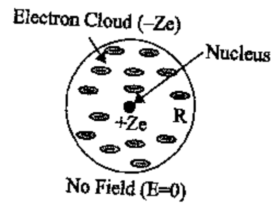
- Electronic polarization
- Ionic polarization
- Orientational polarization
- Space charge polarization.

ELECTRICPOLARIZATION *(6M)*

$$\mu \propto E \quad \Rightarrow \quad \mu = \alpha_e E$$

Calculation of electronic polarisability:

Without electric field:



$$\text{Charge density } = -\frac{3}{4}\frac{Z_e}{\pi R^3}$$

With field:-

$$\boxed{\alpha_e = 4\pi\varepsilon_0 R^3 E}$$

Ionic polarization *(6M)*

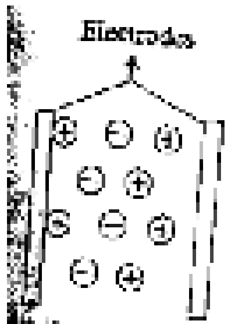
$$x = x_1 + x_2$$

$$\alpha_i = \frac{e}{{w_0}^2}\left[\frac{1}{m} + \frac{1}{M}\right]$$

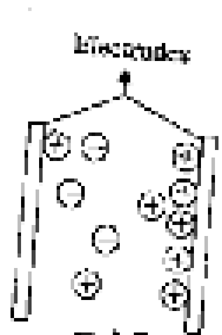
Orientational polarization*(2M)*

$$\alpha_0 = \frac{\mu^2}{3kT}$$

Space charge polarization*(2M)*



In the absence of an electric field



(b) In the presence of an electric field

Total Polarization

$$\alpha = \alpha_e + \alpha_p + \alpha_0$$

$$= 4\pi\varepsilon_0 R^3 + \frac{e^2}{{w_0}^2}\left[\frac{1}{m} + \frac{1}{M}\right] + {}^{\mu^2}/_{3kT}$$

$$P = NE\left[4\pi\varepsilon_0 R^3 + \frac{e^2}{{w_0}^2}\left[\frac{1}{m} + \frac{1}{M}\right] + {}^{\mu^2}/_{3kT}\right]$$

4

Discuss in detail the various dielectric breakdown mechanisms. (Dec.2001, June 2009, 2010, May 2011, My 2018)(16M) BTL2

Answer: Page :5.22 -Dr.P.MANI

Dielectric breakdown:*(2M)*

$$Dielectric\ strength\ = \frac{Dielectric\ \ voltage}{Thickness\ \ of\ \ dielectric}$$

Intrinsic breakdown:

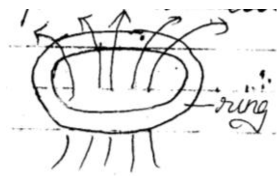
Avalanche breakdown:

Characteristics

- occur even at lower temperature.
- Large electric field
- Short span of time (3M)

Thermal breakdown:

	Characteristics: ➢ Higher temperature ➢ Moderate electric field. ➢ Size& shape ➢ Orders of milliseconds(3M) ***Chemical or electrical properties:*** ***Characteristics:*** ➢ Lower temperature ➢ Magnitude of leakage current. (2M) ***Discharge breakdown:*** ***Characteristics:*** ➢ Low voltages ➢ Presence of gas bubbles (2M) ***Defect breakdown*** *(2M)* ***Remedies for breakdown mechanisms:*** *(2M)* ➢ High resistivity ➢ High dielectric strength. ➢ Mechanical strength ➢ Thermal expansion low
5	**Explain the various properties of super conducting materials.(May 2014, May 2018)(16M)**BTL2 **Answer: Page :6.4 -Dr.P.MANI** ***Properties of superconductors***: ***Electrical Resistance:****(2M)* Zero electrical resistance-Sudden fall resistance. ***Effect of magnetic field:****(2M)* $H_c = H_0[1-(T/T_c)^2]$ ***Effect of electric current****:(2M)* $i_c = 2\pi r H_c$ ***Persistant Current:****(2M)* current persists -even after removal of field.



Meissner effect:*(2M)*

Conditions $T \leq T_c$ & $H \leq H_c$,

Isotopic effect: *(2M)*

By Maxwell $T_c \propto 1/M^{\alpha}$

Effect of pressure:*(2M)*

Tc is directly proportional to pressure - very high temperatures.

Thermal properties:*(2M)*

- Specific heat decreases at room temperatures.
- The thermo electric effect disappears at super conduction state.
- Type *I* superconductor is low.

Explain the type I and Type II superconductor and low and high T_c transition in detail. (2014)(16M) BTL2

Answer: Page :6.12 -Dr.P.MANI

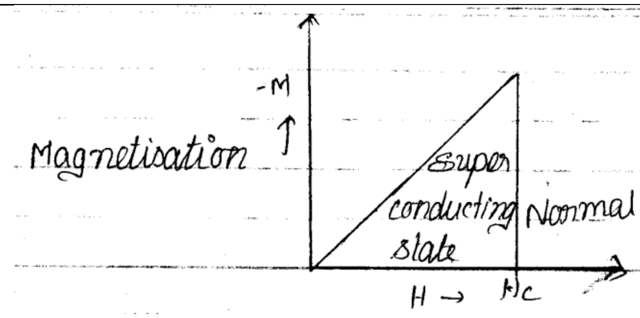
Types of superconductors:

Type I superconductors

Type II superconductors

Type I Superconductors:*(2M)*

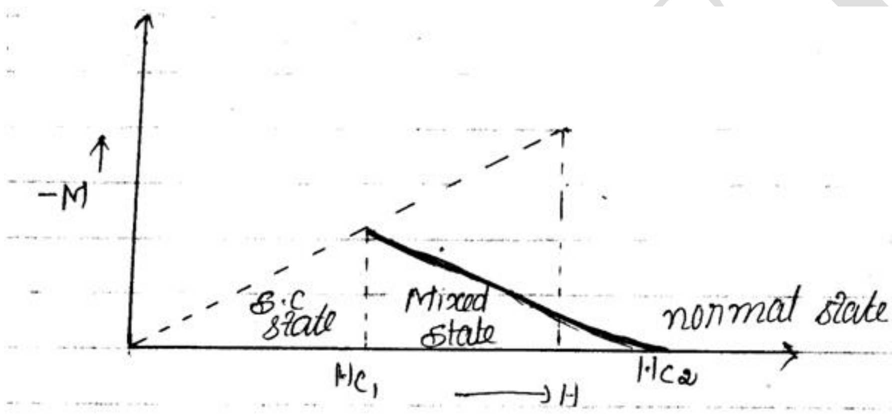
- Exhibiting complete meissner effect
- Magnetization gradually increased



(2M)

Type II superconductors:

- Losses superconducting property
- Increase magnetic field (2M)



(2M)

- Low temperature superconductors
- High temperature superconductors

Low temperature superconductors *(4M)*

- Transition temperature low (<20 K)

High temperature superconductors*(4M)*

- Transition temperature high (> 20 K)

UNIT-V NEW MATERIALS

Ceramics-types and applications – composities: classification, role of matrix and reinforcement, processing of fiber reinforced plastics – metallic glasses: types, glass forming abilityof alloys, melt spinning process, applications-shape memory alloys: phases, shape memory effect, pseudoelastic effect, NiTi alloy, applications –nanomaterials: preparation(bottom up and top down approaches), properties and applications – carbon nanotubes: types.

PART*A

Q.No.	Questions
1.	**What are metallic glasses? (Dec. 2005, June 2009, 2010, May 2011)** BTL1 Metallic glasses are metal alloys which have non crystalline or amorphous structure and exhibit the property of both metals and glasses.

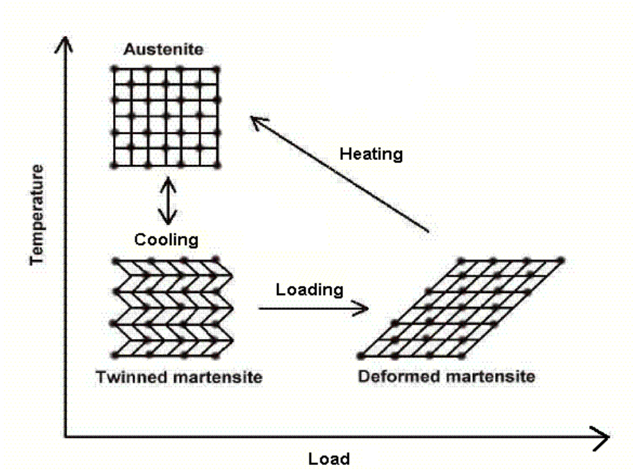
2	**What you mean by the term Quenching?(June 2014)**BTL1 Quenching is a technique used to form metallic glasses. Quenching means extremely rapid cooling of a molten liquid which results in the irregular arrangement of atom.
3	**State any four properties of metallic glasses (June 2009,2010)**BTL3 ➢ They have high corrosion resistance. ➢ The ferromagnetic properties of metallic glasses have received a great deal of attention, probably because of the possibility that these materials can be used as transformer cores ➢ High rupture, strength and toughness ➢ Electrical resistivity is high in amorphous phase of metglasses
4	**What is meant by glass transition temperature?** BTL2 The temperature at which liquid like atomic configuration can be frozen into a solid is said to be glass transition temperature.
5	**List out a few applications of metallic glasses.** BTL4 ➢ Some of the met glasses can behave as superconductors. ➢ They are used in the cores of high power transformers ➢ As they have high corrosion resistance they are used in reactor vessels, marine cables, surgical clips, orthopedicallyimplants , etc. ➢ They are used to make computer memories, magneto-resistance sensors etc.
6	**What are nano phase materials or nanomaterials?**BTL1 Materials with grain size of the order of 1-100 nm are known as nanophase materials.
7	**State few techniques for synthesis of nanophase materials.** BTL5 ➢ Top down approach where bulk materials are broken into nanosizes ➢ bottom-up approach in which nano materials are made by building atom by atom.
8	**Mention some properties of nanomaterials. (June 2009,2010, May 2011)**BTL4 ➢ Size of grains controls the mechanical, electrical, optical, chemical, semiconducting and magnetic properties. ➢ These materials are very strong. the strength of the material is inversely proportional to the grain size. ➢ The melting point of nanophase material is reduced by reducing the grain size. ➢ Undergoes super elastic properties even at lower temperatures. ➢ Magnetic moment is increased by decreasing its material size.
9	**Give some uses of nanophase materials.**BTL1

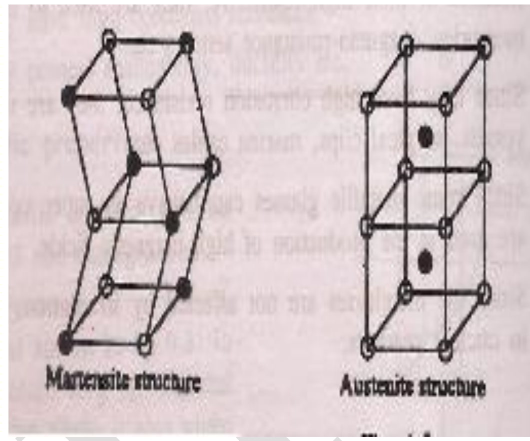
	➢ used as ceramic capacitors to store electrical energy ➢ used in current controlling devices ➢ magnetic devices made from these materials are used in RAM, ➢ READ/WRITE head, sensors etc ➢ They are used to make semiconductor lasers. ➢ They are used in power generation
10	**What are Shape memory alloys?** BTL2 Shape memory alloys are metal alloys which have the ability to return back to their original shape when subjected to some appropriate thermal procedures.
11	**What do you understand by "Martensite" and "Austenite" phases?** BTL1 The crystal structure of SMA at lower temperature is said to be Martensite phase and the crystal structure of SMA at higher temperature is said to be Austenite phase.
12	**Define transformation temperature.** BTL1 Shape memory alloys have the ability to switch from a temporary shape to a parent shape above a certain temperature called as transformation temperature.
13	**Define Pseudoelasticity.** BTL1 Pseudoelasticity occurs in some types of SMA in which the change in its shape will occur even without change in its temperature.
14	**What is meant by a biomaterial?**BTL2 Any materials that are brought into contact with the fluids, cells and tissues of living body is called bio materials.
15	**How are SMA's classified ?**BTL3 ➢ Materials which regain the shape only upon heating are referred to as one-way shape memory. ➢ Materials that take up their own shape not only upon heating but also upon cooling are referred as two way shape memory.
16	**List out some properties of SMA.** BTL4 ➢ The transformation occurs over a range of temperature ➢ They exhibit pseudoelastic or superplastic property ➢ They exhibit hysteresis curve during cooling and heating process.
17	**Mention some uses of shape memory alloys.** BTL4 ➢ iIt is used as a blood-clot filter ➢ They are used to make glass frames

	➢ They are used in the opening and closing of valves. ➢ They are used in controlling and preventing cracks ➢ They are used to correct irregularities in the teeth.
18	**Define ceramic materials or ceramics.** BTL1 Ceramics or ceramic materials are compounds composed of both metallic and non-metallic elements bonded together primarily by ionic and or covalent bonds.
19	**What are the general properties of ceramic materials?** BTL1 ➢ They are hard, wear resistant and brittle with low toughness and ductility. ➢ They are good electrical and thermal insulators due to the absence of conducting electrons.
20	**Classify ceramic materials with examples.** BTL2 Ceramic materials are classified into two groups ➢ Traditional ceramics o Example: Clay products, glasses, refractories and cement. ➢ Advanced ceramics o Example : SiC, Alumina and Silicon nitride.
21	**What is role of silica in clay products?** BTL1 Silica has primary used as a filler material. Silica has high melting temperature and hence experiences little change during high temperature treatment.
	PART * B
1	**Discuss in detail the characteristics of shape Memory alloys (SMA) and applications of SMA, (June 2009, 2011)(16M)** BTL2 **Answer: Page :8.2 -Dr.P.MANI** **DEFINITION** (2M) Shape memory alloys are the alloys which change its shape from its original shape to newshape and while heating/cooling it will return to its original shape. **TRANSFORMATION TEMPERATURE** (2M) The shape recovery process occurs not a single temperature- rather it occurs over a range of temperature –particular temperature- new shape to original shape. **SMA PHASES**(2M) ➢ Martensite ➢ Austenite

PROCESSING OF SMA(4M)

Shape memory effect:





At lower temperature-Martensite structure - when heated -change its shape to Austenite structure -cooling process-Martensite form.

CHARACTERISTICS OF SMA (6M)

Pseudo Elasticity:

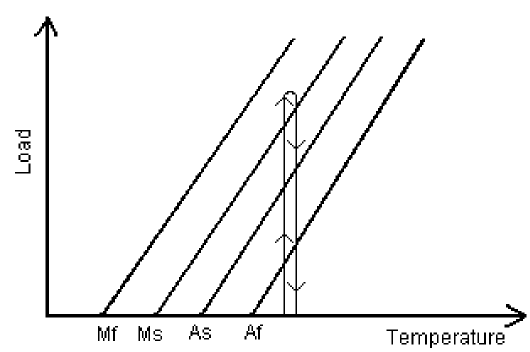
Without change in temperature-pesudoelasticity occurs- load applied-Austenite becomes transformed to Martensite- load decreased- Martensite transformed to Austenite.

SUPER ELASTICITY:

rature-load applied -deformed martensite shape- load is removed- twinned martensite.

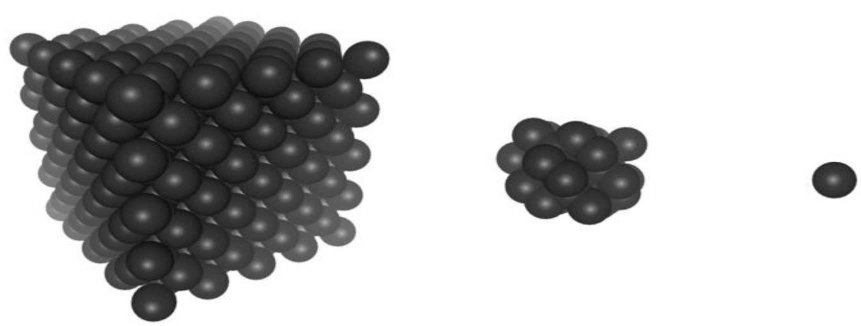
3HYSTERESIS:

During cooling process martensite starts(Ms)&ends -During heating process -Austenite start(As) &ends(A_f).



TYPES OF SMA

- One-way shape memory alloy

	➢ Two-way shape memory alloy **PROPERTIES OF NI-TI ALLOY** More flexible- High melting point- High thermal stability-High corrosion resistance-High Yield strength. **APPLICATION OF SMA** Eye glass frames- Toys –Helicopter blades – Blood clot filter-Fire safety valves **ADVANTAGES** Compact-safe-flexible-Non-Corrosive **DISADVANTAGES** Cost high-Efficiency low-Structural get deformed.
2	**What are nano-phase materials? Describe the method of producing nano materials using chemical vapour deposition method and plasma assisted deposition method. (June 2010, May 2018) (16M)**BTL2 **Answer: Page :9.2 -Dr.P.MANI** **NANOPHASE MATERIALS** (8M) Nanotechnology is a broad term used when refering to any science or technology which Nanograin size -1 to 100 nm range. **SYNTHESIS OF NANOPHASE MATERIALS** **CHEMICAL VAPOUR DEPOSITION** Chemical Vapor Deposition (CVD) is a wide  **CONSTRUCTION AND WORKING** Use to prepare nano-powder- Material heated - form gas - allowed to deposit on solid surface. **APPLICATIONS** Telecommunications-Semi Conductors-Integrated circuits-Sensors.

PULSED LASER DEPOSITION(8M)

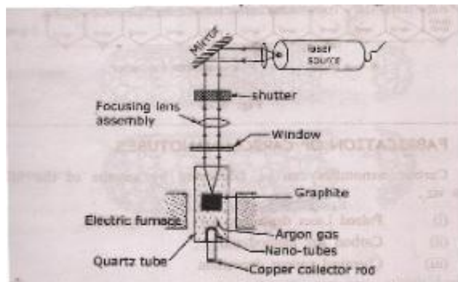


Fig.6.17

PRINCIPLE

Used Laser pulse of high intensity

Evaporate carbon from graphite

Evaporated carbon atoms condensed to form nanotubes.

DESCRIPTION

Quartz tube which contains a graphite target

Kept inside high temperature muffle furnace

Quartz tube filled with argon gas .

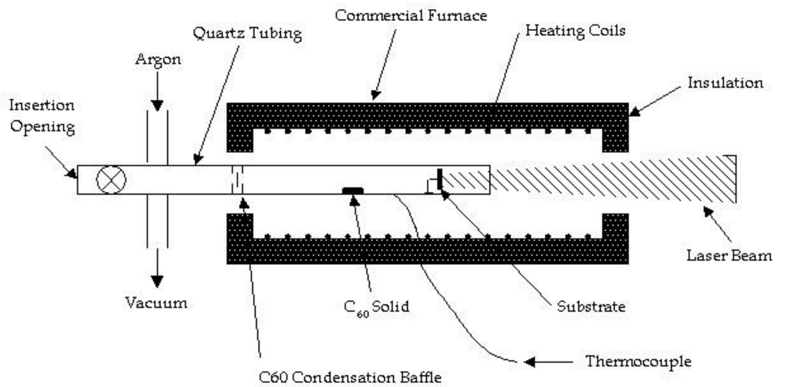
Copper collector fitted at the other end.

Formation of nanotubes.

WORKING

Incident Laser beam

Evaporated carbon atoms are swept from higher temperature



Carbon atoms reach colder copper collector, they condense into nanotubes.

PROPERTIES OF NANO-MATERIALS:

PHYSICAL PROPERTIES

very less-high strength-melting point low

ELECTRONIC PROPERTIES

Energy band very narrow-storing hydrogen atoms

MAGNETIC PROPERTIES

spontaneous magnetization

MECHANICAL PROPERTIES

super-plastic behavior-stress-grain boundaries

APPLICATIONS OF NANO-PARTICLES

Hard metals-magnetic separators-optical switches-pressure sensors.

3. Write a short note on the properties of metallic glasses. **(16M)** BTL2 (June 2009, 2010, May 2018, May 2019)

Answer: Page :9.2 -Dr.P.MANI

DEFINITION:(2M)

Properties of metal + properties of glass = Property of metallic glasses.

TECHNIQUES FOR PREPARATION:

- Melt spinning system(Quenching technique)
- Twin roller system
- Melt extraction system
- Sputtering.

MELT SPINNING TECHNIQUE:(4M)

PRINCIPLE:

Quenching Method

DESCRIPTION&PREPARATION

The set up consists of refractive tube with a fine nozzle at the bottom-

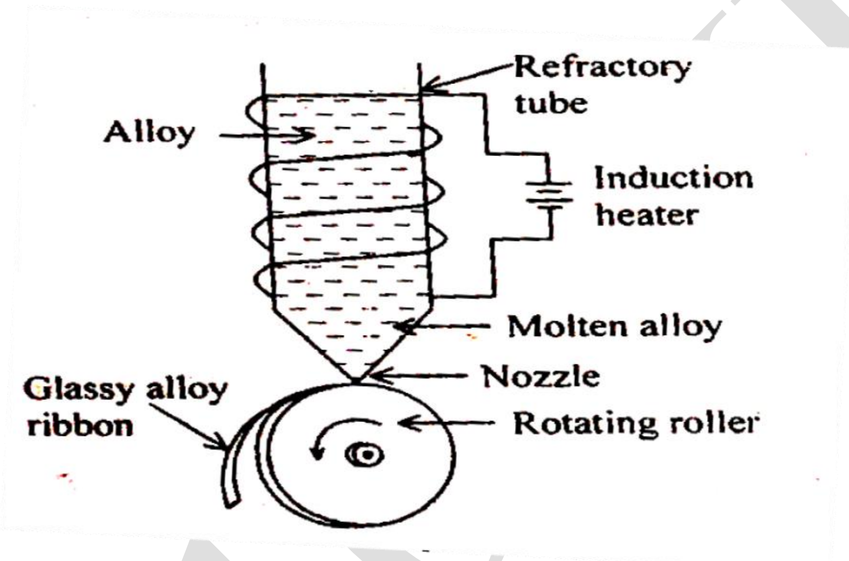
Rotating roller made up of copper.

Inductor heater is switched on.

The molten alloy is ejected through the nozzle of the tube

The ejected rate can be increased

Due to rapid cooling a metallic glass is formed .



(2M)

TYPES OF METTALIC GLASSES:(2M)

- Metal - Metalloid glass.
- Metal - Metal glasses.

PROPERTIES OF METALLIC GLASSES:(4M)

- Structural properties
- Mechanical or general propertie
- Magnetic properties
- Electrical properties

APPLICATIONS OF METALLIC GLASSES:(2M)

High power transformer-Springs-Computer memories-Surgical clips

4

List properties and application of any two type of ceramics. (or)State the properties and applications of two ceramics from the list: PSZ, Si_3N_4, Al_2O_3 and SIALON. (or) Give any two important properties of ceramics. Write short notes on any four ceramics materials. (16M)

Answer: Page :7.2 -Dr.P.MANI

ENGINEERING CERAMICS(2M)

Engineering ceramics, are also known as technical industrial ceramics

Specially used for engineering applications

Classification of Engineering Ceramics(2M)

- Alumina
- Silicon carbide
- Silicon nitride
- Partially stabilised zirconia (PSZ)
- Sialons

Alumina (Al_2O_3)(4M)

Stronger –Good environmental resistance-Poor thermal conductors.

Applications of aluminas:

Metal-cutting tool tips-Rocket nozzles-Pump impellers-Bone filler-Orthopeadic implants.

Silicon Carbide (SiC)(4M)

Semiconducting ceramic material-Silicon carbides.

Types of silicon carbide:

α-SiC: Hexagonal crystalline structure.

β-SiC: Cubic crystalline structure.

Types of silicon carbide ceramics:

- Reaction bonded silicon carbide.
- Clay-bonded silicon carbide.
- Hot-pressed silicon carbide.
- Sintered silicon carbide
- Recrystallised silicon carbide.
- Nitride-bonded silicon carbide.

Characteristics of silicon carbides: (4M)

Higher tensile strength-Stiffness hardness -Lower density-Highest thermal conductivity-

	chemical resistant. ***Applications:*** Bonded abrasive papers-precision optical mirrors-Nuclear reactor fuel elements-refractory tubes.
5.	**Explain the applications of nanophase material in different fileds.(JUNE 2015, May 2019, May 2018)(16M)**BTL1 **Answer: Page :9.22 -Dr.P.MANI** **APPLICATIONS OF NANO MATERIALS** **MATERIALS TECHNOLOGY**(2M) Stronger-Lighter-Optical properties-Energy storage-Current controlling devices. **INFORMATIONTECHNOLOGY** (2M) Data storage-High density magnetic recording-Sensors-Quantum wires. **BIOMEDICALS** (2M) DNA chips-Bone cells. **ENERGY STORAGE**(2M) Hydrogen storage devices-Fabrication of ionic batteries. **OPTICAL DEVICES**(2M) Semiconductor laser -CD's-Eye glasses. **TRANSMISSIONLINES** (2M) Signal processing elements –Filters- Delay lines- Switches. **NANOMICRO-ELECTROMECHANICALSYSTEMS**(2M) ➢ Integrated circuits, ➢ Optical switches, ➢ Pressure sensors and ➢ Mass sensors. **MOLECULAR NANO TECHNOLOGY (MNT)** Robotic machines- Molecular-size power sources - Batteries.**(2M)**

GE8291 ENVIRONMENTAL SCIENCE AND ENGINEERING L T P C
3 0 0 3

OBJECTIVES:

- ✓ To study the nature and the facts about environment.
- ✓ To finding and implementing 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, ECOSYSTEMSAND 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 – 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.

UNIT II ENVIRONMENTALPOLLUTION 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 – 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.

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 individualinconservation 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 ANDTHEENVIRONMENT 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 ANDTHEENVIRONMENT 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 following after completing the course.

- ✓ Public awareness of environmental is at infant stage.
- ✓ Ignorance and incomplete knowledge haslead to misconceptions
- ✓ Development and improvement in std. of living has lead to serious environmental disasters

TEXT BOOKS:

1. Gilbert M.Masters, 'Introduction to Environmental Engineering and Science', 2nd edition, Pearson Education, 2004.
2. Benny Joseph, 'Environmental Science and Engineering', Tata McGraw-Hill, New Delhi, 2006.

REFERENCES:

1. R.K. Trivedi, 'Handbook of Environmental Laws, Rules, Guidelines, Compliances and Standards', Vol. I and II, Enviro Media.
2. Cunningham, W.P. Cooper, T.H. Gorhani, 'Environmental Encyclopedia', Jaico Publ., House, Mumbai, 2001.
3. Dharmendra S. Sengar, 'Environmental law', Prentice hall of India PVT LTD, New Delhi, 2007.
4. Rajagopalan, R, 'Environmental Studies-From Crisis to Cure', Oxford University Press 2005.

Subject Code:GE8291 Year/Semester: I /02
Subject Name:ENVIRONMENTAL SCIENCE AND ENGINEERING
Subject Handler: 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** 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)** 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)** 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)** 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 :**Rauvolserpentina, 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 **EndangeredSpecies**-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. • **ThreatenedSpecies** 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

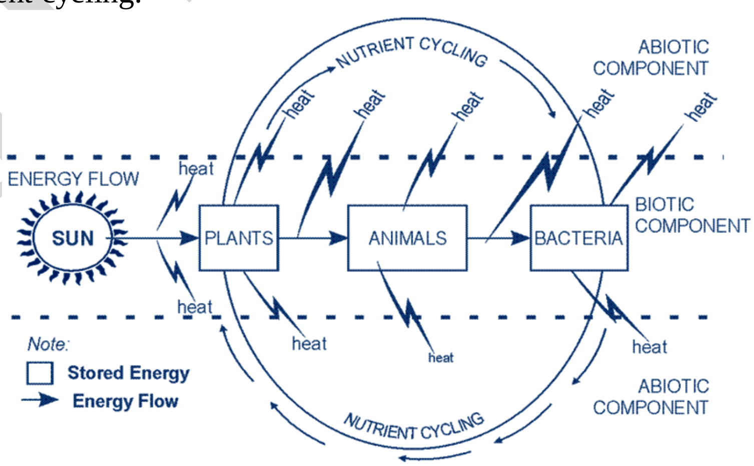
Answer: Page: 1.2–1.4-A. Ravikrishnan
Definition- The sum of all living and non-living things around us influence one another. (2 M)
Types- i) Natural environment – naturally created all biotic and non-biotic components.
ii) Man-made environment- Created by man. (2 M)

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)

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Explain abiotic and various biotic components of an Ecosystem with neat sketch. (13M) (A.U. Dec 2007) 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)

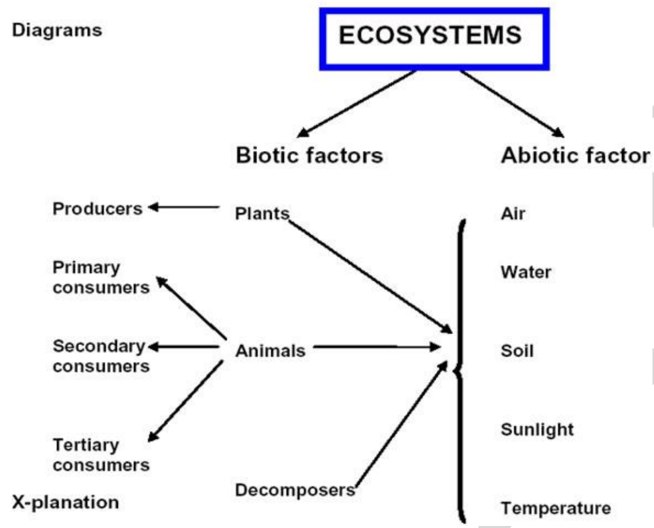

Diagram – (2M)

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Write down the ecological succession and ecological pyramid. (13M)
(A.U. Dec 2010, Apr 2015, May 2006) 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

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	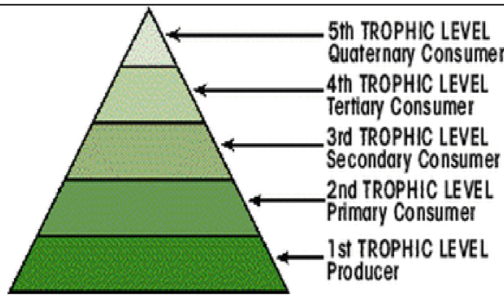 (3 M)
5.	**Explain the structure and function of the following. (i) Forest ecosystem (ii) Grassland ecosystem (iii) Desert ecosystem (iv) Aquatic ecosystem (13M)** **(A.U. May2011, May 2006)** BTL2**Answer: Page: 2.30 – 2.44 - A. Ravikrishnan** **(i) Structure and Function offorest ecosystem:** • **Abiotic 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)** 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) 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. (3 M)

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 (2 M)

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)** 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)Threatsto 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, Pedicularisparroter, 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**–Plantspresent 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: (5 M)

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.

(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, phytoplanktonslike 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.

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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)
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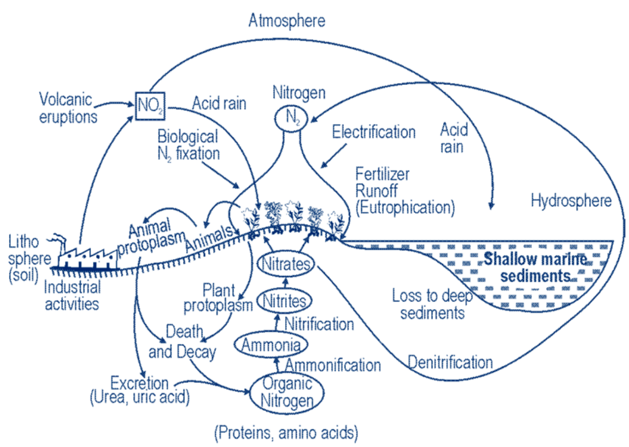
<tr><td>4.</td><td>
(i) Survey the following topics with a neat diagram. (a) Nitrogen cycle b) Oxygen cycle c) Energy flow in the ecosystem. (12M) BTL4
(ii) Analyze in detail about hydrosere and xerosere (3M) BTL4

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)
$$6CO_2 + 6H_2O + Energy \rightarrow C_6H_{12}O_6 + 6O_2\ (Photosynthesis)$$
$$6O_2 + C_6H_{12}O_6 \rightarrow 6O_2 + 6H_2O + Energy\ \ (Respiration)$$
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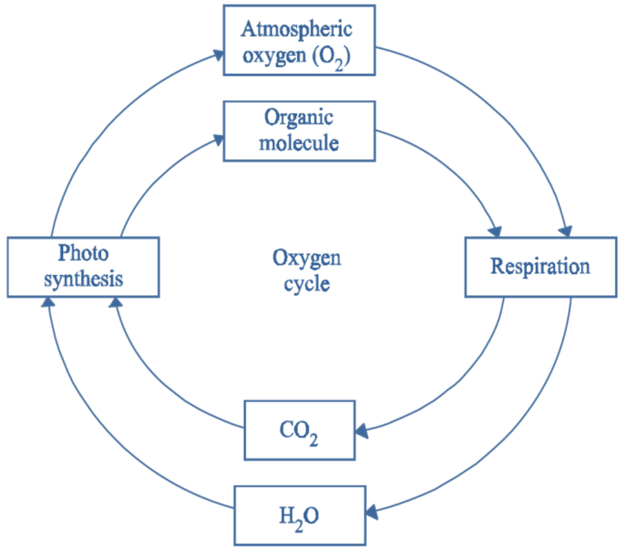

(1 M)

(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)

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) Interferescommunication Hearing damage (90dB) Physiological and Psychologicaldisorders

	• **Control and preventive measures** (1M) Reduction in source ofnoise Noise making machines should be kept in containers with sound absorbingmedia Proper oiling will reduce noise frommachinery Using silencers – fibrousmaterial Plantingtrees Legislation can prevent excess sound production, unnecessary horn blowingetc.
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

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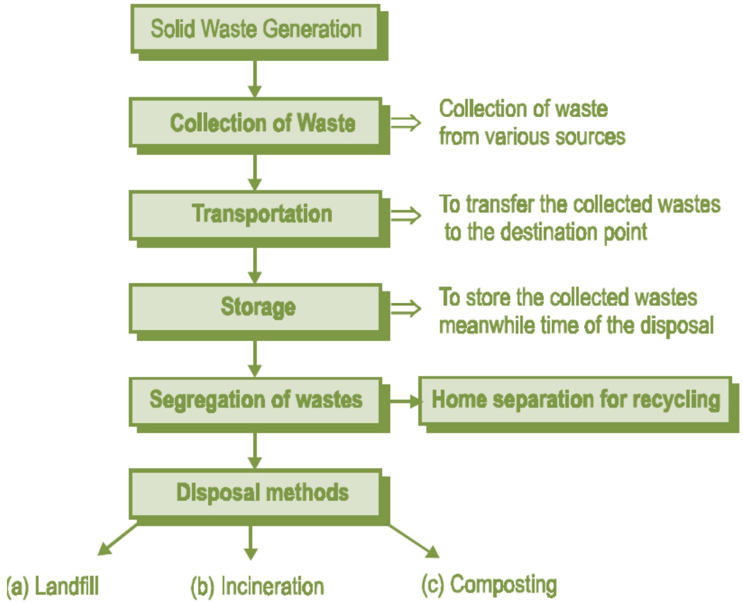

(2 M)

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)
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<tr><td>5</td><td>
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)
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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:
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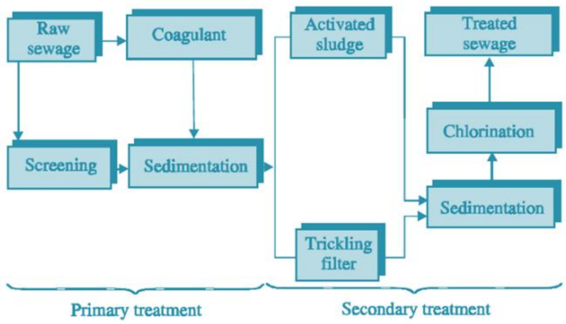
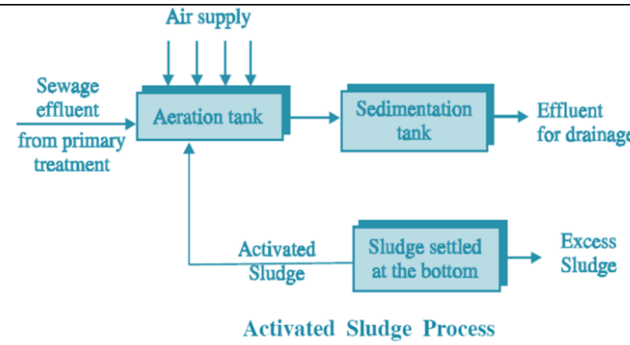
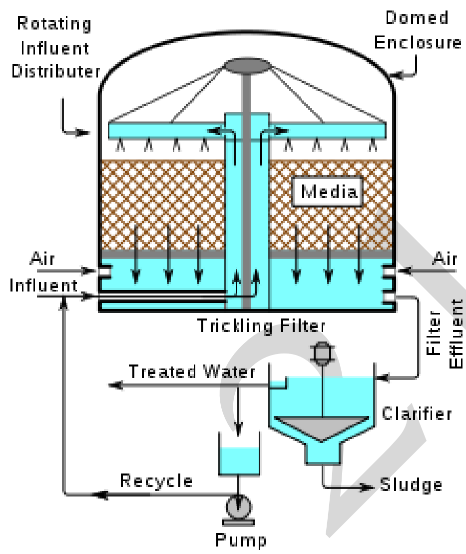
	Use stairs instead ofelevators Use public transportation walk or ride abicycle Plant trees aroundbuilding Turn off lights, television sets and computer when not inuse. Pay immediate attention to leaks inpipes. Install waste savingequipments. Recycle glass metal andpaper. Compost gardenwaste Segregate waste andrecycle Buy locally made long losingmaterial Buy environmentally degradableproducts. Take some bag from home to market topurchase.
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 odouris unacceptable and unsuitable for drinking and other purposes. 2. highly turbid and very hard water is unpleasant to drink, foodprocessing 3. acid and alkaline water cause serious healthproblem 4. water borne infectious enteric disease like typhoid, cholera, dysentery, are the predominant health hazard arising from drinking contaminatedwater 5. radioactive pollution enter human body through food and get accumulated in thyroid gland, liver, bones andmuscles 6. biodegradable waster deplete D O in the receiving stream, affect the flora cause creates anaerobicconditions 7. non biodegradable waste and pesticides travel the food chain and ultimately reach human where they accumulate in fattytissues 8. thermal discharge in stream depletes DO 9. phosphate, nitrate, promote the growth of algae and encourageeutrophication

	10. Industrial effluents result in addition of poisonous chemicals such as arsenic, mercury, lead may reach human body through contaminatedfood. **Control measures of water pollution** (4M) a) lay down standardfor a. drinkingwater b. disposal of waste water into watercourse/sewer/land monitoring b) Waste watertreatment • preliminarytreatment • primarytreatment • secondarytreatment • advancedtreatment
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







(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 birdskilled. • **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 thApril,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 60km.
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)** **1. The common specifications recommended by the U.S Public Health for Drinking Water are given below.** 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. **Physical and Chemical Characteristics of marine water: (7M)** Marine Ecosystem.

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 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.

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

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<tr><td>It can be used again and again</td><td>Cannot be used again</td></tr>
<tr><td>It is pollution free</td><td>It pollutes the atmosphere</td></tr>
<tr><td>Available in unlimited amount in nature</td><td>Available in limited amount</td></tr>
<tr><td>It is developed in a short period</td><td>It is developed in a long period It is developed in a long period</td></tr>
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<tr><td>23</td><td>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.</td></tr>
<tr><td>24</td><td>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</td></tr>
<tr><td>25</td><td>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</td></tr>
<tr><td>26</td><td>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.</td></tr>
<tr><td>27</td><td>Mention the factors causing soil erosion. (TCY A.U. Dec2008) BTL4
1. Water 2. Wind 3. Biotic agents 4. Landslides 5. Construction</td></tr>
<tr><td>28.</td><td>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.</td></tr>
<tr><td>29.</td><td>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</td></tr>
<tr><td>30.</td><td>Define the term Nuclear energy. (A.U DEC2014, A.U.Apr.2015) 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</td></tr>
<tr><td>31.</td><td>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</td></tr>
<tr><td colspan="2">PART * B</td></tr>
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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** **<u>Developmental Projects:</u> (6 M)** 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) **<u>Mining operations</u>** Mining have a serious impact on forest areas. Mining operation reduces the forest area. Examples Mica, coal, manganese, limestone, etc. (1 M) **<u>Raw materials for industries</u>** Wood is the important raw material for so many purposes. Example - For making boxes, furniture, match-boxes, pulp, etc., (1 M) **<u>Fuel requirements</u>** 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) **<u>Shifting cultivation:</u>**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) **<u>Forest fires:</u>**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 (6 M)** **<u>Global warming:</u>**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. **<u>Loss of genetic diversity:</u>**Destruction of our forest destroys the greatest storehouse of genetic diversity on earth, which provides new food and medicines for the entire world **<u>Soil erosion:</u>**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 **<u>Loss of biodiversity:</u>**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. **<u>Loss of food grains:</u>**As a result of soil erosion, the countries lose the food grains **<u>Unemployment problems:</u>**The people living around forest areas lose their livelihood **<u>Flood and Landslides:</u>**Frequent floods, landslides in hilly areas and wind speed are heavy. **<u>Preventive measures (or) avoid of deforestation (or) methods of conservation of forest</u>**(1 M) • 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 **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 (2 M)

- 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.

Conservation of water (2 M)

- 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.

Conservation of soil (2 M)

- 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

Conservation of Food Resources (1 M)

- 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. **Conservation of Forest (1 M)** • 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.
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
4	**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 :(2 M)** 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 **Ground subsidence: (2 M)** 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. **Lowering of water table (2 M)** 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. **Intrusion of salt water: (1 M)** In coastal areas, over exploitation of ground water would lead to rapid intrusion of salt water from sea. **Earthquake and landslides: (2 M)** Over-utilization of ground leads to decrease in water level, which cause earth quake, landslides

	and famine **Drying up of wells: (2 M)** 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. **Pollution of water : (2 M)** 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.
5	**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** **<u>Overgrazing:</u>** Process of, "eating away the forest vegetation without giving it a chance to regenerate" **<u>Agriculture</u>**: An art, science and industry of managing the growth of plants and animals for human use. (1 M) **<u>Effects (or) impacts of overgrazing</u>** **<u>Land degradation</u>** ✓ 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) **<u>Soil erosion</u>** ✓ 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) **<u>Loss of useful species</u>** ✓ 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) **<u>Traditional agriculture:</u>** ✓ 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 **<u>Effects (or) impacts of Traditional agriculture</u>** **<u>Deforestation:</u>** ✓ Cutting and burning of trees in forests to clear the land for cultivation results in loss of forest cover. **<u>Soil erosion:</u>** ✓ Clearing of forest cover exposes the soil to wind and rainfall, resulting in loss of top fertile soil layer. **<u>Loss of nutrients:</u>** ✓ 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)
6	**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 radiowaste 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)
7	**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)
8	**(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** **<u>(a) Micronutrient imbalance</u>** ✓ 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) **<u>(b) Blue Baby syndrome (Nitrate pollution)</u>** ✓ 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) **<u>(c) Eutrophication.</u>** ✓ 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) **<u>Problems in using pesticides</u>** 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. **<u>Death of non-target organisms</u>**

- ✓ 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)

9 **Explain the environmental impacts of mineral extraction (mining) and uses (8 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. (1 M)

Types of mining: (1 M)

(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: (4 M)

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**.**

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.

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. **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. **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. **Effects of over exploitation of Mineral resources: (1 M)** 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 **Uses of mining: (1 M)** 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.
10	**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 (1 M)** 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 **Types of Food Supply: (3 M)** 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: (2 M)** 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. **World food problem** (1 M)
11	**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 (3 M)** • 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. **Reason for over exploitation in India: (2 M)** 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. **Causes of over exploitation: (2 M)** (a) Increasing agricultural production. (b) Increasing industrial activities. (c) Increase in demand of wood resources.
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)
14	**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)
15.	**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)
16.	**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) **Causes of desertification (or) reason for desertification** **1. Deforestation:** ✓ 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. Over grazing:** ✓ 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)
17.	**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

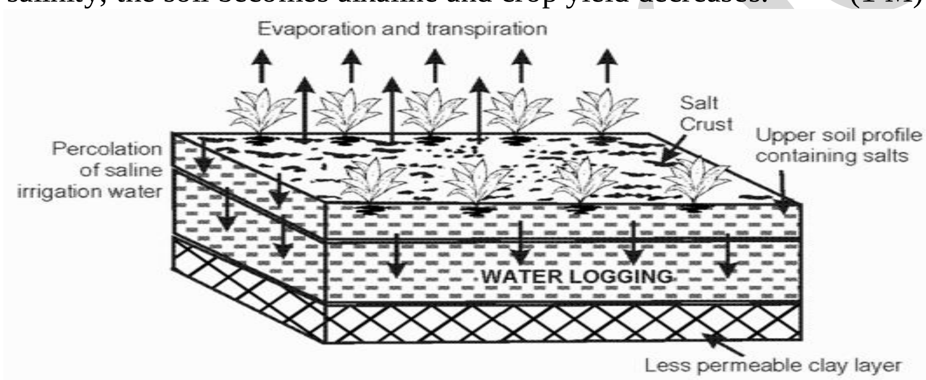
- ✓ Preventing excessive irrigation, sub surface draining technology and bio-drainage by trees like Eucalyptus tree are some method of preventing water logging. (1 M)

(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)

Remedy for salinity

- ✓ 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

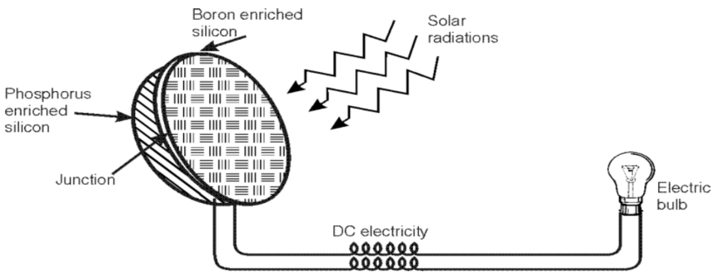
Answer : Page : 5.34 – 5.42 - A. Ravikrishnan

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

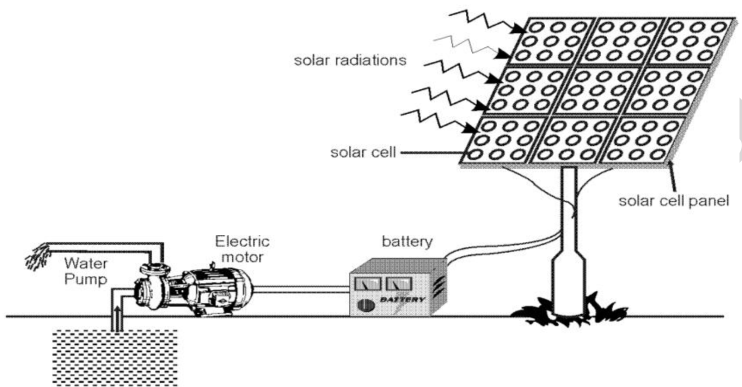


Solar cell (PV cell)

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.



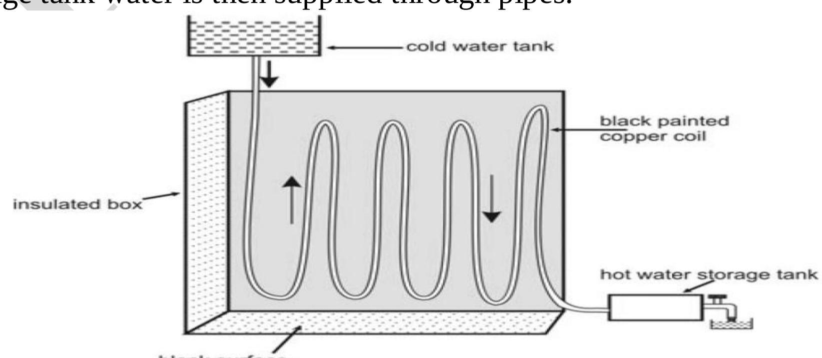
(2 M)

- **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**

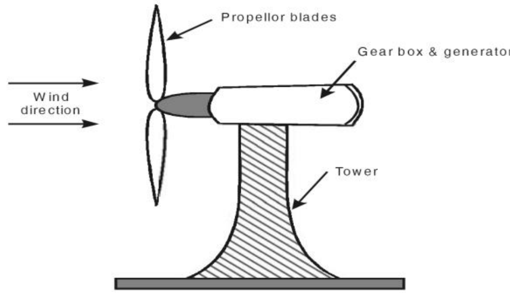
It consists of an insulated box inside of which is painted with black paint. It is also provided with a glass lid to receive and store solar heat. Inside the box it has black painted copper coil, through which cold water is allowed to flow in, wl1ich gets heated up and flows out into a storage tank. 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.



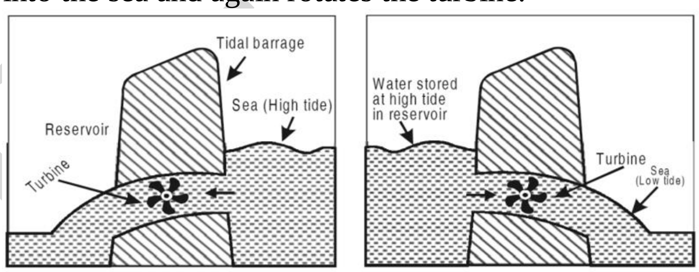
- **Wind Farms.**

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.

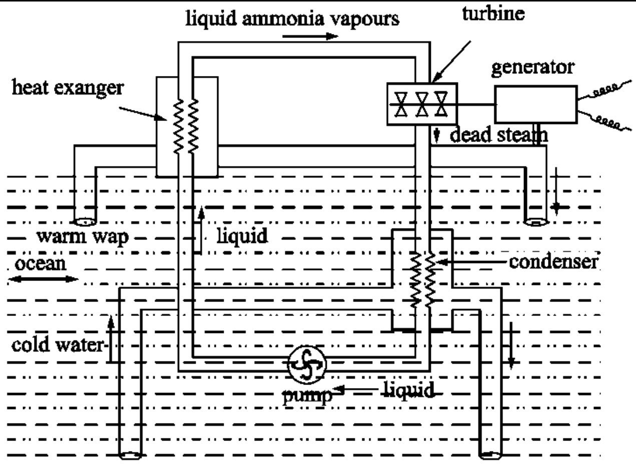
- **Tidal energy (or) Tidal power**
  - ✓ Ocean tides, produced by gravitational forces of sun and moon, contain enormous amount of energy.
  - ✓ The 'high tide' and 'low tide' refer to the rise and fall of water in the oceans.
  - ✓ The tidal energy can be harnessed by constructing a tidal barrage.
  - ✓ 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**

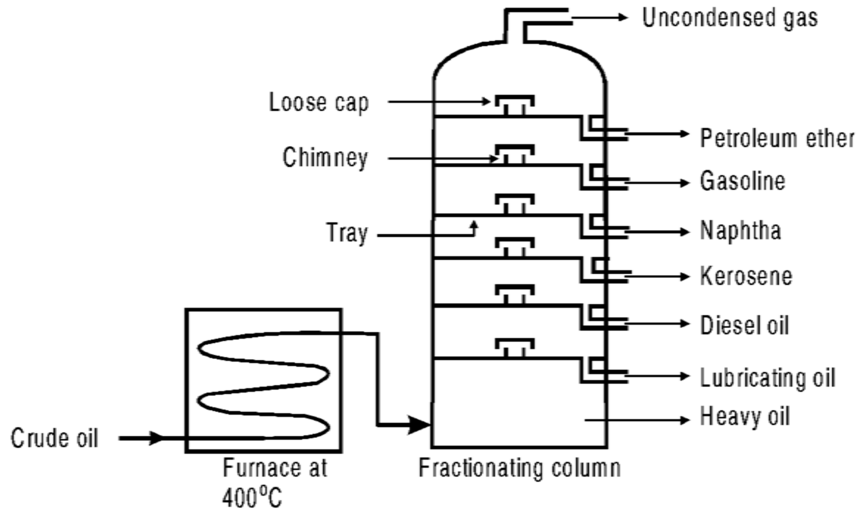
   Petroleum or crude oil is a thick liquid contains more than hundreds of hydrocarbons with small amount of S, N, O as impurities.

   <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)

Fractional distillation of petroleum

From petroleum various hydrocarbons are separated by purifying and fractionating using fractionating coloumn. (Fig.)

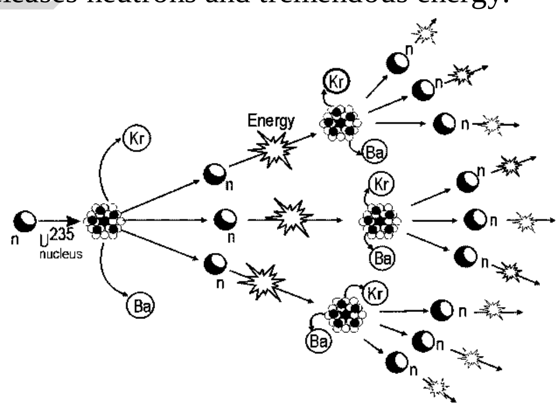


(2 M)

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**

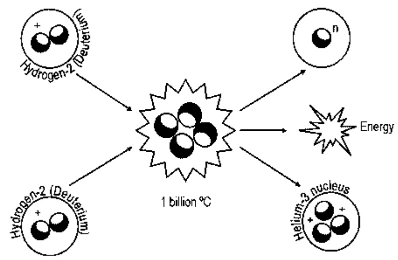
   Energy released by nuclear fission or nuclear fusion.

   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)

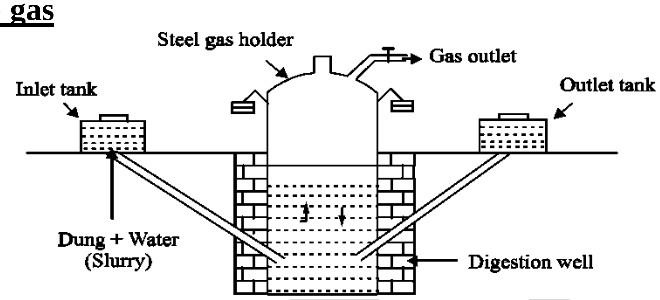
Nuclear Fusion: When two lighter nuclei combined together to form a heavier nucleus at very high temperature releases tremendous energy and neutrons.



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)

Uses of Bio Gas

	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)

UNIT - IV SOCIAL ISSUES AND THE ENVIRONMENT	
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 protection 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.	
Q.No.	**PART – A**
1	**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".
2	**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.
3	**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.
4.	**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.
5.	**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. • 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) i. Prevention and control ii. Estabilishment of State and Central boards. iii. Framing Guidelines and Standards. iv. Punishment for violations.
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) . Prevention and control i. Estabilishment of State and Central boards. ii. Framing Guidelines and Standards. iii. Punishment for violations.
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** **<u>Rain water harvesting :</u>** A technique of capturing and storing of rain water for further utilization (1 M) **<u>Objective:</u>** • 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)
13.	**Discuss the causes, effects and control measures of Acid rain. (8 M)** BTL2 Introduction (1 M)

	Formation of acid rain (2M) Effects of Acid rain (3M) i. Effects on Human beings. ii. Effects on buildings iii. Effects on Ecosystem. Control measures. (2 M)
14.	**Discuss the causes, effects and control measures of ozone layer depletion. (8 M)** Importance of Ozone layer with diagram (1 M) Formation of Ozone (2 M) Mechanism (2 M) Ozone depleting substance (1) Effects (1 M) Control measures (1 M)
15.	**Give Short notes on Climatic change and Green House Effect. (8 M)** BTL 3 Definition (2 M) Causes (1 M) Effects (1 M)
PART–C	
1	**What is an Acid rain? Write about its causes, effects and measures to face the Acid rain. (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** (a)Climatic changes (b) Global Warming (c) Ozone layer Depletion **(15 M)** BTL2 **Answer : Refer : 6.52 – 6.57 - A. Ravikrishnan**

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. $Doublingtime = Td = \frac{70}{r}$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

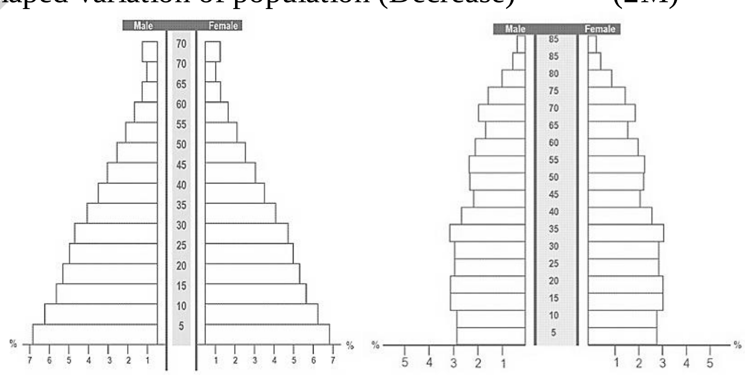
	opportunistic infections.
26.	**What are the factors which do not influence transmission of HIV?** BTL1 Tears, food, air, cough, handshake, mosquito, flies, insect bites, urine, saliva during kissing, sharing of utensils, cloths, toilet, bathroom etc.
27.	**Mention some effects of HIV/AIDS. (Chen A.U. 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

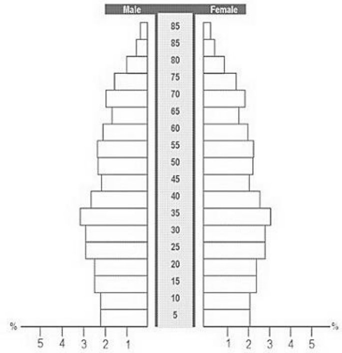
33.	**What is environmental impact assessment?** BTL1 Formal process of predicting the environmental consequences of any development projects. Used to identify the environmental, social and economic impacts of the project prior to decision making.
34.	**What is GIS?** BTL1 Graphical Information System (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 MahilaMandals • 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

(ii) 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 environmentis 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)
	(iii) 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-styleSocio-economic conditions. Disease result from complex interaction between manand 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; Chlorofluoro 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 theobjectives, 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 MahilaMandals
	• 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 infectionand control and preventive measures.(15M)** BTL2 **Answer: Page:**7.24 – 7.28**-A. Ravikrishnan** **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. (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)

BE8253	**BASIC ELECTRICAL, ELECTRONICS AND INSTRUMENTATION ENGINEERING**	**L T P C** **3 0 0 3**

OBJECTIVES:

To impart knowledge on

- Electric circuit laws, single and three phase circuits and wiring
- Working principles of Electrical Machines
- Working principle of Various electronic devices and measuring instruments

UNIT I ELECTRICAL CIRCUITS 9

Basic circuit components -Ohms Law - Kirchhoff's Law – Instantaneous Power – Inductors - Capacitors – Independent and Dependent Sources - steady state solution of DC circuits - Nodal analysis, Mesh analysis- Thevinin's Theorem, Norton's Theorem, Maximum Power transfer theorem- Linearity and Superposition Theorem.

UNIT II AC CIRCUITS 9

Introduction to AC circuits – waveforms and RMS value – power and power factor, single phase and three-phase balanced circuits – Three phase loads - housing wiring, industrial wiring, materials of wiring

UNIT III ELECTRICAL MACHINES 9

Principles of operation and characteristics of DC machines, Transformers (single and three phase)

, Synchronousmachines, three phases and single-phase induction motors.

UNIT IV ELECTRONIC DEVICES & CIRCUITS 9

Types of Materials – Silicon & Germanium- N type and P type materials – PN Junction –Forward and Reverse Bias –Semiconductor Diodes –Bipolar Junction Transistor – Characteristics – Field Effect Transistors – Transistor Biasing –Introduction to operational Amplifier –Inverting Amplifier – Non Inverting Amplifier –DAC – ADC .

UNIT V MEASUREMENTS & INSTRUMENTATION 9

Introduction to transducers - Classification of Transducers: Resistive, Inductive, Capacitive, Thermoelectric, piezoelectric, photoelectric, Hall effect and Mechanical,Classification of instruments

- Types of indicating Instruments - multimeters –Oscilloscopes- – three-phase power measurements

– instrument transformers (CT and PT)

TOTAL: 45 PERIODS

- Understand electric circuits and working principles of electrical machines
- Understand the concepts of various electronic devices
- Choose appropriate instruments for electrical measurement for a specific application

TEXT BOOKS

1. Leonard S Bobrow, ―Foundations of Electrical Engineering‖, Oxford University Press, 2013
2. D P Kothari and I.J Nagarath, ‖Electrical Machines ―Basic Electrical and Electronics Engineering‖, McGraw Hill Education(India) Private Limited, Third Reprint ,2016
3. Thereja .B.L., ―Fundamentals of Electrical Engineering and Electronics‖, S. Chand & Co. Ltd., 2008

REFERENCES

1. Del Toro, ―Electrical Engineering Fundamentals‖, Pearson Education, New Delhi, 2007
2. John Bird, ―Electrical Circuit Theory and Technology‖, Elsevier, First Indian Edition, 2006
3. Allan S Moris, ―Measurement and Instrumentation Principles‖, Elseveir, First Indian Edition, 2006
4. Rajendra Prasad, ―Fundamentals of Electrical Engineering‖, Prentice Hall of India, 2006
5. A.E.Fitzgerald, David E Higginbotham and Arvin Grabel, ―Basic Electrical Engineering‖, McGraw Hill Education(India) Private Limited, 2009
6. N K De, Dipu Sarkar, ―Basic Electrical Engineering‖, Universities Press (India)Private Limited 2016E

	UNIT I ELECTRICAL CIRCUITS
	Basic circuit components -Ohms Law - Kirchhoff's Law – Instantaneous Power – Inductors - Capacitors – Independent and Dependent Sources - steady state solution of DC circuits - Nodal analysis, Mesh analysis- Thevinin's Theorem, Norton's Theorem, Maximum Power transfer theorem-Linearity and Superposition Theorem.
	PART*A
Q.No	**Questions**
1.	**State ohm's law.A/M 16 ,N/D 17 A/M 16,15 BTL1** At constant temperature, the current flowing through a conductor is directly proportional to the potential difference across the ends of the conductor. **V α I (or) V = I * R.** Where **R** is the resistance of the conductor in ohm.
2	**Define current. BTL1** The rate of flow of charge (Free electron) is called as current. Current is represented by **'I'**. Its unit is Ampere **(A).**
3	**Define Voltage or emf.BTL1** Voltage or electro motive force (emf) represents the electric pressure or potential difference between two ends of the conductor that tends to create an electron flow. Voltage is represented by '**V' (or) 'E'**. Its unit is volt.
4	**Define potential difference. BTL1** The work done in moving a coulomb of charge between the two points is called the potential difference. It is measured in volt.
5	**Define power.BTL1** Power is the rate of doing work and its unit is Watt (or) Joule persecond.It is the product of current and voltage.**P = V x I (DC Circuits)**
6	**What is meant by electrical energy?** BTL1 The total work done in an electric circuit is called electrical energy. It is the product of power and time for which current flows through a circuit. Its unit is Joules (or) Watt-sec Energy = P x t = V x I x t = I x R x t

ONE electrical unit = 1 kWh

7 **State Kirchhoff's current law. (KCL)** BTL1 A/M 18

It states that the algebraic sum of the currents meeting at any junction iszero(Or) It can be also stated that the sum of current entering the junction is equal to the sum of current leaving the junction.$\mathbf{I_1 + I_2 = I_3 + I_4}$

8 **Define Active element.** BTL1

Active elements are those which supplies voltage or current to the circuit to operate it. It can be either voltage or current source. Examples: Generator, Transistor, Vacuum Tubes, etc.

9 **State Kirchhoff's voltage law. (KVL)**A/M 18 BTL1

It states that in a closed circuit the algebraic sum of the product of the current and resistance of all the elements plus the algebraic sum of the EMFs induced in the circuit is equal to zero.(Or) It can be stated that the sum of the Potential drop is equal to the sum of the Potential rise.

Σ IR + Σ emf = 0 (for DC circuits) or Σ IZ + Σ emf = 0 (for AC circuits)Where, R-Resistance Z- Impedance.

10 **Define Passive element.** BTL1

Passive elements are defined as the one which either dissipates energy in the form of heat or one which stores the energy.

Examples: Resistance dissipates energy in the form of heat

Inductance stores energy in the form of magnetic field.

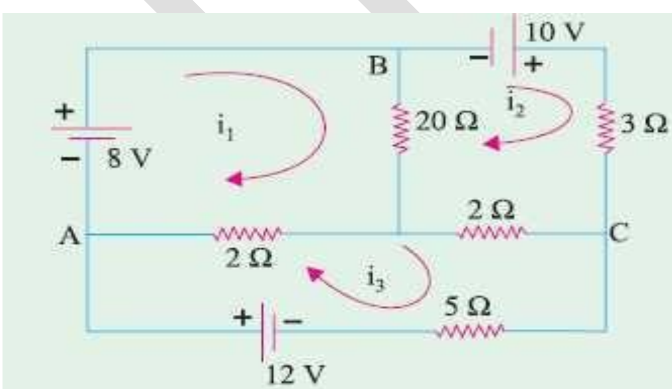
Capacitance stores energy in the form of electrostatic field.

11 Differentiate between AC and DC supply. BTL3

Sl. No.	AC supply	DC supply
1	Its magnitude varies with time	Here the magnitude is constant with respect to time
2	It has a constant frequency or variable frequency	Generally it has zero frequency
3	It is bidirectional in nature	It is unidirectional
4.	AC cannot be stored	DC can be stored Eg:Battery

12 **Define one cycle.**BTL1

	One complete set of positive and negative values of a alternating quantity is defines as one cycle.
13	**Define Time period.**BTL1 The time required for an alternating quantity to complete one cycle is defines as the period. It is denoted by 'T'.
14	**Distinguish between a Loop & Mesh of a circuit (DEC, '10),N/D 17,A/M 18**BTL1 The closed path of a network is called a Loop. An elementary form of a loop which cannot be further divided is called a mesh. In other words Mesh is closed path does not contain an other loop within it.
15	**Define Amplitude or peak value or crest value.** BTL1 The maximum value of the alternating quantity in a cycle is defined as amplitude. It is otherwise known as peak value or crest value.
16	**Define Phase difference.**BTL1 When two alternating quantity of same frequency have different zero points or maximum points, they are said to be out of phase. i.e. they have phase difference between them.
17	**Define instantaneous values.** BTL1 The value of alternating quantity at any instant is called instantaneous values.
18	**Define average value.** BTL1 It is defined as the average of instantaneous values taken over one complete cycle of the wave.
19	**Define RMS (Root mean square) value.** BTL1 The steady current (DC) which when flows through a given resistor for a given time produces the same amount of heat as is produced by the alternating current when flowing through the same resistor for the same time is call RMS or Effective value of the alternating current.
20	**Define Form factor.** BTL1 Form factor is defined as the ratio of RMS value to average value of an alternating quantity.
21	**Define Peak factor.** BTL1 Peak factor is defined as the ratio of Peak value to RMS value of an alternating quantity. It is also known as Amplitude or Crest factor.
22	**State Super position theorem. BTL2** In a linear network containing several sources the overall response in any branch in the network equals the algebraic sum of the response of each individual source considered separately with all other sources made inoperative i.e replace by their internal resistance or impedances.

23.	**State Thevenin's theorem**. BTL2 Across a pair of terminals AB, any linear network can be replace by an equivalent circuit composed of a voltages source V_{ac} in series with resistance R_{th} .The voltage V_{ac} is the voltage across the open circuited terminal AB and Rth is the equivalent resistance of the network as seen from terminals AB with all, independent sources replaced by their internal resistances.
24.	**State Norton's theorem**. BTL2 Any two terminals network containing linear,passive and active elements may be replaced by an equivalent current sources IN in parallel with a may be replaced by an equivalent sources IN in parallel with a resistances Rth where IN is the current flowing through a short circuit placed across the terminals AB and Rth is the equivalent resistance of the network as seen from two terminals with all independent sources
25.	**State Maximum power transfer theorem**. N/D 18 BTL2 In DC circuits maximum power is transferred from a source to the load when the load resistance is made equal to the resistance of the network as viewed from the load terminals with load removed and all the source replace by their internal resistances.
26.	**State reciprocity theorem. A/M 18** BTL2 In any linear network containing bilateral linear resistances and energy sources, the ratio of a voltage V introduced in one mesh to the current I in any second mesh is the same as the ratio obtained if the positions of V and I are interchanged, other voltage sources being removed.
27.	**Define Linearity theorem.** BTL2 For any circuit containing resistances and independent voltages and current source ,energy node voltage and branch currents is a linear function of the source value and has the form $\Sigma a_i V_I$ where V_I is the source value and is suitably constant value.
	PART*B
1	**Determine current in 5ohm resistor by any onemethod D/J 17**  Matrix-method for **Mesh analysis** can be used. Mark three loops as shown, in Fig. Resistance-matrix should be evaluated for current in 5-ohm resistor. Only, *i*3 is to be found.

$R_{11} = 3, R_{22} = 6, R_{33} = 9 \qquad R_{12} = 1, R_{23} = 2, R_{13} = 2$

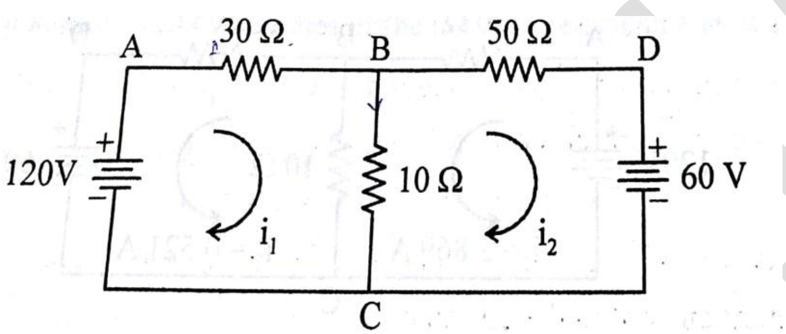
Voltage-source will be a column matrix with entries serially as : $-$ 8 Volts, + 10 Volts, + 12 Volts.

$$\Delta = \begin{vmatrix} 3 & -1 & -2 \\ -1 & 6 & -2 \\ -2 & -2 & 9 \end{vmatrix} = 3\times(54-4)+1(-9-4)-2(2+12) = 109$$

$$\Delta_3 = \begin{vmatrix} 3 & -1 & 8 \\ -1 & 6 & 10 \\ -2 & -2 & 12 \end{vmatrix} = 396$$

$$i_3 = \Delta_3/\Delta = 396/109 = 3.633 \text{ amp.}$$

2 **Solve the mesh and branch shown in figure.BTL2 A/M 18**



Answer: Page: 1.31-BEEI N.Dhanasekar

Definition: Assign the value of two meshes ABCA and BDCB.

I2=-0.521A--------------------(3M)

I1=2.869A----------------------(3M)

I=i1+i2-------------------------(4M)

I=3.39A--------------------------(3M)

3. **Discuss about the procedure of Norton’s theorem with a simple circuit.BTL2 A/M 19**

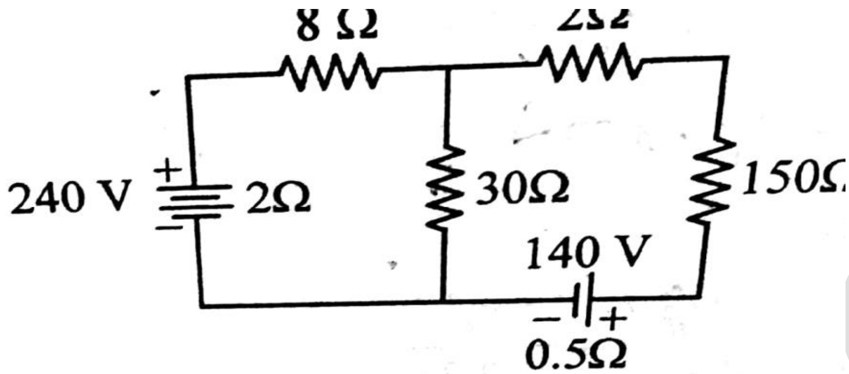
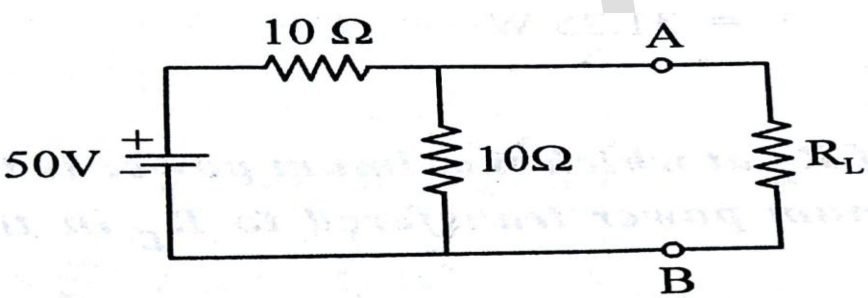
Answer: Page: 1.68-Dhanasekar

Definition: Two terminal network with the current sources voltage sources and resistances can be replaced by equivalent circuit. ----------------(4 M)

Short circuit current------------(3M)

Thevenin’s resistance-----(3M)

Calculating load resistance-----(3M)

4.	Analyses the current in 150Ω load resistor and the power consumed in it by the principle of superposition.  **Answer: Page: Page: 1.86-Dhanasekar** **Definition**: Voltage sources are short circuited and Current sources are open circuited. --------------(2M) Load current=6.84A---------(2M) Thevenin's resistance=35.07Ω-----(3M) Load current of each active source=5.94A-------(3M) Power =529.03W---------(3M)
5.	**Calculate the value of RL so that maximum power is transferred from battery.**  **Answer: Page: 1.76-Dhanasekar** **Definition**: Maximum power is transferred from a source to a load when the load resistance is equal to the internal resistance of the source--------------(3M) V_{TH}=25V------------(2M) R_{TH}=5Ω-----------(4M) P_{max}=31.25W---------(4M)
5.	**Explain the procedure of Thevinin'stheorem.N/D 18** **Answer: Page: 1.60- Dhanasekar** **Definition:** Any two terminal network having several a voltage and current sources can be replaced by equivalent

circuit--------(3M)

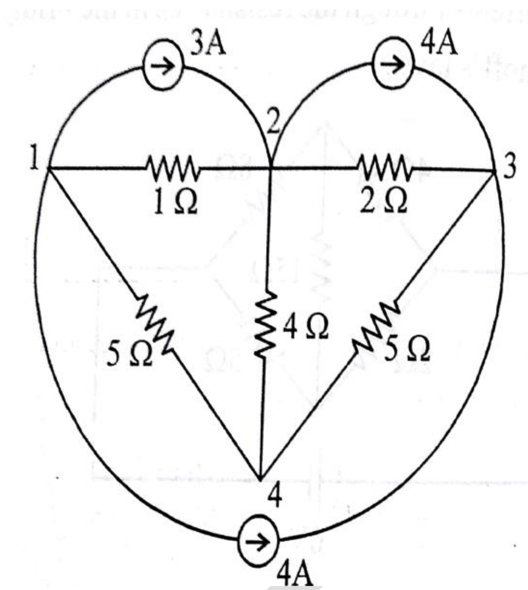
To calculate Voc-----(3M)

To calculate Rth-----(3M)

Thevenin’s impedance---(4M)

PART*C

1. **Write the nodal equations for the network shown in fig. Find the potential differences between nodes 2 and 4.BTL3**



Answer: Page: 1.42-Dhanasekar

Definition: It is used to analyses multisource circuits the methods of Kirchhoff’s current law and voltage laws.--------(4M)

I1=5A----------(3M)

I2=10 A---------(4M)

I=15 A----------(4M)

2. **Explain about Delta to star conversion and star to delta conversion.**BTL2

Answer: Page: 1.52-Dhanasekar

Definition: It is used to simplify certain network problems. -----------------(6 M)

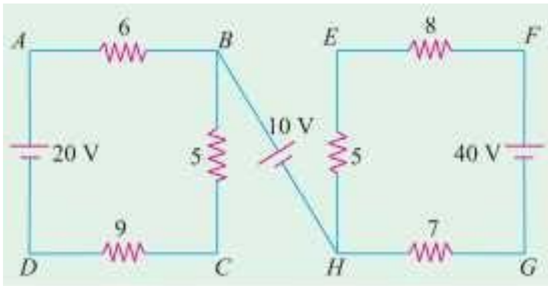
I)Delta to star conversion

$R_{AB}=R_{BC}=R_{CA}=R$.--------(4M)

II)Star to delta conversion

RAB=RBC=RCA=3R--------(5M)

3 **For the circuit shown in Fig, find VCE andVAG N/D 19 BTL 2**



Consider the two battery circuits of Fig. separately. Current in the 20 V battery circuit *ABCD* is 20 (6 + 5 + 9)
= 1A. Similarly, current in the 40 V battery circuit EFGH is = 40/(5 + 8 + 7) = 2A. Voltage drops over different resistors can be found by using Ohm's law.

i.e. voltage of point *C* with respect to point *E*, we will start from point *E* and go to *C* via points *H* and *B*. We will find the algebraic sum of the voltage drops met on the way from point *E* to *C*. Sign convention of the voltage drops and battery e.m.fs. would be the same as discussed in Art. 2.3. For finding*VCE*

$$\therefore \quad V_{CE} = (-5 \times 2) + (10) - (5 \times 1) = -5\text{V}$$

The negative sign shows that point *C* is negative with respect to point *E*.

$$V_{AG} = (7 \times 2) + (10) + (6 \times 1) = 30 \text{ V}.$$

The positive sign shows that point *A* is at a positive potential of 30 V with respect to point*G*.

<table>
<tr><td></td><td>UNIT II AC CIRCUITS</td></tr>
<tr><td></td><td>Introduction to AC circuits – waveforms and RMS value – power and power factor, single phase and three-phase balanced circuits – Three phase loads - housing wiring, industrial wiring, materials of wiring</td></tr>
<tr><td>Q.No.</td><td>Questions</td></tr>
<tr><td>1.</td><td>What is the expression for 3-phase power?BTL1

$P = 3\ V_{\Phi}\ I_{\Phi}\ \cos \Phi$ Watts

Where, V_{Φ} – is the phase voltage
I_{Φ} – is the phase current
Φ – Phase angle between V & I

(Or)

$P = \sqrt{3}\ V_L\ I_L\ \cos \Phi$ Watts
Where, V_L – is the line voltage
I_L– is the line current
Φ – Phase angle between V & I</td></tr>
<tr><td>2</td><td>What are line and phase voltages and what is the relation between them?BTL1
Line-Line voltage or simply line voltage is defined as the voltage between any two lines of a 3-phase system. It is represented by E_L. Various line voltages are E_{RY}, E_{YB}, and E_{BR}.
Phase voltage is defined as the voltage between one line and the neutral wire of a star connected system. It is represented by E_p. Various phase voltages are E_{RN}, E_{YN}, and E_{BN}.
In Delta Connected System, Line voltage = Phase Voltage ($E_L = E_P$)
In Star Connected System, Line voltage = $\sqrt{3}$ Phase Voltage ($E_L = \sqrt{3}\ E_P$)</td></tr>
<tr><td>3</td><td>What are line and phase currents and what is the relation between them? BTL1
Line current is one which that flows in the 3 lines. It is represented by E_L. Various line currents are I_R, I_Y, and I_B.
Phase current is one which that flows between any two phases. It is represented by $I_{P.}$ Various phase currents are I_{RY}, I_{YB}, and I_{BR}.
In Delta Connected System, Line current = $\sqrt{3}$ Phase current ($I_L = \sqrt{3}\ I_P$) In Star Connected System,</td></tr>
</table>

Line current = Phase current ($I_L = I_P$)

4 **What are the advantages of 2-wattmeter method of power measurement over the 3-wattmeter method?** BTL1

- Number of wattmeter required is less. i.e. only two instead of three.
- Since number of wattmeter is reduced the losses due to the wattmeter coils is less and hence the accuracy is more.
- Power factor of the system can also be determined using 2-wattmetermethod.

5 **Define balanced load.A/M 18** BTL1

A load is said to be a balanced load, if the power factor and phase current in the 3-phase are equal.

6 **What is phase sequence?**BTL1

The order in which voltage in the three phases reach their maximum value or minimum value is called the phase sequence

7 **Give advantage of 3 phase system over single phase system.N/D 18** BTL3

- In a three-phase circuit, the total power is more uniform unlikely, in a single-phase circuit the power varies widely.
- Generation, transmission and distribution of power is more economical in three phase system compared to single phase system.
- Three phase machines have better power factor and efficiency.

8 **What is the difference between single-phase and three-phase AC supply?**BTL1

Sl. No.	**Single phase AC supply**	**Three phase AC supply**
1	It has one conductor	It has three conductors
2	Low power applications	Huge power applications
3	It has two lines Phase(P) and Neutral line(N) for return path	It has three or four lines. ▫ R-Red ▫ Y-Yellow ▫ B-Blue ▫ N-Neutral ▫In a three wire system for current flow in R phase Y & B

	acts as the return path and so on. □ Four wire system which includes Neutral is found in star connected systems
9	**Define leading and lagging angle**.BTL1 **Leading angle**: The leading quantity is one which reaches its maximum orminimum value earlier as compared to the reference quantity. **The angulardifference between reference vector and leading vector.** **Lagging angle:** The lagging quantity is one which reaches its maximum orminimum value after the reference quantity. **The angular difference betweenreference vector and lagging vector.**
10	**What is meant by cycle?** BTL1 One complete cycle is set of positive and negative values of an alternating quantity.
11	**Define Amplitude.** BTL1 The maximum value, either a positive and negative of an alternating quantity is called amplitude.
12	**What is phase sequences?** BTL1 The order in which the voltage in the phase reach their maximum value or minimum value is called phase sequences.
13	**What is meant by balanced system?** BTL1 A balanced system means that currents in the three phases are equal in magnitude in a system are equal are displaced by 120 degrees.
14	**Define phase voltage and phase current**. BTL2 Phase voltage is nothing but voltage across each circuit. The current flowing in the phases is called phase current(I_{ph})
15	**Define balanced load.** BTL2 A load is said to be a balanced load, if the power factor and phase current in the 3 phase are equal is called balanced load.
16	**What are three types of power used in AC circuits?A/M 18BTL1** Real or active power P=EI cos Φ Reactive power Q=EI sin Φ
17	**Define Capaictence.**BTL1 A capacitor is circuit element which like the inductor store energy during periods of time and returns the energy during others. In the capacitor storage take place in an electric field by an insulating system.

18	**Define Crest factor.** BTL1 It is defined as the ratio of Maximum value and RMS value.
19	**Define powerfactor..BTL1 N/D 18** Power factor is defined as the cosine of angle between voltage and current. If φ is the angle between voltage and current then cos φ is called as the power factor. 
20	**What is housewiring?BTL1 N/D 19** House wiring is defined as any wiring or electrical system used in a home or itssurroundingareas.In a home, the wiring system includes outlets, the main panel and meter base, and it is essential that all pieces are installed and function together properly to keep the home safe.
21	**Write is meant by industrialwiring?BTL1 A/M 18** Smart industrial wiring is based on 3-phase electrical power. 3-phase electric allows less workload to be placed on each wire involved while at once allowing them to work together to give you maximum results. With 3-phase electric, the wires are smaller and the motor is smaller than a typical single-phase motor. These factors allow greater efficiency and longer lasting motors and wires. There are four types of 3-phase electrical power: • Common 3Wire • Common 4Wire • 3 Wire with Grounded HotLeg • Special 4Wire No matter which type of 3-phase electrical power you choose to use, you'll need a voltage meter in order to determine the actual voltages that are available to you. The type does not determine this. Industrial wiring typically runs through metal conduits, armored cable, or a raceway. These enclosures are the safety ground–never the neutral wire
	PART * B
1.	**Explain in detail the performance analysis of single-phase AC circuits and derive the average value, RMS value, form factor and instantaneous drive**. **BTL2 A/M 18** **Answer: Page: 2.32-Dhanasekar** **Definition: Single-phase** electric power is the distribution of alternating current electric power using a system in which all the voltages of the supply vary in unison. **Single-phase** distribution is used when loads are mostly lighting and heating, with few large electric motors. --------(2M) Poly phase AC circuits ---------------------------(4M) Multi phase AC circuits -------------------(4 M) Explanation:Single Phase connection is no problem at all. The 1.5Ton AC will also run on single phase only. The only thing you need to worry about is the sanctioned maximum load that you have for your house connection from the electricity distribution utility -------(3M)

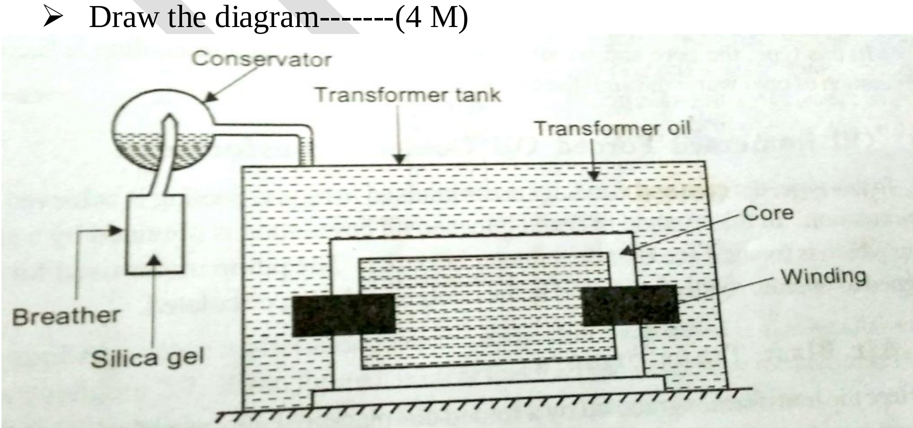
2	**What is the relationship between line and phase voltage and current in star and delta connected circuits? Explain.BTL 2** **Answer: Page: -2.32Dhanasekar** **Definition:**Three-phase electric power is a common method of alternating current electric power generation, transmission, and distribution. It is a type of polyphase system and is the most common method used by electrical grids worldwide to transfer power. It is also used to power large motors and other heavy loads. --------(2M) Delta connection---------------------------(4M) Star connection -------------------(4 M) **Explanation:**One distinct advantage of a Δ-connected system is its lack of a neutral wire. ... Even with a source winding failure, the line voltage is still 120 V, and load phase voltage is still 120 V. The only difference is extra current in the remaining functional source windings. -------(3M)
3	**Draw the phasor diagram of series RLC circuit energised by a sinusoidal voltage showing their relative positions of current and voltage when $X_L > X_C$ and $X_L = X_C$.(13M)BTL3 N/D 18** **Answer: Page: -2.22Dhanasekar** **Definition:phase angle** refers to the angular component of the complex number representation of the function. The notation for a vector with magnitude (or amplitude) A and **phase angle** θ, is called **angle** notation. ... In the context of periodic phenomena, such as a wave, **phase angle** is synonymous with **phase**. --------(2M) RLC circuit---------------------------(4M) Inductive reactance and Capaictence -------------------(4 M) **Explanation:**The resonance of a series RLC circuit occurs when the inductive and capacitive reactance's are equal in magnitude but cancel each other because they are **180 degrees** apart in phase. The sharp minimum in impedance which occurs is useful in tuning applications. ---------------------------(3M)
4	**Distinguish between (i)Apparent power (ii)Active power(iii)Reactive power is AC circuits. (13M)BTL2** **Answer: Page: -2.20Dhanasekar** **Definition:**In an AC circuit, the product of the rms voltage and the rms current is called apparent power. When the impedance is a pure resistance, the apparent power is the same as the true power. But when reactance exists, the apparent power is greater than the true power.-------------------------------------(2M) Apparent power ---------------------------(4M) Active power and reactive power -------------------(4 M) **Explanation:**The combination of reactive power and true power is called apparent power, and it is the product of a circuit's voltage and current, without reference to phase angle. Apparent power is measured in the unit of Volt-Amps (VA) and is symbolized by the capital letter S.---------------------------(3M)

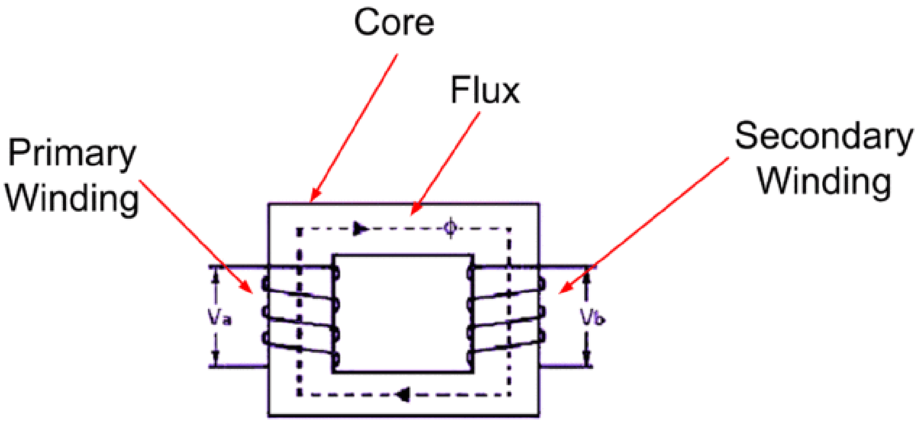
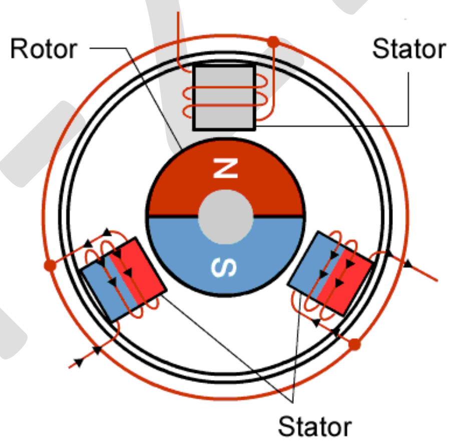
5	**Show that in three phase star connected system line voltage is times the phase voltage. (13M)BTL3** **Answer: Page: -2.32 Dhanasekar** **Definition:Three-phase electric power** is a common method of alternating current **electric power** generation, transmission, and distribution. It is a type of polyphase system and is the most common method used by electrical grids worldwide to transfer **power**. It is also used to **power** large motors and other heavy loads.--------(2M) Star connected in line voltage ---------------------------(4M) Phase voltage across line -------------------(4 M) **Explanation:**The Delta configuration has the three phases connected like a triangle, whereas the Wye (or "star") configuration has all three loads connected at a single neutral point. Delta systems have **four wires**—three hot and one ground. Wye systems have **five wires**—three hot, one neutral and one ground.-------------------------(3M)
	PART*C
1.	**A series RC circuit has R=100Ω and Xc=200 Ω. The supply voltage is 50V.Find the apparent power,real power, reactive power for the circuit.(14 M)1BTL3 A/M 19** **Answer: Page: -2.23Dhanasekar** **Z=223.6 Ω------------(2M)** **Cos Φ=0.447--------(2M)** **S=11.15VA----------(2M)** **P=4.984W------------(4M)** **Q=9.96 VAR-----------(3M)**
2	**A sinusoidal voltage V=50 sin wt is applied to a series RL circuit.The current in the circuit is given by i=25 sin(wt-53). Determine (a)Apparent power (b)Power factor(c)Average power.BTL3 N/D 19** **Answer: Page: -2.17Dhanasekar** **P=625KVA-----------------(3M)** **COS θ=0.6---------------------(4M)** **Pav=375W----------------------(4M)** **P r=V eff I eff sin θ-------------------(6M)**
3	**What are the materials used for electricalwiring?A/M 19** • AC power plugs andsockets. • Cabletray. • Electricalconduit.

	• Mineral-insulated copper-cladcable. • Multiwayswitching. • Steel wire armouredcable. • Ringcircuit. • Thermoplastic-sheathedcable.
	UNIT –III ELECTRICAL MACHINES
	Principles of operation and characteristics of DC machines, Transformers (single and three phase), Synchronous machines, three phases and single-phase induction motors.
Q.No.	**PART*A**
1.	**What is a generator?**BTL1 Generator is an electrical machine, in which mechanical energy is converted into electrical energy.
2	**What is the principle of a DC Generator?N/D 18,**BTL1 Whenever a conductor cuts magnetic flux, dynamically induced EMF is produced in it according to Faraday's laws of Electromagnetic induction. This EMF causes a current to flow if the conductor circuit is closed.
3	**State the principle of a DC motor. A/M 17,18**BTL1 A DC motor is an electrical machine which converts electric energy into mechanical energy.It is based on the principle that when a current carrying conductor is placed in a magnetic field, it experiences a mechanical force whose direction is given by Fleming's Lefthand rule and the magnitude of the force in given by $F = B\ I\ l$ Newton.
4	**Mention the types of DC Motor &Applications.A/M 15, 16**BTL2 (a) **DC Series motor** -- Constant speed motor Used in Drilling, Spinning, etc… (b) **DC Shunt motor** -- Variable speed motorUsed in Electric Traction, conveyors, etc… (c) **DC Compound Motor** –Variable speed motor Used in Rolling Mills, Printing press, etc.
5	**What is the use of a commutator in a DC Generator?A/M 16** BTL2 Commutator is also called as split rings. Its function is to rectify i.e. to convert the alternating current induced in the armature conductors into unidirectional current in the external load circuit.
6	**Mention the types of loss occurring in a D.C machine.BTL3** **(a) Iron loss** i) Hysteresis loss : It is due frequent magnetic reversals ii) Eddy current loss: It is due leakage flux in the air gap.

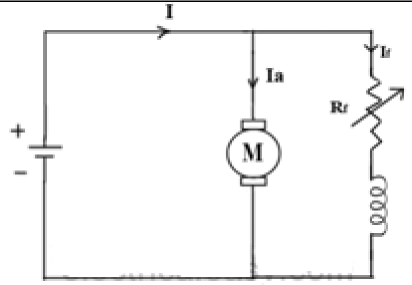
	(b) Copper loss -- occurs due to the resistance of the windings **(c) Mechanical loss** - Friction loss -- Due to frictions in the bearings and brushes - Winding loss-- Losses occurring in the air gap of themachine.
7	**What is the working principle of single phase induction motor?A/M 17,18 BTL2** The working principle of induction motor is mutual induction, which is similar to that of a transformer. The stator receives electrical supply which produces a revolving flux in the rotor and hence the rotor rotates.
8	**Why single phase induction motor is not self-starting.**BTL3**N/D 17,A/M 18** • When a single phase supply is fed to stator winding, it produces a flux which is only alternating (or pulsating) in nature. • It does not produce synchronously revolving flux, as in case of a two or three phase stator winding, fed from two or three phase supply. • Now, the alternating or pulsating flux acting on a stationary rotor cannot produce rotation. That's why single phase induction motor is not self starting. • If the rotor of such a machine is given an initial start by hand or some other means, then immediately a torque arises, and the motor accelerates to its final speed.
9	**What are the types of single phase induction motors?**BTL1 • Split phase • Capacitor start induction run • Capacitor start capacitor run • Shaded pole.
10	**What is an alternator?**BTL2 An alternator or AC generator is a synchronous machine which converts mechanical energy into electrical energy and produces alternating emf.
11	**What is the principle of an alternator?**BTL2 The alternator works on the principle of Faraday's law of electromagnetic induction. Whenever a conductor links with a magnetic field either the conductor is moving, or the field is moving an emf is induced in the conductor.
12	**What are the different types of alternators? Which is in commonuse?**BTL1 Alternators are of two types • Rotating armature type • Rotating field and stationary armature type. • Rotating field type.

13	**What are the main parts of an alternator?**BTL1 The main parts of an alternator are i) Rotor (Salient pole type or cylindrical type), ii) Stator (Frame, core and Armature conductors) and iii) Exciter.
14	**What is a Transformer? BTL1A/M 19** A transformer is a static device, which is used to increase or decrease the voltage level without change in frequency.The basic principle of a transformer is Mutual induction between two coils which are linked by a common magnetic flux.
15	**Mention the losses occurring in Transformer?**BTL3 • **Core loss or iron loss:** This includes, o Hysteresis loss : It is due frequent magnetic reversals o Eddy current loss: It is due leakage flux in the air gap. • **Copper loss:** This loss occurs due to the resistance of thetransformer windings.
16	**What are the advantages of Thermal power plant?**BTL1 • The fuel (i.e. coal) used is quite cheap. • Less initial cost as compared to other generating stations. • It requires less space as compared to the hydro power plant. • The cost of generation is lesser than that of the diesel power plant.
17	**What are the disadvantages of Thermal power plant?**BTL1 It pollutes the atmosphere due to the production of large amount of smoke and fumes. Running cost is more.
18	**What are the advantages of Hydro power plant?**BTL1 • It requires no fuel as water is used for the generation of power and hence less running cost. • Pollution is less as no smoke or ash is produced. • It is comparatively simple in construction and requires less maintenance. • In addition to the generation of electrical energy, they also help in irrigation and controlling floods.
19	**What are the disadvantages of Hydro power plant?**BTL1 • It involves high capital cost due to construction of dam. • There is uncertainty about the availability of huge amount of water due to dependence on weather conditions. • It requires high cost of transmission lines as the plant is located in hilly areas which are quite away from the consumers.

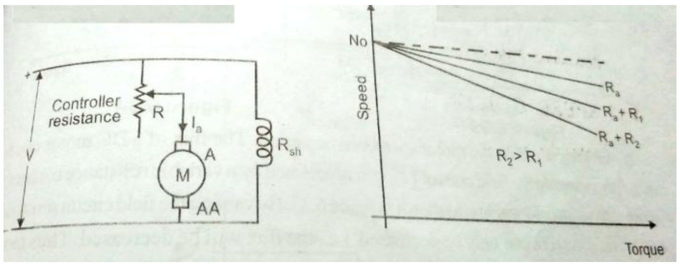
20	**Name the types of Alternator based on their rotor construction.**BTL3 • Alternators can be classified into the following **two types** according to its rotor construction: • Smooth cylindrical type alternator (non projected) • Salient pole alternator (projected type)
21	**What is the use of commutator and brush in a D.C machine? BTL1** The commutator converts the alternating emf into unidirectional or direct emf. The brushes are mainly used to collect current from the commutator.
22	**What is the basic principle of operation of D.C motor?BTL1** The basic principle of operation of D.C motor is that a current carrying conductor placed in a magnetic field, experiences a force tending to move it.
23	**What is a prime mover?BTL1** The basic source of mechanical power, which drives the armature of the generator, is called prime mover.
24	**State Lenz's law .BTL1** Any induced emf will circulate a current in such a direction as to oppose the cause producing it.$e = -N\,d\varphi/dt$
25	**How are hysteresis and eddy current losses minimized?BTL1** • Hysteresis loss can be minimized by selecting materials for core such as silicon steel & steel alloys with low hysteresis co-efficient and electrical resistivity. • Eddy current losses are minimized by laminating the core.
	PART-B
1	**Describe the Construction and working principle of a transformer.**BTL2 A/M 18,19,N/D 15**(13M)** **Answer: Page :4.3 – Dr.C.Ramesh babu Durai** ➢ Draw the diagram-------(4 M)  ➢ Explain the parts----------(5 M) ✓ Magnetic core

	✓ Primary and Secondary Winding ✓ Insulation of winding ✓ Expansion tank and Conservator ✓ Lead and tappings for coils – support, terminal and terminal insulator ✓ Tank , Oil , cooling arrangements , temperature gauge , oil gauge ✓ Buchhols relay ✓ Silica gel breather ➢ Explain the working Principle(4 M)  ✓ Electromagnetic induction Principle Faradays law
2	**Explain the working of BLDC motor.** BTL2 **(13M)** **Answer: Page :5.10 – Dr.C.Ramesh babu Durai**  • Brushless DC motors do not use brushes. • With brushed motors, the brushes deliver current through the commutator into the coils on the rotor. • A brushless motor pass current to the rotor coils? It doesn't—because the coils are not located on the rotor. • the coils do not move, there is no need for brushes and a commutator. • rotation is achieved by controlling the magnetic fields generated by the coils on the rotor • To change the rotation speed, you change the voltage for the coils. • A BLDC motor, it is the permanent magnet that rotates; rotation is achieved by changing the direction of the magnetic fields • A BLDC motor with three coils on the stator will have six electrical wires • Wiring in the BLDC motor case is more complicated than simply connecting the power cell's positive and negative terminals

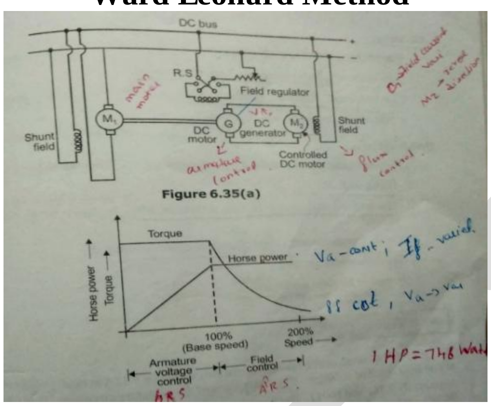
	• One big advantage is efficiency, as these motors can control continuously at maximum rotational force (torque) • The second big advantage - related to the first - is controllability • Precision control in turn reduces energy consumption and heat generation
3	**Derive the EMF equation of a DC generator and explain about the significance of back emf .**BTL3,A/M 18,N/D 16 **Answer: Page :3.11 – Dr.C.Ramesh babu Durai** ➢ Derive the DC generator EMF equation (10 M) ✓ Ø = flux/pole in Wb (weber) ✓ Z = total no. of armature conductors ✓ P = No. of generator poles ✓ A = No. of parallel paths in armature ✓ N = rotational speed of armature in revolutions per min. (rpm) ✓ E = emf induced in any parallel path in armature By Faradays law, e=PNϕ/60 = PNϕ/60 * Z/A (3 M) For wave A = 2 wound e=PNϕZ/120 for lap A=P wound e= NϕZ/60
4	**Describe the following methods of speed control of DC Shunt Motor (i) Flux Control Method (ii) Armature Rheostat Control Method (iii)Ward Leonard Method. (13M)** BTL2 **Answer: Page :3.41 – Dr.C.Ramesh babu Durai** ➢ Draw the circuit (6 M) ➢ Explain the speed control (7 M) **Flux control method:** ✓ SpeedControlOfDcShuntMotor - Vaisthevoltageappliedacrossthearmature, Nistherotorspeedandφisthefluxper poleandisproportionaltothefieldcurrentI_f. ✓ ArmaturecurrentIa is decidedbythemechanicalloadpresentontheshaft. ✓ VaryingVaand$I_f$wecan varyn. **VaryingArmatureResistance** ✓ Fixedsupplyvoltageandthemotorconnectedasshuntwecanvary Va by controllinganexternalresistanceconnectedinserieswiththearmature. ✓ Ifofcoursecanbe variedbycontrollingexternalfieldresistanceRf connectedwiththefieldcircuit ✓ The inherentarmature resistance Ra being small, speed n versus armature current(Ia)characteristicwillbeastraightlinewithasmallnegativeslopeasshowninfigure. **Flux Control Method**



Armature Rheostat Control Method



Ward Leonard Method

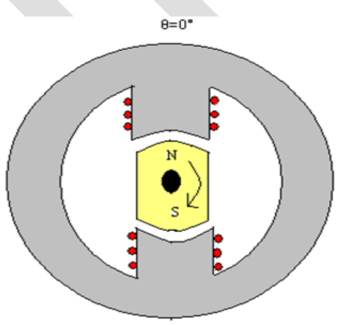


5

Discuss the construction and working principle of Hybrid stepper motor with neat diagrams. (13 M)BTL4

Answer: Page :5.9 – Dr.C.Ramesh babu Durai

Diagram &construction : (2 M)

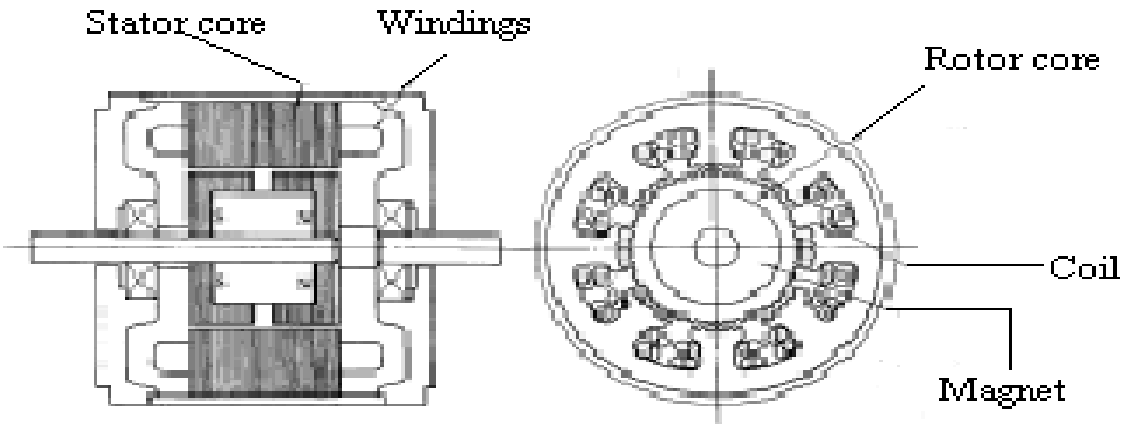


variable reluctance and permanent magnet motors: (2 M)

1. It is salient pole type rotor
2. Permanent magnet rotor
3. It has the features of both VR stepper motor PMSM.

4. A four phase hybrid stepper motor shown.
5. Two coils at a pole are wound in the bifilar scheme
6. Produce different magnetic polarities on excitation.

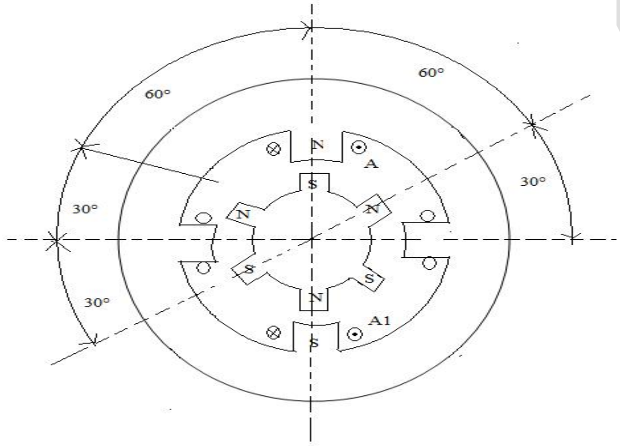
Cross section of hybrid stepper motor: (3 M)



Hybrid stepper motor with 8 stator poles : (4 M)

1. A cylindrical magnet lies in the rotor core.
2. Magnetized lengthwise to produce a unipolar field.
3. Each pole of the magnet covered with uniformly toothed soft steel.

Principle of operation : (2 M)



1. Phase winding A is energized with current i_a, N pole at A_1 and S pole at A_2 are created on the stator.
2. Pole at A_1attracts S pole of far end and pole at A_2 attracts N pole of front end.
3. This equilibrium position of rotor structure results in maximizing the flux linkages
4. phase winding 'A'. Here rotation $\theta=0°$
5. For the rotor clockwise through a step, de-energize phase winding A excite phase winding B so that N pole at B_2 are created on stator.

6 **Explain stepper motor type merits, demerits and comparison. (15 M)**BTL5

Answer: Page :5.9– Dr.C.Ramesh babu Durai

Advantages and disadvantages of variable reluctance motor : (5 M)

1. High torque to inertia ratio
2. Low rotor inertia
3. High rates of acceleration
4. High speed slewing capability
5. No detent torque available when windings are de energized
6. Low efficiency at low voltage

Advantages and disadvantages of permanent magnet stepper motor : (5 M)

1. Provides detent torque winding de energized
2. Higher holding torque capability
3. Less tendency to resonate.
4. High stepping rate capability.
5. Slower acceleration and response.
6. Performance affected by change in magnet strength.

Advantages and disadvantages of hybrid stepper motor : (5 M)

1. Small step length.
2. Detent torque with windings de energized.
3. Higher holding torque capability.
4. More expensive than variable reluctance stepper motor.
5. Performance affected by change in magnet strength.

7

Derive the EMF equation of a Static AC machine or Transformer. BTL3 **N/D 17(13M)**

Answer: Page :4.6 – Dr.C.Ramesh babu Durai

- When a sinusoidal voltage - applied to the primary winding of a transformer
- Alternating flux ϕ_m sets up in the iron core of the transformer.
- This sinusoidal flux links with both primary and secondary winding.
- The function of flux is a sine function.
- The rate of change of flux with respect to time is derived mathematically.

The derivation of **EMF Equation** of the transformer is shown below. Let

- ϕ_m be the maximum value of flux in Weber
- f be the supply frequency in Hz
- N_1 is the number of turns in the primary winding
- N_2 is the number of turns in the secondary winding
- Φ is the flux per turn in Weber

As shown in the above figure that the flux changes from + ϕ_m to – ϕ_m in half a cycle of 1/2f seconds.

By Faraday's Law

Let E_1 is the emf induced in the primary winding

$$E_1 = -\frac{d\psi}{dt}$$

Where $\Psi = N_1\varphi$

$$E_1 = -N_1 \frac{d\varphi}{dt}$$

$$E_1 max = N_1 w\varphi_m$$

But $w = 2\pi f$

$$E_1 max = 2\pi f N_1 \varphi_m$$

EMF Equation of a Transformer

EMF Equation of a Transformer

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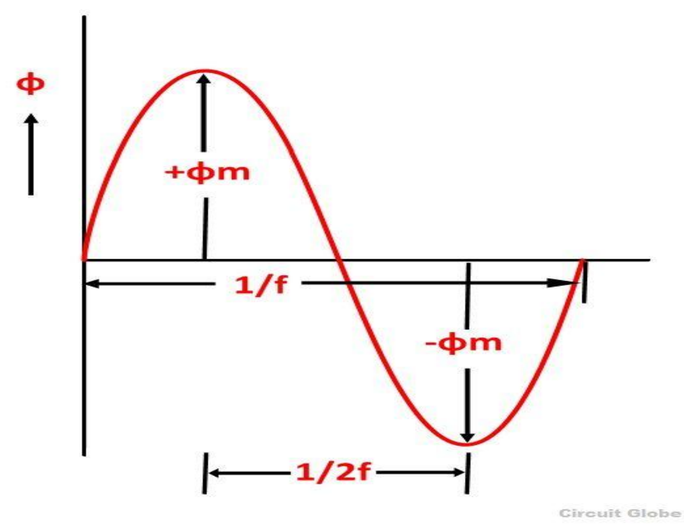
Φ is the flux per turn in Weber



As shown in the above figure that the flux changes from $+\phi_m$ to $-\phi_m$ in half a cycle of 1/2f seconds.

By Faraday's Law

Let E_1 is the emf induced in the primary winding

$$E_1 = -\frac{d\psi}{dt} \dots\dots\dots (1)$$

Where $\Psi = N_1\phi$

$$\text{Therefore, } E_1 = -N_1 \frac{d\varphi}{dt} \dots\dots\dots (2)$$

Since ϕ is due to AC supply $\phi = \phi_m Sinwt$

$$E_1 = -N_1 \frac{d}{dt}(\varphi_m \, \text{Sinwt})$$

$$E_1 = -N_1 \, w\varphi_m \, \text{Coswt}$$

$$E_1 = N_1 w\varphi_m \, \text{Sin}(wt - \pi/2) \dots\dots\dots (3)$$

So the induced emf lags flux by 90 degrees.

Maximum valve of emf

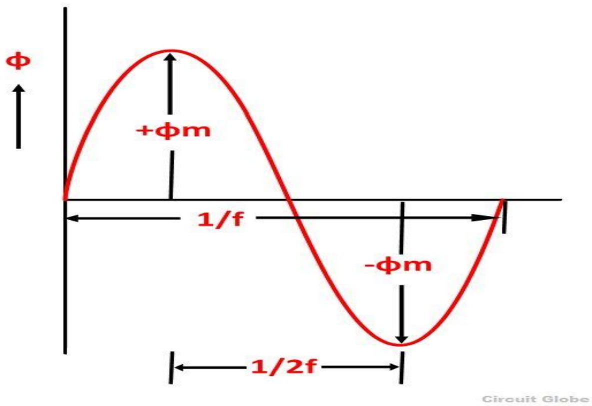
$$E_1 max = N_1 w\varphi_m \dots\dots\dots (4)$$

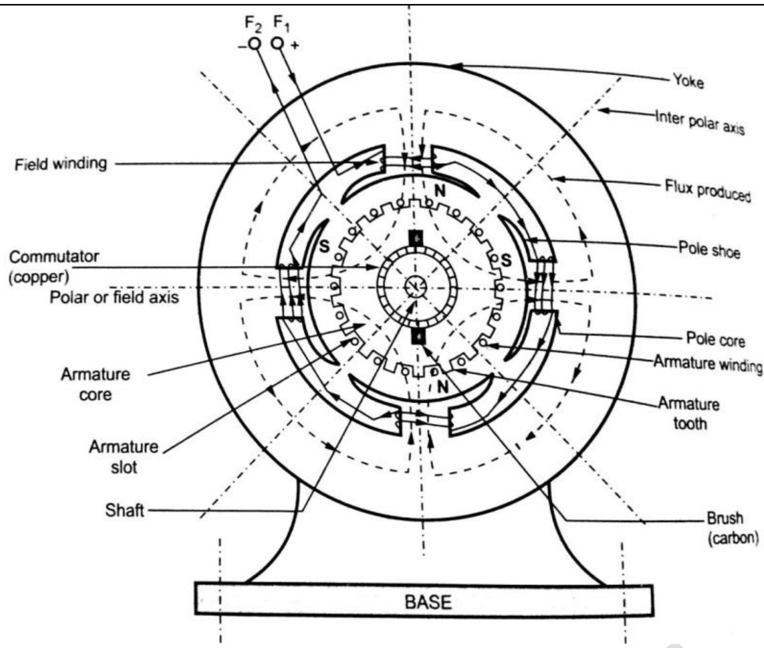
But $w = 2\pi f$

$$E_1 max = 2\pi f N_1 \varphi_m \dots\dots\dots (5)$$

$$\frac{\text{R.M.S value}}{\text{Average value}} = \text{Form factor} = 1.11$$

Root mean square RMS value is

	$$E_1 = \frac{E_{1max}}{\sqrt{2}}$$ Putting the value of E_1max in equation $$E_1 = \sqrt{2}\pi f N_1 \varphi_m$$ $$E_1 = 4.44 f N_1 \varphi_m$$ $$E_2 = \sqrt{2}\pi f N_2 \varphi_m$$ $$\frac{E_2}{E_1} = \frac{4.44 f N_2 \varphi_m}{4.44 f N_1 \varphi_m}$$ 
	PART*C
1	**Describe the construction and principle of operation of DC generator. (13M)** BTL2 A/M 18 **Answer: Page :3.3 – Dr.C.Ramesh babu Durai** ➢ Draw the diagram (7 M) ➢ Explain the parts in detail (6M)

	 ➢ The major parts can be identified as ✓ Frame/Yoke -Protecting cover ✓ Poles of Technology Madras ✓ Armature – laminated sheets of silicon steel ✓ Main pole and inter pole ✓ Winding – small section copper ✓ Commutator – DC to AC ✓ Brush gear – supply to external circuit ✓ Commutating poles ✓ Compensating winding- reduce the sparking
2	**A 8pole DC shunt generator with 778 wave connected armature conductors and running at 500 rpm supplies a load of 12.5Ω resistance at a terminal voltage of 250 V. The armature resistance is 0.24 Ω and field resistance is 250 Ω respectively. Calculate the armature current and induced emf and flux per pole. (13M)** BTL4**A/M 17** **Answer: Page :3.49 – Dr.C.Ramesh babu Durai** ➢ Write the formula ➢ Substitution with answer Load current I_L =V/R_L = 20 A (2 M) Shunt field current I_{sh}=V/R_{sh} =1 A(2 M) Armature current Ia= I_L + I_{sh}(2 M) =21 A (1 M) Induced EMF Eg = V+ IaRa (2M) =255.04 A(1M) Flux per pole (ϕ) = P ϕZN/60A (2M) =19.66 mwb(1M)

3	**Find all day efficiency of a transformer having maximum efficiency of 98% at 15 Kva at unity power factor and loaded as follows:** **12 hours – 2 KW at 0.5 p.f lag** **6 hours – 12 KW at 0.8 p.f lag** **6 hours – at no load** BTL4 **(13M)** **Answer: Page :4.9 – Dr.C.Ramesh babu Durai** ➢ Write the formula (7M) ➢ Answer (6M) Input power = output power / efficiency (2 M) = 5.306 kW (1 M) Total losses = Input power – output power (2 M) = 0.306 kW (1 M) Full load copper loss = Iron loss = Total loss / 2 (1 M) = 0.153 kW (2 M) η all-day = Output power in Kwh/Input power in kWh *100 (2 M) =95.31% (2 M)

	UNIT IV ELECTRONIC DEVICES & CIRCUITS
	Types of Materials – Silicon & Germanium- N type and P type materials – PN Junction –Forward and Reverse Bias –Semiconductor Diodes –Bipolar Junction Transistor – Characteristics – Field Effect Transistors – Transistor Biasing –Introduction to operational Amplifier –Inverting Amplifier –Non Inverting Amplifier – DAC – ADC
Q.No.	**PART*A**
1.	**Define amplifier.**BTL1 An amplifier is a device which amplifies or increases magnitude of any current or voltage applied at its input.
2	**What is rectifier?** BTL1 A rectifier is defined as an electronic device for conversion of AC voltage or current into unidirectional (DC) voltage or currents. A semiconductor diode is used as a rectifier.
3	**What is meant by half wave rectifier?** BTL1 A half wave rectifier is one which converts an AC voltage into a pulsating DC voltage for only half cycle of the applied voltage.
4	**What is meant by full wave rectifier?** BTL1 N/D 17 A full wave rectifier is a two diode rectifier that converts the applied alternating voltage into a pulsating DC (unidirectional) voltage for the full cycle of the AC voltage.
5	**Define ripple factor.**BTL2 A/M 16 It is defined as the ratio of the effective value of the AC components of voltage or current to the direct or average value of the voltage or current.
6	**What is meant by ripple?**BTL1 The pulsating output voltage of a rectifier consists of a DC component and alternating voltage components. The unwanted AC components of rectified voltage constitute the 'ripple voltage'.
7	**What is ripple voltage?**BTL1 Ripple voltage is not a pure sinusoidal voltage but consists of a fundamental sine wave component and harmonics, therefore in progressively reducing amplitudes. In case of full wave rectifier, the fundamental ripple frequency is twice the supply voltage frequency.
8	**What are semiconductors?** BTL1 The materials whose electrical property lies between those of conductors and insulators are known as semiconductor.eg Germanium, Silicon .It has two types Intrinsic semiconductor and Extrinsic semiconductor.

9	**Write the application of PN junction diode.** BTL3**A/M 19** • Can be used as rectifier in DC power supplies • Demodulation or detection circuits • Clipping networks used as DC restores.
10	**Define pinch off voltage. BTL3** It is the voltage at which the channel is pinched off, i.e all the free charge from the channel get removed.At pinch off voltage VP the drain current becomes constant.
11	**Mention the applications of FET.BTL2** Buffer in measuring instruments it has high impedance and low output impedance. RF amplifiers in FM tuners and communication equipment for the low noise level. Phase shift oscillator because frequency drift is low.
12	**What is biasing? BTL1** To use the transistor in any application it is necessary to provide sufficient voltage and current to operate the transistor. This is called biasing.
13	**Base on the transistor configuration how amplifiers are classified**. **BTL3N/D 18** • Common emitter amplifier • Common collector amplifier • Common base amplifier
14	**Which is most commonly used transistor configuration? why?BTL3A/M 17** • High current gain • High voltage gain • High power • Moderate input to output ratio.
15	**Define operational amplifier**. BTL1**A/M 19** An operational amplifier is a direct coupled high gain amplifier consisting of one or more differential amplifier. By properly selecting the external components it can be used to perform a variety of mathematical operations.
16	**Mention the characteristics of an ideal op-amp.** BTL2 • Open loop voltage gain infinity • Input impedance infinity • Output impedance is zero. • Bandwidth is infinity
17	**Define Early effect.** BTL1**A/M 16,17 N/D 18** A variation of the base-collector voltage results in a variation of the quasi neutral width in the base. The gradient of the minority carrier density in the base therefore changes, yielding increased collector current as the collector base current is increased. This effect is referred to as the early effect.
18	**List the broad classification of ADCs**.BTL2 • Direct type ADC • Integrating type ADC
19	**List out the direct type ADCs.**BTL2 • Flash type converter • Counter type converter • Tracking converter • Successive approximation converter.

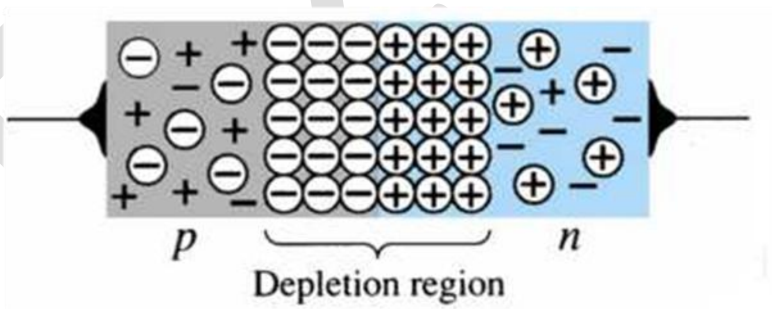
20	**Define conversion time**. BTL2 It is defined as the total time required converting an analog signal into its digital output. It depends on their conversion technique use and propagation delay of circuit components. The conversion time of a successive approximation type ADC.
21	**List out some integrating type converters**. BTL2 • Charge balancing ADC • Dual Slope ADC.
22	**Define resolution of a data converter**.BTL2 The resolution of a converter is the smallest change in voltage which may be produced at the output or input of the converter.
23	**List the types of DAC**.BTL2 • Weighted resistor DAC • R-2R ladder • Inverted R-2R ladder
	PART*B
1.	**With a neat diagram, explain the working of a PN junction diode in forward bias and reverse bias and explain its VI characteristics. (13M)A/M 19 N/D 18**

Answer: Page 7.4 - Dr. C. Ramesh Babu Durai

Diagram: 2M

Construction: 3M

Forward bias and reverse bias: 8M



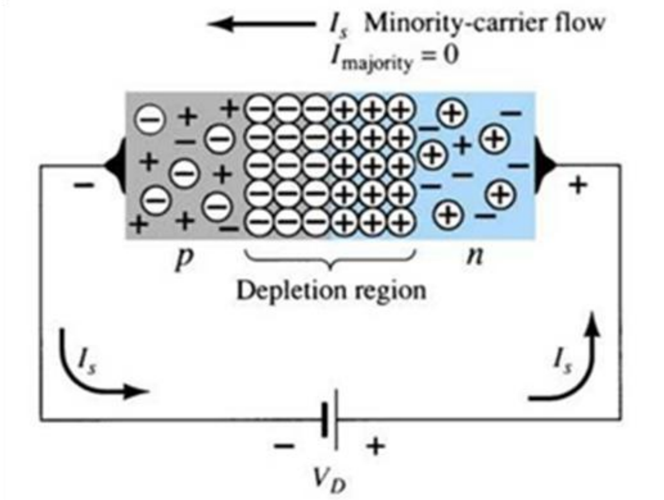
At the *p-n* junction, the excess conduction-band electrons on the *n*-type side are attracted to the valence-band holes on the *p*-type side.

The electrons in the *n*-type material migrate across the junction to the *p*-type material (electron flow).

The electron migration results in a negative charge on the p-type side of the junction and a positive charge on the n-type side of the junction.

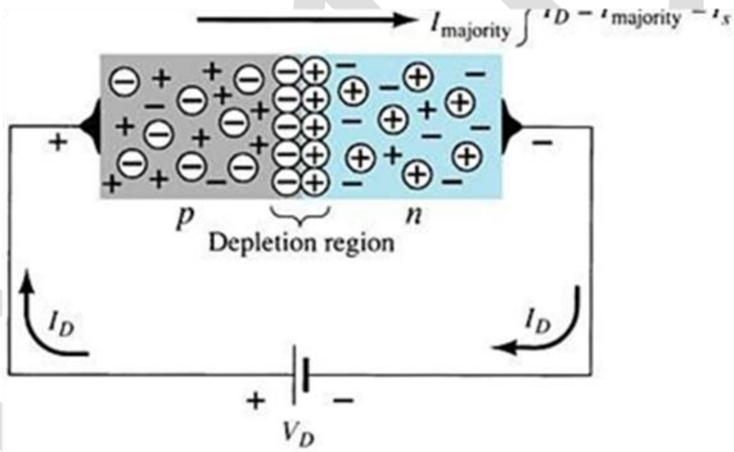
The result is the formation of a depletion region around the junction.

Reverse Bias:



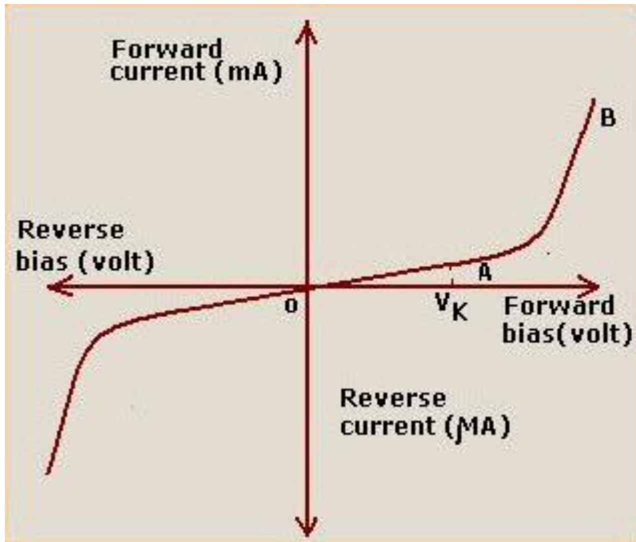
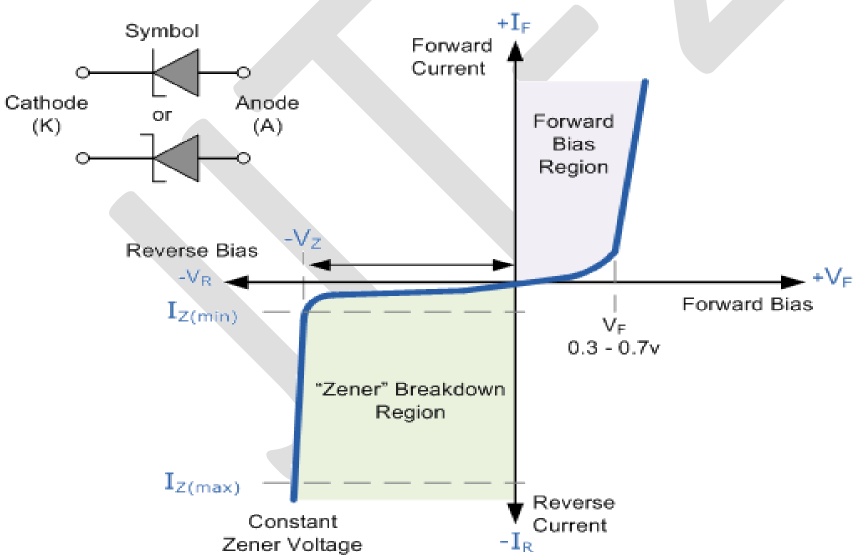
External voltage is applied across the *p-n* junction in the opposite polarity of the *p-* and *n*-type materials.

Forward Bias:



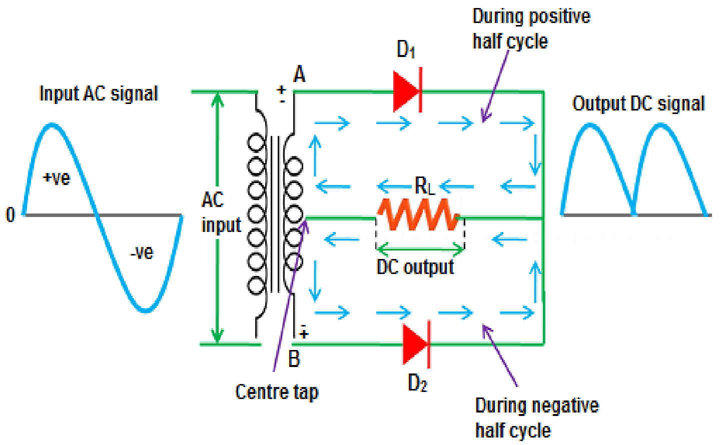
External voltage is applied across the *p-n* junction in the same polarity as the *p-* and *n*-type materials.

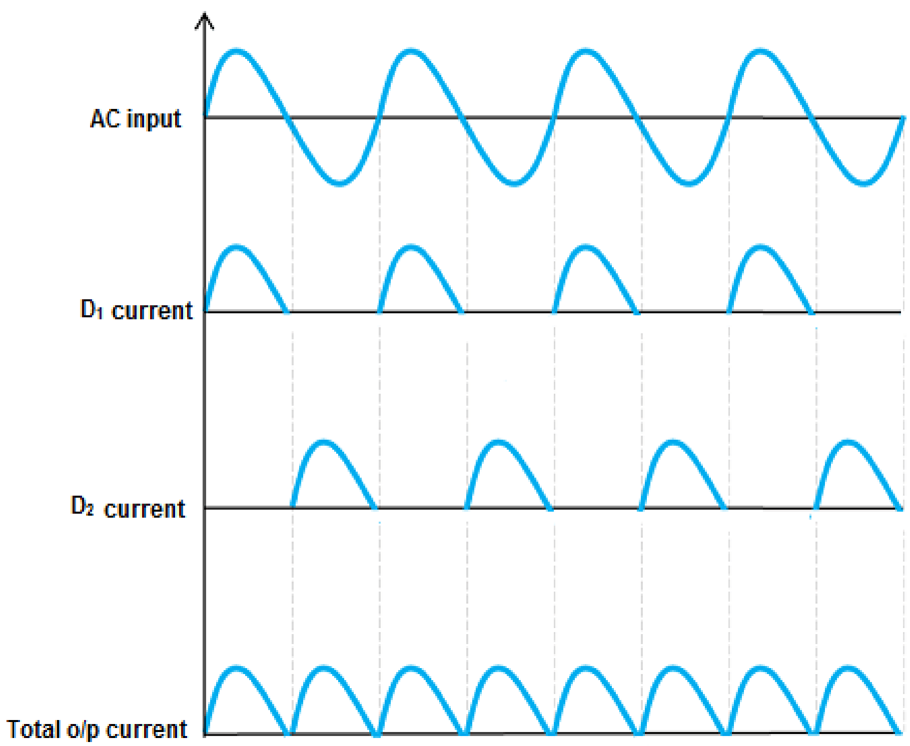
VI characteristics:

	
2	**Explain the VI characteristics of Zener diode.(13M) A/M 17, N/D 19**BTL2 **Answer: Page 7.10 - Dr. C. Ramesh Babu Durai** **Zener diode:** 1. Defintion and Symbol (2M) 2. Forward Bias (2M) 3. Reverse Bias (2M) 4. VI characteristics (3M) 5. Zener diode as voltage regulator (2M) 
3	**Draw the circuit diagram and explain the working of full wave rectifier and derive the expression of average output voltage and rectification efficiency. (13M)** BTL3 A/M 18,N/D 19 **Answer: Page 7.22 - Dr. C. Ramesh Babu Durai**

Construction and working: 5M

Derivation: 8M (Each 4)





Ripple factor $\gamma = 0.48$

The rectifier efficiency of a full wave rectifier is 81.2%.

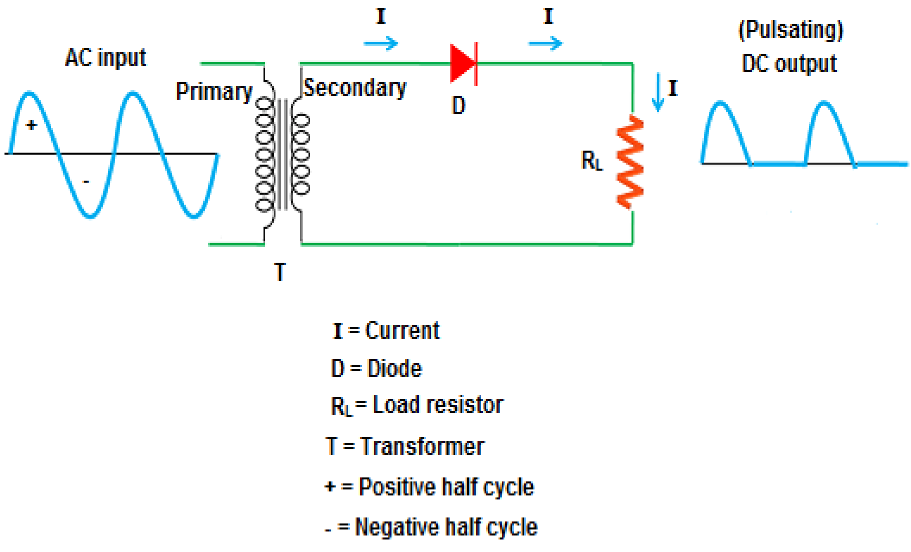
$V_{DC} = 2V_{max} / \pi$

4 **What is half wave rectifier? Explain the working with neat sketch. (13M)** BTL2

Answer: Page 7.15 - Dr. C. Ramesh Babu Durai

Construction and working: 5M

Derivation: 8M (Each 4)



Half wave rectifier

Ripple factor: γ **= 1.21**

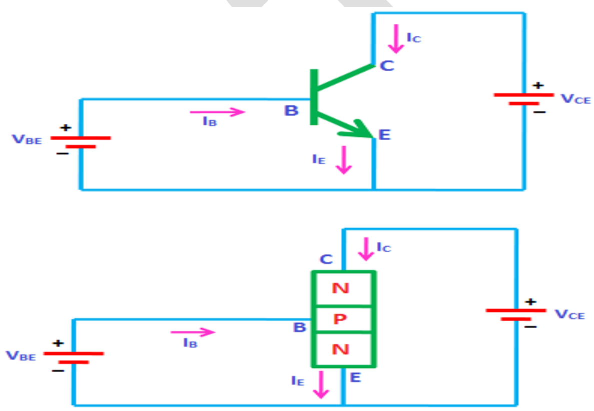
The rectifier efficiency of a half wave rectifier is 40.6%

5 **Draw and explain the input and output characteristics of a BJT in CE configuration (13M) BTL2 N/D 18,A/M 19**

Answer: Page 8.9 - Dr. C. Ramesh Babu Durai

CE configuration diagram and explanation: 5M

Input and output characteristics: 8M (Diagram- each 2, explanation- each 2)

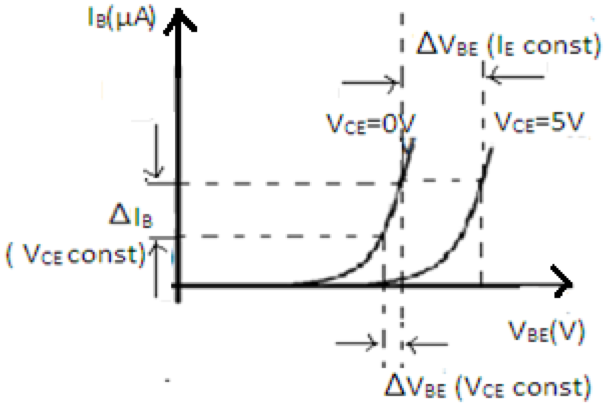


Common emitter configuration

Input characteristics:

The output voltage $\mathbf{V_{CE}}$ is maintained constant and the input voltage $\mathbf{V_{BE}}$ is set at several convenient levels.For each level of input voltage, the input current $\mathbf{I_B}$ is recorded.

$\mathbf{I_B}$is then plotted versus $\mathbf{V_{BE}}$ to give the common-base input characteristics.



Output characteristics:

The Base current $\mathbf{I_B}$ is held constant at each of several fixed levels. For each fixed value of $\mathbf{I_B}$ **,**the output voltage $\mathbf{V_{CE}}$is adjusted in convenient steps and the corresponding levels of collector current $\mathbf{I_C}$are recorded

For each fixed value of $\mathbf{I_B}$, $\mathbf{I_C}$level is Recorded at each $\mathbf{V_{CE}}$step.For each $\mathbf{I_B}$ level, $\mathbf{I_C}$is plotted versus $\mathbf{V_{CE}}$ to give a family of characteristics.

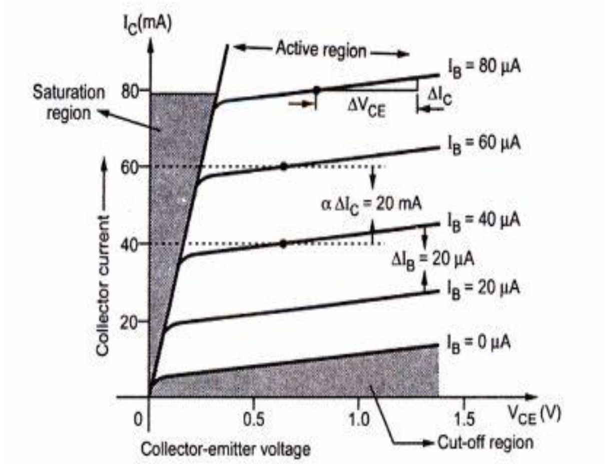


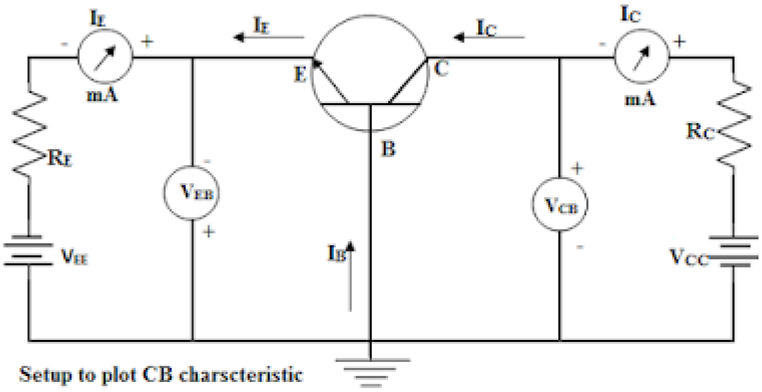
Fig 3.3: Output characteristics of the transistor in CE configuration

6 **Explain the input and output characteristics in CB configuration and explain the early effect. (13M)** BTL2

Answer: Page 8.6 - Dr. C. Ramesh Babu Durai

CB configuration diagram and explanation, early effect: 5M

Input and output characteristics: 8M (Diagram- each 2, explanation- each 2)

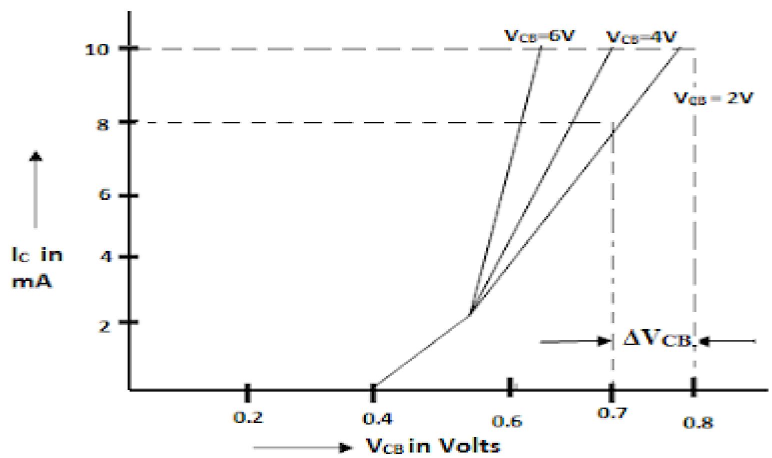


Setup to plot CB charscteristic

Input characteristics:

The output(CB) voltage is maintained constant and the input voltage (EB) is set at several convenient levels.For each level of input voltage, the input current $\mathbf{I_E}$ is recorded.

$\mathbf{I_E}$is then plotted versus $\mathbf{V_{EB}}$ to give the common-base input characteristics.

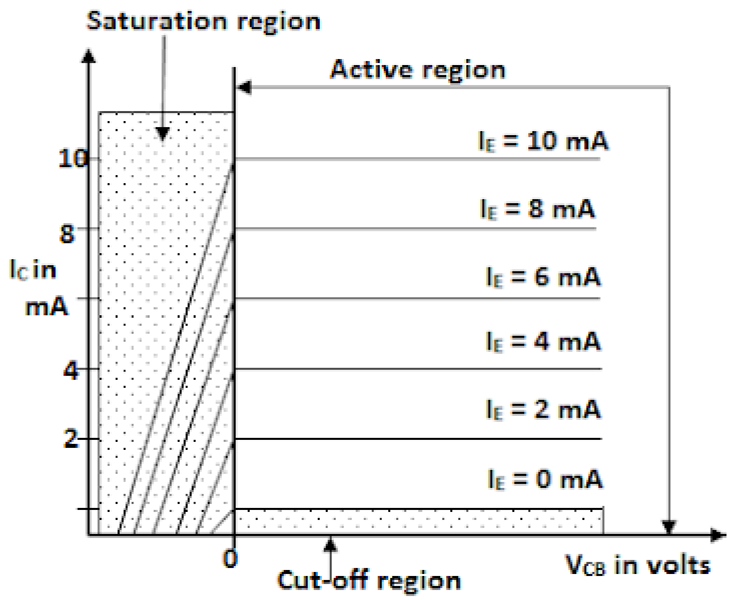


Input Characteristic of CB configuration

Output characteristics:

The emitter current$\mathbf{I_E}$ is held constant at each of several fixed levels. For each fixed value of $\mathbf{I_E}$ **,**the output voltage $\mathbf{V_{CB}}$is adjusted in convenient steps and the corresponding levels of collector current $\mathbf{I_C}$are recorded

For each fixed value of $\mathbf{I_E}$, $\mathbf{I_C}$is almost equal to $\mathbf{I_E}$ and appears to remain constant when $\mathbf{V_{CB}}$ is increased



Output characteristic of common base configuration

Early effect:

The variation in the effective width of the base in a bipolar junction transistor (BJT) due to a variation in the applied base-to-collector voltage. A greater reverse bias across the collector–base junction, for example, increases the collector–base depletion width, thereby decreasing the width of the charge carrier portion of the base.

PART*C

1. **Explain the operation of Colpitts oscillator with neat circuit diagram. Also derive the expressions for the frequency of oscillation and the condition for maintenance of oscillation. (15M)** BTL3

Answer: Page 8.29 - Dr. C. Ramesh Babu Durai

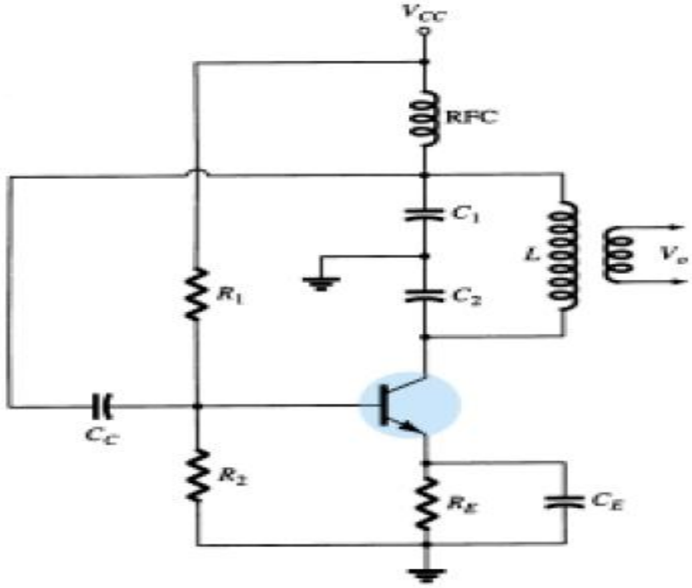
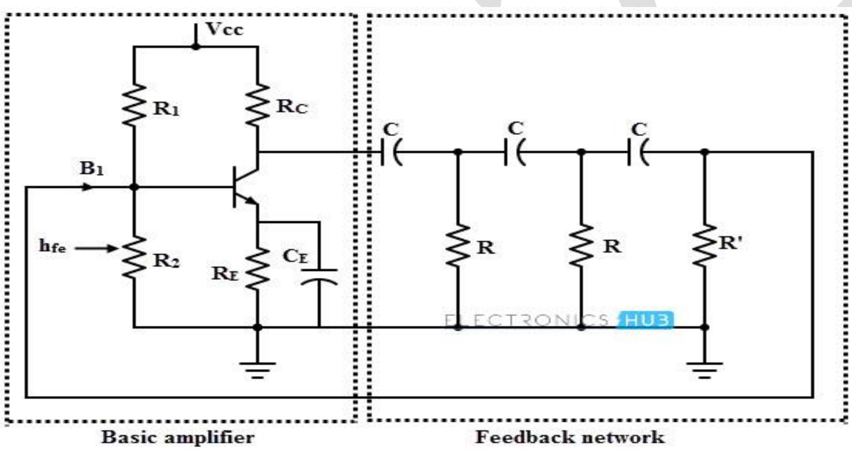
General equation for the oscillator: 4M

Diagram: 3M

Derivation: 8M

$$\boxed{f_o = \frac{1}{2\pi\sqrt{LC_{eq}}}}$$

$$C_{eq} = \frac{C_1 C_2}{C_1 + C_2}$$

	
2	**Explain the operation of RC phase shift oscillator with neat circuit diagram. Also derive the expressions for the frequency of oscillation and the condition for maintenance of oscillation. (15M)** BTL3 **Answer: Page 8.29 - Dr. C. Ramesh Babu Durai** Diagram and explanation: 5M Derivation: 10M  Oscillator with a feedback network consistingof three RC high-pass networks connected in seriesthat produce 180 phase shift. $\boxed{f = \frac{1}{2\pi RC\sqrt{6}}}$ $\beta = \frac{1}{29}$

$A > 29$

3 **a)i) Explain the binary weighted resistor technique of D/A conversion. (8M)** BTL3
Answer: Page 8.37 - Dr. C. Ramesh Babu Durai

- Binary weighted resistor DAC block diagram & Explanation

Digital-to-analogue conversion is much simpler to achieve than analogue-to-digital conversion and the cost of building the necessary hardware circuit is considerably less. It is required wherever a digitally processed signal has to be presented to an analogue control actuator or an analogue signal display device. A common form of digital-toanalogue converter is illustrated in Figure 5.24. This is shown with 8 bits for simplicity of explanation, although in practice 10 and 12 bit D/A converters are used more frequently. This form of D/A converter consists of a resistor-ladder network on the input to an operational amplifier.

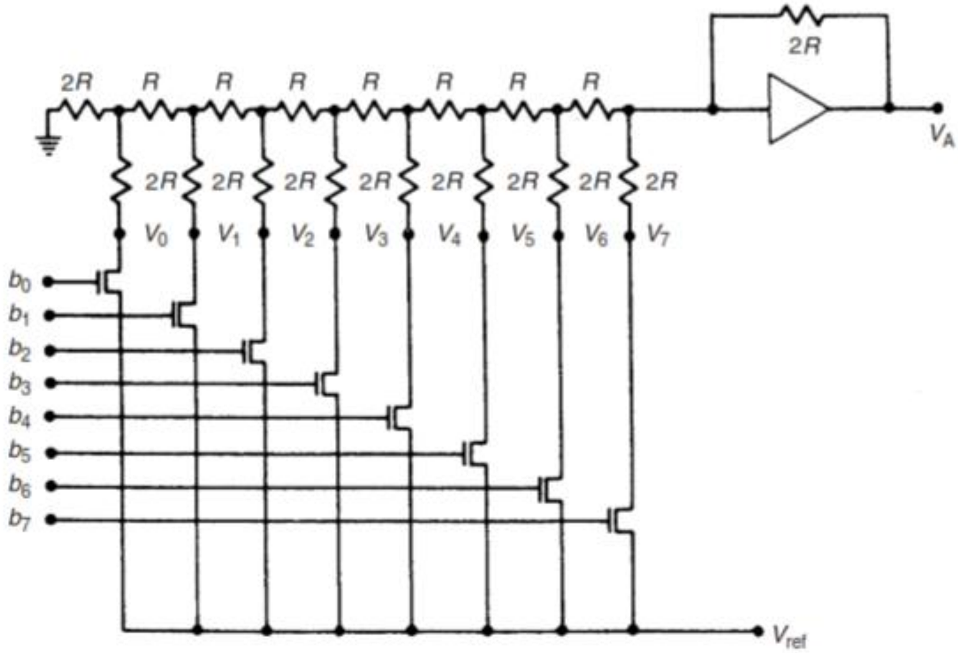
$$V_7 = V_6 = V_4 = V_2 = V_{\text{ref}}; \quad V_5 = V_3 = V_1 = V_0 = 0$$

The analogue output from the converter is then given by:

$$V_A = V_{\text{ref}} + \frac{V_{\text{ref}}}{2} + \frac{V_{\text{ref}}}{8} + \frac{V_{\text{ref}}}{32}$$

a)ii) Discuss R-2R& inverter R-2R ladder type D/A converter. (7M) BTL3
Answer: Page 8.39 - Dr. C. Ramesh Babu Durai

- R-2R ladder type converter circuit diagram (3M)



- Explanation(4M)
- Digital-to-analogue conversion is much simpler to achieve than analogue-to-digital conversion and the cost of building the necessary hardware circuit is considerably less. It is required wherever a digitally processed signal has to be presented to an analogue control actuator or an analogue signal display device.
- This is shown with 8 bits for simplicity of explanation, although in practice 10 and 12 bit D/A converters are used more frequently. This form of D/A converter consists of a resistor-ladder network on the input to an operational amplifier.

$$V_A = V_7 + \frac{V_6}{2} + \frac{V_5}{4} + \frac{V_4}{8} + \frac{V_3}{16} + \frac{V_2}{32} + \frac{V_1}{64} + \frac{V_0}{128}$$

V0 to V7 are set at either the reference voltage level Vref or at zero volts according to whether an associated switch is open or closed. Each switch is controlled by the logic level of one of the bits 0 – 7 of the 8 bit binary signal being converted. A particular switch is open if the relevant binary bit has a value of 0 and closed if the value is 1.

4. **Explain the successive approximation type ADC. (15M)**BTL3 **A/M 18**

Answer: Page 8.45 - Dr. C. Ramesh Babu Durai

- Block diagram (6M)
- Working operation (6M)
    1. When start command is given, SAR sets MSB, d1=1 with all other bits to zero sp that the trail code is 1000 0000. The output Vd from DAC is now compared with analog input Va. If Va>Vd, then 1000 0000 is less than correct digital representation.
    2. This procedure is, repeated for all subsequent bits (i.e., from MSB to LSB), one at a time until all bits positions have been tested.
- Advantages: (3M)
    1. High resolution
    2. It is very versatile

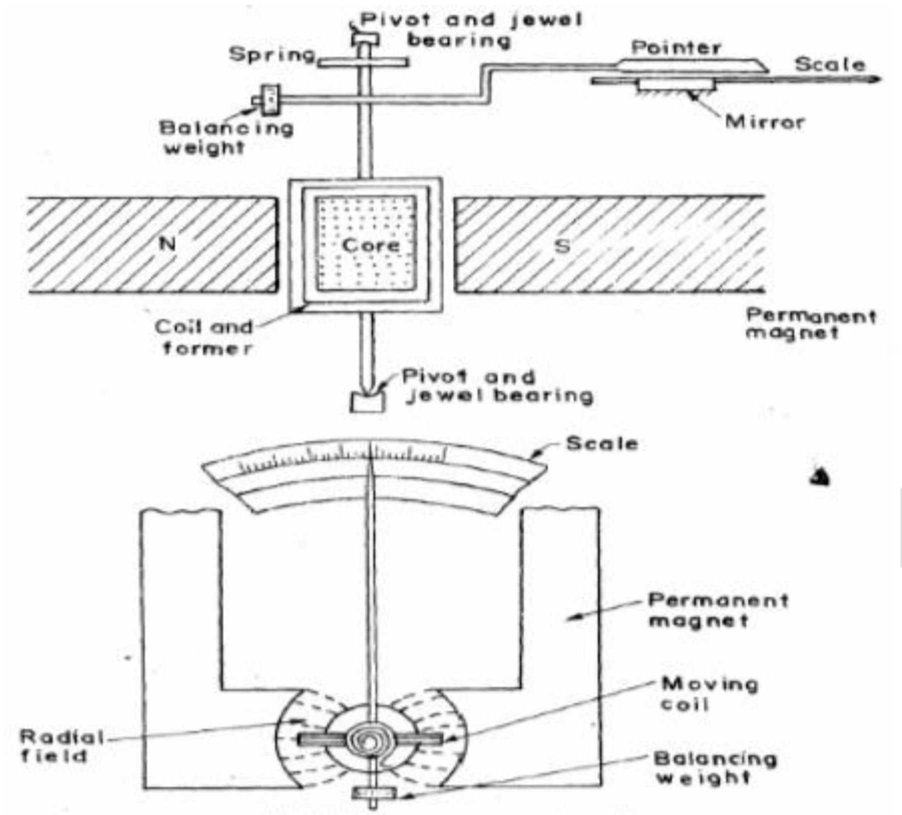
	High speed
5	**Explain the various types of ADC with suitable sketches. (15M)** BTL3 **Answer: Page 8.41 - Dr. C. Ramesh Babu Durai** 1. Direct type 2. Indirect type • Direct types are classified as (3M) 1. Flash (comparator) type converter 2. Staircase type converter 3. Tracking or servo converter 4. Successive approximation type converter • **Indirect type are classified as (2M)** **1.** Charge balancing analog to digital converter **2.** Dual slope analog to digital converter • **Explanation of each type (10M)**

	UNIT V MEASUREMENTS & INSTRUMENTATION
	Introduction to transducers - Classification of Transducers: Resistive, Inductive, Capacitive, Thermoelectric, piezoelectric, photoelectric, Hall effect and Mechanical, Classification of instruments- Types of indicating Instruments - multimeters –Oscilloscopes- – three-phase power measurements– instrument transformers (CT and PT)
Q.No.	**PART*A**
1.	**What is transducer? BTL1** It converts one form of energy into another form of energy,it is preferably electrical energy.
2	**How transducer are classifying?** BTL2 A/M 17 • Based on transduction form used. • As primary and secondary transducer. • As active and passive transducer.
3	**Define primary and secondary transducers.BTL1** Primary transducer When the input signal is directly sensed by the transducer and physical phenomenon is converted into electrical from directly then such a transducer is called the primary transducer. Secondary transducer When the input signal is sensed first by some detector or sensor then its output being of some from other than input signals is given an input to a transducer for conversion into electrical form, such a transducer falls in the category of secondary transducers.

4	**What are the selection criteria for the transducers?**BTL1 • Operating range • Sensitivity • Electrical output characteristics • Accuracy
5	**Write the working principle of capacitive transducers. BTL2** The principle of capacitive transducer is based on the familiar equation of Capaictence parallel plate capacitor.
6	**Define inverse transducer with an example. BTL1** • An inverse is defined as device which converts an electrical quantity into an electrical quantity. • It is a precision actuator which has an electrical input and a low power nonelectrical output.
7	**What is piezo electric effect? BTL1 A/M 18** A piezo electric material is one in which an electric potential appears across certain surfaces of the crystal if the dimensions of the crystals are changed by the application of a mechanical force this potential is produced by the displacement of charges. The effect is reversible. This phenomenon is known as piezo electric effect.
8	**What is calibration?BTL1 N/D 18** Calibration is the process of checking the accuracy of instrument by comparing the instrument reading with a standard meter of known accuracy.
9	**Define static error. BTL2** The static error of a measuring instrument is the numerical difference between the true value of a quantity and its value as obtained by measurement.
10	**Define instrumental errors. BTL2 A/M 19** These errors arise due to inherent short coming in the instrument, misuse of the instruments and loading effects.
11	**What are the basic elements of a measurement system? BTL1** • Primary sensing element. • Variable conversion element. • Variable manipulation element. • Data transmission element.

	• Data presentation element.
12	**What is meant by measurement? BTL1** The process of determining the present value is called as measurement.
13	**Define environmental error. BTL1** This error occurs due to external conditions to the measuring device, including conditions in the area surrounding the instrument, such as the effects of change in temperature, humidity, magnetic or electrostatic fields.
14	**Define integrating instruments.BTL1** These instruments measure the total quantity of electricity delivered over period. Example: energy meter
15	**What is the main difference between in operation between DC potentiometer and AC potentiometer?BTL1** In the DC potentiometer only, the magnitude of the unknown emf and slide wire voltage drop must be made equal to obtain balance, where as in the AC potentiometer the phases of the two voltages, as well as their magnitudes, must be equal for balance to be obtained.
16	**What is Maxwell's bridge? BTL1 N/D 19** The Maxwell bridge is used to measure both a given inductance and its series resistance by comparison to a standard capacitance.
17	**Define interference. BTL2** The instruments used for electrical measurements are in an environment which contains many sources of electrical magnetic energy. These sources can produce undesirable signals called interference.
18	**What is the basic operating principle of digital tape recording? BTL1** Digital data can be recorded and stored in magnetic tapes using a variety of techniques. The basic principle used to modulate the digital data in some form and then record this modulated data in the tape.
19	**Define the deflection sensitivity of CRT.BTL2** The deflection sensitivity of a CRT is defined as the deflection of the screen per unit deflection voltage.
20	**What are the functions of a data logger?BTL1** • The main function of the data logger is to measure electrical output from any type of transducer. • The data logger is used to automatically record of the readings of instruments located at different parts of the plant.
	PART* B
1.	**Describe the static and dynamic characteristics of measuring instrument. (13M)** BTL2 **Answer: Page 9.1- Dr. C. Ramesh Babu Durai**N/D 18 **Static characteristics: (7M)** • Accuracy: The closeness with which an instrument reading approaches the true value of the quantity

	being measured. • Precision: It is a measure of reproducibility of the measurements, i.e., given a fixed value of a quantity, precision is a measure of the degree of agreement with in a group of measurements. • Static sensitivity: If the input is slowly increased from some arbitrary (non-zero) input value, it will again be found that output does not change at all until a certain increment is exceeded. • Reproducibility: It is the degree of closeness with which a given value may be repeatedly measured. It may be specified in terms of units for a given period of time. • Drift: Gradual change in instruments measurements. • Static error: Numerical differences between true value of a quantity and its value as obtained by measurement. • Dead zone: It is defined as the largest change of input quantity for which there is no output of the instrument. **Dynamic Characteristics: (6M)** • Speed of response: The rapidity with which an instrument responds changes in measured quantity. • Measuring lag: The difference between the true and measured value with no static error. • Fidelity: Delay in the response of an instrument to changes in the measured variable. • Dynamic error: The degree to which an instrument indicates the changes in the measure variable without dynamic error (faithful reproduction).
2	**Discuss in detail various types of errors associated in measurement and how these errors can be minimized?(13M)** BTL3 **Answer: Page 9.15- Dr. C. Ramesh Babu Durai** **Error: (2M)** The algebraic difference b/w the indicated value and the true value of the quantity to be measured is called an error. **Types: (11M)** • Static error: It is defined as the difference between the measured value and the true value of the quantity under measurement. • Gross errors: is due to human fault. • Systematic errors: 1. Instrumental errors 2. Environmental errors 3. Observational errors • Random errors: due to causes that cannot be directly established. • Hysteresis error: Hysteresis is a non---coincidence of loading and unloading curves. Hysteresis in a system arises due to the fact that all the energy put into the stressed parts when loading is not recoverable upon unloading.
3	**Describe the construction and working of permanent magnet moving coil instrument. Also derive the expression for deflection. 13M** BTL3 N/D 18 **Answer: Page 9.12 - Dr. C. Ramesh Babu Durai** **Construction and working: (7M)**



A moving-coil meter is a very commonly used form of analogue voltmeter because of its sensitivity, accuracy and linear scale, although it only responds to d.c. signals. As shown schematically in Figure 6.2, it consists of a rectangular coil wound round a soft iron core that is suspended in the field of a permanent magnet. The signal being measured is applied to the coil and this produces a radial magnetic field. Interaction between this induced field and the field produced by the permanent magnet causes a torque, which results in rotation of the coil.

Torque equation: (4M)

Deflecting torque Td= NBAI

N=number of turns of coil

B= Flux density in air gap

A= coil area

I= Current through moving coil

Final steady deflection Tc=Td

Advantages & disadvantages: (2M)

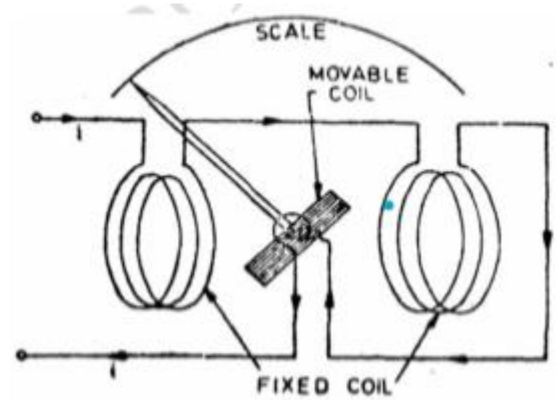
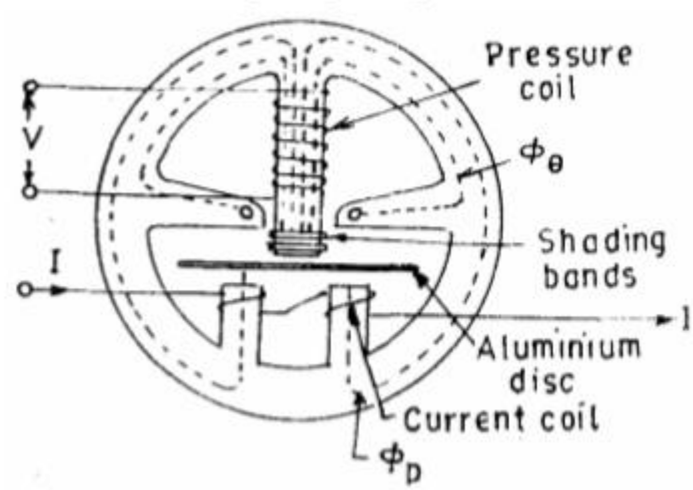
Advantages:

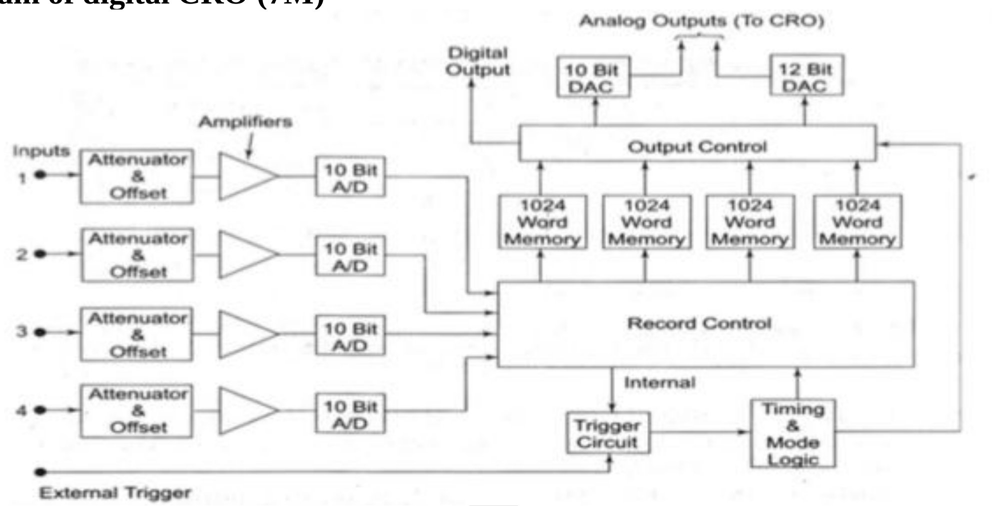
- The sensitivity is high
- Uniform scale
- Operating current is small

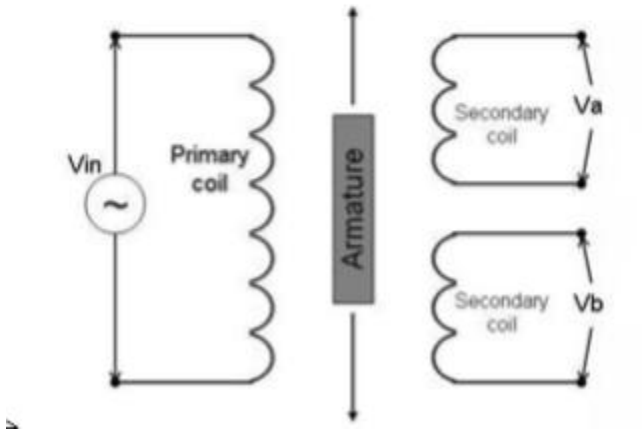
Disadvantages:

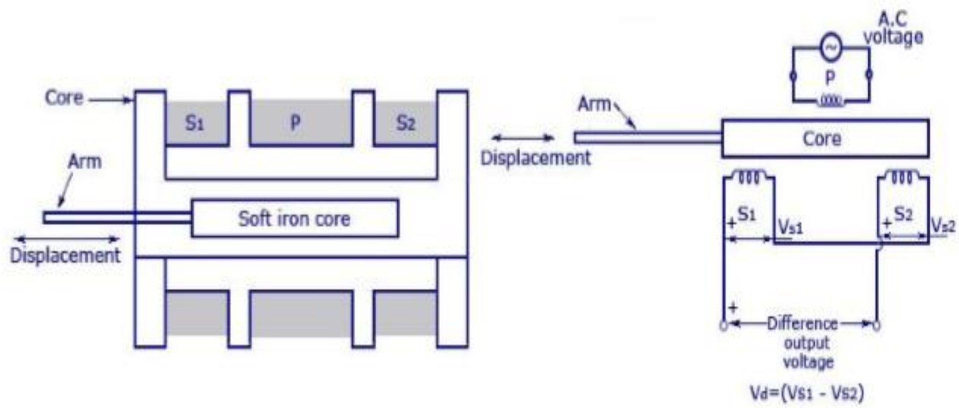
- Not suitable for AC measurements
- Ageing of PMMC introduces the errors
- Cost is high

4 **With a neat diagram explain the construction and working of electrodynamometer type instruments. Also derive its torque equation. (13M)** BTL2

	Answer: Page 9.28 - Dr. C. Ramesh Babu Durai • Circuit diagram **(3M)**  • Operating principle of Electrodynamo meter instruments **(4M)** • Torque equation **(4M)** • Advantages and disadvantages **(2M)** Adv 1. As the coils are air cored, these instruments are free from hysteresis and eddy current losses. 2. They have a precision grade accuracy for frequencies from 40 HZ to 500 Hz. Dis-Adv 1. They have a low torque/ weight ratio hence have a low sensitivity Increases frictional losses.
5	**Give the construction and principle of operation of single phase induction type energy meter. Also derive its torque equation. 13M** BTL4 **Answer: Page 9.33 - Dr. C. Ramesh Babu Durai** • **Construction & working of single phase energy meter (6M)**  **(Fig) single phase energy meter** • **Explanation (4M)** 1. Driving system 2. Moving system

	3. Braking system 4. Counting system/ Registering mechanism • **Errors caused by braking system & advantages (3M)**
6	**Draw and explain the block diagram of digital CRO. (13M)** BTL2 N/D 19 **Answer: Page 9.42 - Dr. C. Ramesh Babu Durai** • **Block diagram of digital CRO (7M)**  • **Working (6M)** The input is amplified and attenuated with input amplifier as in any oscilloscope. The sample and hold circuit effectively snaps a picture of the voltage level. The output of S/H circuit is connected to an ADC. CRT accepts only the analog signals and thus the signal in the digital memory is converted in to an analog signal by means of digital to analog converter.
	PART*C
1.	**Explain the construction and working of LVDT with a neat sketch. (13M)** BTL 2**A/M 18** **Answer: Page 9.52 - Dr. C. Ramesh Babu Durai** • **Construction & working of LVDT** (6M & 7M) • An LVDT, or Linear Variable Differential Transformer, is a transducer that converts a linear displacement or position from a mechanical reference (or zero) into a proportional electrical signal containing phase (for direction) and amplitude information (for distance). • The LVDT operation does not require electrical contact between the moving part (probe or core rod assembly) and the transformer, but rather relies on electromagnetic coupling; this and the fact that they operate without any built-in electronic circuitry are the primary reasonswhy LVDTs have been widely used in applications where long life and high reliability under severe environments are a required, such as Military/Aerospace applications.





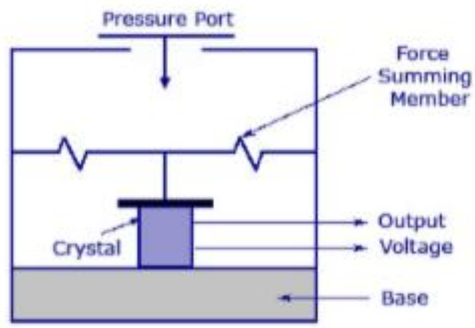
Construction of LDVT Circuit Connection

2

Explain the principle of piezo electric transducers and name any two piezo electric materials. (15M) BTL3

Answer: Page 9.55 - Dr. C. Ramesh Babu Durai

- **Piezo electric diagram & Principle of operation (10M)**
  1. Piezoelectric transducers produce an output voltage when a force is applied to them. They are frequently used as ultrasonic receivers and also as displacement transducers, particularly as part of devices measuring acceleration, force and pressure.
  2. In ultra- sonic receivers, the sinusoidal amplitude variations in the ultrasound wave received are translated into sinusoidal changes in the amplitude of the force applied to the piezoelectric transducer.
  3. In a similar way, the translational movement in a displacement transducer is caused by mechanical means to apply a force to the piezoelectric transducer.
  4. Piezoelectric transducers are made from piezoelectric materials. These have an asymmetrical lattice of molecules that distorts when a mechanical force is applied to it.
  5. This distortion causes a reorientation of electric charges within the material, resulting in a relative displacement of positive and negative charges.
  6. The charge displacement induces surface charges on the material of opposite polarity between the two sides. By implanting electrodes into the surface of thematerial, these surface charges can be measured as an output voltage.
  7. For a rectangular block of material, the induced voltage is given by:
     V = kFd/A



Piezo-Electric Transducer

	Modes of operation , advantages & dis-advantages **(5M)**
3	**Explain different strain gauges with the principle of operation. (15M)** BTL3 **Answer: Page 9.49 - Dr. C. Ramesh Babu Durai** • Working principle **(5M)** 1. A strain gauge is an example of a passive transducer that uses the variation in electrical resistances in wires to sense the strain produced by a force on the wires. 2. If a metal conductor is stretched or compressed, its resistances changes on account of the fact that both length and diameter of conductor change. • Theory and operating principle of resistance strain gauge derivation **(10M)**
4	**Explain in detail about the different types of moving iron instruments.(15M)** BTL3 **Answer: Page 9.16 - Dr. C. Ramesh Babu Durai** • Types (2M) 1. Attraction type 2. Repulsion type • Explanation with diagram (10M) • Torque equation (3M)

GE8292 ENGINEERING MECHANICS

L T P C
3 2 0 4

OBJECTIVES:

- To develop capacity to predict the effect of force and motion in the course of carrying out the design functions of engineering.

UNIT I STATICS OF PARTICLES 9+6

Introduction – Units and Dimensions – Laws of Mechanics – Lami's theorem, Parallelogram and triangular Law of forces – Vectorial representation of forces – Vector operations of forces -additions, subtraction, dot product, cross product – Coplanar Forces – rectangular components – Equilibrium of a particle – Forces in space – Equilibrium of a particle in space – Equivalent systems of forces – Principle of transmissibility

UNIT II EQUILIBRIUM OF RIGID BODIES 9+6

Free body diagram – Types of supports –Action and reaction forces – stable equilibrium – Moments and Couples – Moment of a force about a point and about an axis – Vectorial representation of moments and couples – Scalar components of a moment – Varignon's theorem – Single equivalent force -Equilibrium of Rigid bodies in two dimensions – Equilibrium of Rigid bodies in three dimensions

UNIT III PROPERTIES OF SURFACES AND SOLIDS 9+6

Centroids and centre of mass – Centroids of lines and areas - Rectangular, circular, triangular areas by integration – T section, I section, - Angle section, Hollow section by using standard formula –Theorems of Pappus - Area moments of inertia of plane areas – Rectangular, circular, triangular areas by integration – T section, I section, Angle section, Hollow section by using standard formula – Parallel axis theorem and perpendicular axis theorem – Principal moments of inertia of plane areas – Principal axes of inertia-Mass moment of inertia –mass moment of inertia for prismatic, cylindrical and spherical solids from first principle – Relation to area moments of inertia.

UNIT IV DYNAMICS OF PARTICLES 9+6

Displacements, Velocity and acceleration, their relationship – Relative motion – Curvilinear motion - Newton's laws of motion – Work Energy Equation– Impulse and Momentum – Impact of elastic bodies.

UNIT V FRICTION AND RIGID BODY DYNAMICS 9+6

Friction force – Laws of sliding friction – equilibrium analysis of simple systems with sliding friction –wedge friction-. Rolling resistance -Translation and Rotation of Rigid Bodies – Velocity and acceleration – General Plane motion of simple rigid bodies such as cylinder, disc/wheel and sphere.

TOTAL : 45+30=75 PERIODS

OUTCOMES:

On successful completion of this course, the student will be able to

- illustrate the vectorial and scalar representation of forces and moments
- analyse the rigid body in equilibrium
- evaluate the properties of surfaces and solids
- calculate dynamic forces exerted in rigid body
- determine the friction and the effects by the laws of friction

TEXT BOOKS:

1. Beer, F.P and Johnston Jr. E.R., "Vector Mechanics for Engineers (In SI Units): Statics and Dynamics", 8th Edition, Tata McGraw-Hill Publishing company, New Delhi (2004).
2. Vela Murali, "Engineering Mechanics", Oxford University Press (2010)

REFERENCES:

1. Bhavikatti, S.S and Rajashekarappa, K.G., "Engineering Mechanics", New Age International (P) Limited Publishers, 1998.
2. Hibbeller, R.C and Ashok Gupta, "Engineering Mechanics: Statics and Dynamics", 11th Edition, Pearson Education 2010.
3. Irving H. Shames and Krishna Mohana Rao. G., "Engineering Mechanics – Statics and Dynamics", 4th Edition, Pearson Education 2006.
4. Meriam J.L. and Kraige L.G., " Engineering Mechanics- Statics - Volume 1, Dynamics- Volume 2", Third Edition, John Wiley & Sons,1993.
5. Rajasekaran S and Sankarasubramanian G., "Engineering Mechanics Statics and Dynamics", 3rd Edition, Vikas Publishing House Pvt. Ltd., 2005.

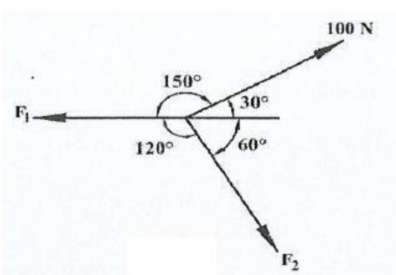
Subject Code: GE8292 **Year/Semester: I /02**
Subject Name: Engineering Mechanics **Subject Handler: Mrs.I.SHARON MARISHKA**

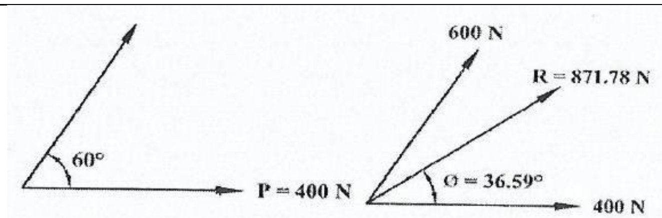
UNIT I STATICS OF PARTICLES

Introduction – Units and Dimensions – Laws of Mechanics – Lami's theorem, Parallelogram and triangular Law of forces – Vectorial representation of forces – Vector operations of forces -additions, subtraction, dot product, cross product – Coplanar Forces – rectangular components – Equilibrium of a particle – Forces in space – Equilibrium of a particle in space – Equivalent systems of forces – Principle of transmissibility

PART * A

Q.No.	Questions
1	**State the principle of transmissibility. BTL2(May 2017, May 2015, Dec 2007)** A force need not be considered to act at a point but may be considered to be applied at any point on its line of action without affecting the net effects external to the rigid body on which it acts.
2	**Find the resultant and direction of Force $\vec{F} = 3\vec{\imath} - 4\vec{\jmath}$. BTL3(May 2017)** Resultant = $\sqrt{3^2 + (-4)^2}$ = 5 Units $cos\ cos\ \theta_x = \frac{3}{5} \Rightarrow \theta_x = 53.13°$ $cos\ cos\ \theta_y = \frac{-4}{5} \Rightarrow \theta_y = 143.13°$
3	**Two forces 30 N and 40 N acts at a point 'O' The included angle between them is 60^0. Find the magnitude and the direction of the resultant. BTL4 (May 2016)** Magnitude of the resultant = $\sqrt{30^2 + 40^2 + (2 \times 30 \times 40 \times cos\ cos\ 60°\ )}$ = **60.828 N** Direction $\alpha = (\frac{B\ Sin\ \theta}{A + B\ Cos\ \theta})$ = **34.72^0**
4	**What are the minimum requirements for equilibrium of a particle in space? BTL1 (May 2016)** Conditions of equilibrium are: $\sum F_x = 0; \sum F_y = 0; \sum F_z = 0$
5	**Find the length of line joining the origin with the point (2,1,-2). BTL2 (Dec. 2015)** Length of the line = $\sqrt{2^2 + 1^2 + (-2)^2}$ = **3**
6	**State triangle law of forces. BTL2 (Dec. 2015, Nov. 2007)** If two coplanar, concurrent forces acting at a point are represented in magnitude and direction by the two adjacent sides of a triangle then the resultant of the two forces is given in magnitude and

	direction by the third side of the triangle, the sense being taken in the opposite order.
7	**A vector $\vec{F}$ starts at point (2,-1,2) and passes through (-1,3,5). Find its unit vector. BTL3 (May 2015)** Force vector = (-1-2) $\vec{i}$ + 3 - (-1) $\vec{j}$ +(5 - 2) $\vec{k}$ = -3 $\vec{i}$ + 4 $\vec{j}$ + 3 $\vec{k}$ $Unit\ vector = \frac{Force\ vector}{Magnitude} = \frac{-3\,\vec{i} + 4\,\vec{j} + 3\,\vec{k}}{\sqrt{(-3)^2 + (4)^2 + (3)^2}}$ $Unit\ vector = -0.51\,\vec{i} + 0.69\,\vec{j} + 0.51\,\vec{k}$
8	**Give the static equilibrium equations. BTL2 (Dec. 2014, May 2010)** ● The algebric sum of all the forces in the horizontal plane is equal to zero; $\sum H = 0$. ● The algebric sum of the all the forces in the veritical plane is equal to zero; $\sum V = 0$. ● The algebric sum of the all the moments about any point is equal to zero; $\sum M = 0$.
9	**Define Lami's theorem. BTL1 (Dec. 2014, May 2012, Nov 2009)** "If a particle acted upon by three forces remains in equilibrium then each force acting on the particle bears the same proportionality with the sine of the angle between the other two forces". Lami's theorem is also known as law of sines.
10	**Resolve the 100 N force acting 30° to horizontal into two component one along horizontal and other along 120° to horizontal. BTL4 (May 2014)**  Applying Lami's Equation: $\frac{F_1}{Sin\ 90°} = \frac{100}{Sin\ 120°} = \frac{F_2}{Sin\ 150°}$ **F_1 = 115.47 N ; F_2 = 57.74 N**
11	**Two forces of 400 N and - 600 N act at an angle 60° to each other. Determine the resultant in magnitude and direction. BTL4 (May 2014)**



$R = \sqrt{P^2 + Q^2 + 2PQCos\,\theta}$; **R = 871.78 N**

$Tan\,\alpha = \frac{Q\,Sin\,\theta}{P + Q\,Sin\,\theta}$ α = 36.59^0

12 **What is meant by force-couple system? BTL1 (May 2013)**

The given system of forces can be replaced by an equivalent force a. couple at any point. This system is called a force couple system.

13 **Find the unit vector of a force $\vec{F} = 4\vec{\imath} - 5\vec{\jmath} + 8\vec{k}$ BTL1 (May 2013, May 2008)**

Unit vector $\lambda = \frac{F^{\rightarrow}}{F}$

$$\lambda = \frac{4\vec{\imath} - 5\vec{\jmath} + 8\vec{k}}{\sqrt{4^2 + (-5)^2 + 8^2}} = 0.39\vec{\imath} - 0.49\vec{\jmath} + 0.78\vec{k}$$

To check: The magnitude of unit vector should be 1

Magnitude = $\sqrt{0.39^2 + (-0.49)^2 + 0.78^2} = 1$

14 **Distinguish between a resultant force and equivalent force? BTL4 (May 2012)**

S.NO.	Resultant force	Equivalent force
1	It is a single force which will produce the same effect as produced by the given force system on body. It is represented by $\vec{R}$.	Equilibrant is a force which is equal in magnitude to resultant but in opposite direction. When the resultant of a number of forces acting on a particle is zero, the particle is in equilibrium. The force which makes the set of forces to equilibrium is called as equilibriant (E).
2	Mathematically, $\vec{R} = R_x\vec{\imath} + R_y\vec{\jmath} + R_z\vec{k}$ $\lvert\vec{R}\rvert = \sqrt{R_x^2 + R_y^2 + R_z^2}$	Mathematically, $\lvert\vec{R}\rvert = \lvert\vec{E}\rvert$

15 **Define (i) coplanar forces (ii) Concurrent forces BTL1 (May 2010)**

(i) Coplanar forces :

A system of forces that are contained in a single plane or systems of forces having their line of actions in the single plane are called “coplanar forces”.

(ii) Concurrent forces:

When the line of action of all the forces of a system intersect at a common point. These forces are called “concurrent forces”.

16 **A Force $\vec{F} = (8.25\vec{\imath} + 12.75\vec{\jmath} - 18\vec{k})$N acts through the origin. What is the magnitude of**

	this force and angles it makes with x,y and z axes. BTL4 (Nov 2009) $F_x = 8.25$ N, $F_y = 12.75$ N, $F_z = -18$ N $F = \lvert\vec{F}\rvert = \sqrt{F_x^2 + F_y^2 + F_z^2} = 23.55$ N $\theta_X = \left(\frac{F_x}{F}\right) = 69.49^0$; $\theta_y = \left(\frac{F_y}{F}\right) = 57.22^0$ $\theta_X = \left(\frac{F_z}{F}\right) = 139.84^0$
17	**Determine the resultant of the three concurrent forces $F_1 = (2i + 3j - 2.5\,k)$; $F_2 = (-i + 5\vec{j} - 3\,\vec{k})$ and $\vec{F}_3 = (7\vec{i} - 7\vec{j} + 6\,\vec{k})$. BTL5 (May 2008)** $\vec{R} = (\vec{F_1} + \vec{F_2} + \vec{F_3}) = 8\vec{i} + \vec{j} + 0.5\,\vec{k}$; R = $\sqrt{R_x^2 + R_y^2 + R_z^2}$ =8.077 N
18	**What is a unit vector? BTL1 (May 2009)** Unit vectors are used to specify directions of the vectors. E.g., $\vec{a} = 3\vec{i} + 4\vec{j}$ is a vector in two dimensions, where $\vec{i}$ and $\vec{j}$ are unit vectors in the x and y directions. If $\hat{n}$ is a unit vector, mathematically, $$\hat{n} = \frac{\vec{n}}{\lvert\vec{n}\rvert}$$ Where, $\lvert\vec{n}\rvert$= modulus of $\vec{n}$
19	**State parallelogram law of forces. BTL1 (Dec 2008)** The parallelogram law of forces states that if two forces comprise the adjacent sides of a parallelogram, passing through a point, then the diagonal passing through the same point of parallelogram represents the resultant of the two forces and mathematically given as Resultant (R) = $P^2 + Q^2 + 2PQ\cos\theta$ $P^2 + Q^2 + 2PQ\cos\theta$ Where, P and Q are two forces; θ – Angle between these two forces
20	**$\vec{F} = (3\vec{i} - 5\vec{j} + 7\vec{k})$ N acts at A of co-ordinates (1,3,4). Determine the moment of force $\vec{F}$ about the coordinate axes. BTL5** $\vec{F} = (3\vec{i} - 5\vec{j} + 7\vec{k})$ $$\vec{M_o} = \vec{r} \times \vec{F}$$ $\vec{r} = \vec{i} + 3\vec{j} + 4\vec{k}$ $M_o = \begin{vmatrix} i & j & k \\ 1 & 3 & 4 \\ 3 & -5 & 7 \end{vmatrix} = 41\vec{i} + 5\vec{j} - 14k$
	PART * B
1	**Forces 32 kN, 24 kN, 24 kN and 120 kN are concurrent at origin (0,0,0) and are respectively through the points whose coordinates are A(2,1,6), B(4,-2,5), C (-3,-2,1) and D(5,1,-2). Determine resultant of the system. BTL5 (May 2017)**

Let O be the origin. $\vec{F}_1, \vec{F}_2, \vec{F}_3$ and $\vec{F}_4$ be the forces along OA, OB, OC and OD respectively.

Force along OA $(\vec{F}_1)$ = Magnitude of $\vec{F}_1 \times$ unit vector along OA.

$$= 32 \times \frac{(2i + j + 6k)}{\sqrt{(2^2 + 1^2 + 6^2)}} = 10\vec{i} + 5\vec{j} + 30\vec{k}$$

Force along OB $(\vec{F}_2) = 24 \times \frac{(4i - 2j + 5k)}{\sqrt{4^2 + (-2)^2 + 5^2}}$

$$= 14.31\vec{i} - 7.16\vec{j} + 17.89\vec{k}$$

Force along OC $(\vec{F}_3) = 24 \times \frac{(-3i - 2j + k)}{\sqrt{(-3)^2 + (-2)^2 + 1^2}}$

$$= -19.24\vec{i} - 12.83\vec{j} + 6.41\vec{k}$$

Force along OD $(\vec{F}_4) = 120 \times \frac{(5i + j - 2k)}{\sqrt{(5^2 + 1^2 + (-2)^2}}$

$$= 109.54\vec{i} + 21.91\vec{j} - 43.82\vec{k}$$

Resultant of the forces $\vec{R} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \vec{F}_4$

$$= (10\vec{i} + 5\vec{j} + 30\vec{k}) + (14.31\vec{i} - 7.16\vec{j} + 17.89\vec{k})$$

$$+ (-19.24\vec{i} - 12.83\vec{j} + 6.41\vec{k}) + (109.54\vec{i} + 21.91\vec{j} - 43.82\vec{k})$$

$$= (10 + 14.31 - 19.24 + 109.54)\vec{i} + (5 - 7.16 - 12.83 + 21.91)\vec{j}$$

$$+ (30 + 17.89 + 6.41 - 43.82)\vec{k}$$

$$\overrightarrow{R} = (114.61\vec{i} + 6.92\vec{j} + 10.48\vec{k})\,\text{kN}$$

$$\text{Magnitude of the resultant} = \sqrt{(114.61)^2 + (6.92)^2 + (10.48)^2}$$

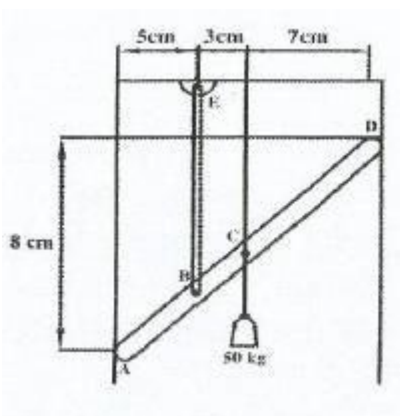
$$= 115.296 \text{ kN}$$

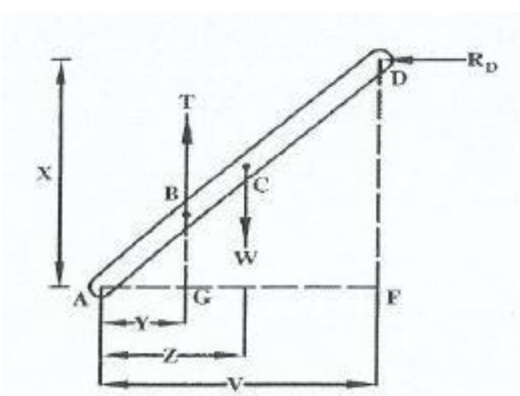
Answers:

1. Resultant of the forces = $(114.61\vec{i} + 6.92\vec{j} + 10.48\vec{k})$ kN

2. Magnitude of the resultant = 115.296 kN

2 **A light bar AD is suspended from a cable BE and supports a 50 kg block at C as shown in Fig. The ends A and D of the bar are in contact with frictionless vertical walls. Determine the tension in cable BE and the reactions at A and D. BTL5 (May 2017)**

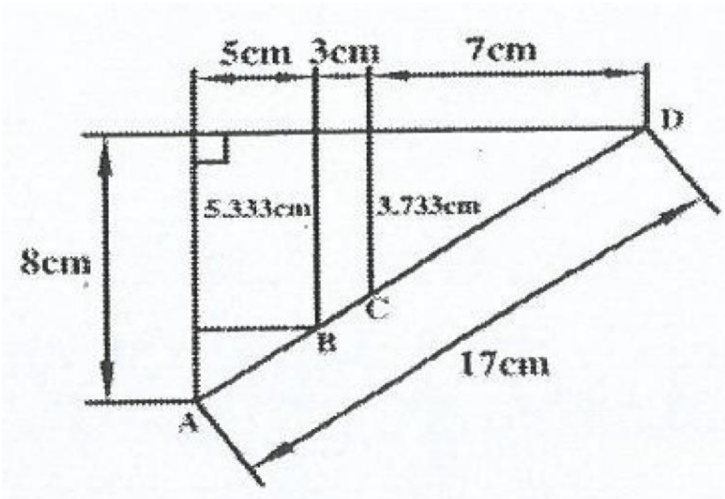




Angle made by rod with horizontal is 28.07°

mass = 50 kg

Since the rod is supported on the vertical walls on a frictionless vertical walls, the reaction at A and D (R_A and R_D) has only horizontal components as shown in fig 12b(i)



$$AD = \sqrt{(5+3+7)^2 + 8^2} = 17\,\text{cm}$$

$$CD = \sqrt{7^2 + 3.733^2} = 7.933\,\text{cm}$$

$$AB = \sqrt{5^2 + 2.667^2} = 5.667\,\text{cm}$$

$$\text{In } \Delta ADF, \sin\theta = \frac{x}{AD}$$

$$x = AD \sin 28.07° = 17 \times \sin 28.07° = 8 \text{ cm}$$

$$\text{In } \Delta ABG, \cos\theta = \frac{y}{AB}$$

$$y = AB \cos 28.07° = 5.667 \times \cos 28.07° = 5 \text{ cm}$$

$$\text{In } \Delta ADF, \cos\theta = \frac{v}{AD}$$

$$v = AD \cos 28.07° = 17 \times \cos 28.07° = 15 \text{ cm}$$

$$z = \frac{V}{2} = \frac{15}{2} = 7.5\,\text{cm}$$

Using $\Sigma F_x = 0 \quad [\rightarrow(+)]$

$R_A - R_D = 0 \Rightarrow R_A = R_D$

Using $\Sigma M = 0$ (moments about A) [$\because$ Anticlockwise (–)]

$$T(y) - W(z) + R_D\,(x) = 0$$

$$5T - 7.5\,W + 8\,R_D = 0 \quad \rightarrow \quad (1)$$

Using $\Sigma F_y = 0 \qquad [\because \text{Upward } (+)]$

$T - W = 0 \Rightarrow T = W \qquad \rightarrow \qquad (2)$

$W = 509.81 = 490.5\ N$

Substitute eqn (2) in eqn (1) $\Rightarrow$

$5T - 7.5W + 8\,R_D = 0$

$(5 \times 490.5) - (7.5 \times 490.5) + 8\,R_D = 0$

$R_D = \dfrac{1226.25}{8}$

$\boxed{R_D = 153.28\ N}$; $\boxed{R_A = 153.28\ N} \qquad [\because R_A = R_B]$

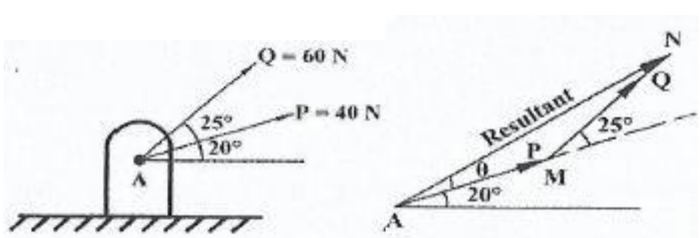
Answers:

1. Tension in cable BE = 50 kg (or) 490.5 N

2. Reaction R_A = 153.28 N

3. Reaction R_D = 153.28 N

3 **(i) Two forces P and Q of magnitude 40 N and 60 N respectively act on a bolt A. Determine their resultant if P and Q make 20º and 45º respectively with horizontal. BTL5 (7) (May 2016)**



$R^2 = P^2 + Q^2 - 2PQ\ \text{Cos}\ M$

M is the angle included by the two forces.

$P = 40N;\ Q = 60N;\ M = 180° - 25° = 155°$

$R^2 = 40^2 + 60^2 - 2 \times 40 \times 60 \times Cos155° = 9550.277\ N^2$

$\boxed{\mathbf{R = 97.73\ N}}$

Applying the law of sines to the triangle ANM,

$$\frac{\sin \angle A}{Q} = \frac{\sin \angle M}{R}$$

$$\frac{\sin\theta}{60} = \frac{\sin 155^\circ}{97.73}$$

$$\sin\theta = \frac{\sin 155^\circ}{97.73} \times 60 = 0.259$$

$$\theta = \sin^{-1}(0.259)$$

$$\boxed{\theta = 15.01^\circ}$$

The angle of inclination of the resultant with the horizontal

$= 20^0+\theta = 20^\circ + 15.01^\circ = 35.01^\circ$

Answers :

1. *Magnitude of the resultant = 97.73 N*
2. *The direction of the resultant = 35.01°*

Alternate Method:

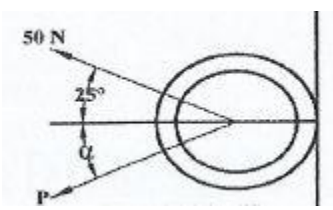
$$R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$$

where θ is the angle between the two forces.

$$R = \sqrt{40^2 + 60^2 + 2 \times 40 \times 60 \times \cos 25^\circ}$$

$$\boxed{R = 97.73\ N}$$

(ii) Two forces are applied to a hook support as shown in Fig. Knowing that the magnitude of P is 35 N determine (1) the required angle α if the resultant forces applied to the support is to be horizontal, (2) the corresponding magnitude of R. (6) BTL5 (May 2016)



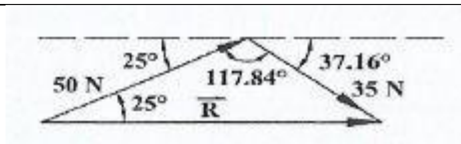
1. **The required angle α, if the resultant R of the two forces applied to the support is to be horizontal :**

$$P = 35N \Rightarrow \frac{\sin 25^\circ}{35} = \frac{\sin\alpha}{50}$$

$$\sin\alpha = \sin 25^\circ \times \frac{50}{35} = 0.604$$

$$\boxed{\alpha = 37.16^\circ}$$

2. **The corresponding magnitude of R:**



$$R = \sqrt{50^2 + 35^2 - (2 \times 50 \times 35 \times \cos 117.84^\circ)}$$

$$\boxed{R = 73.209N}$$

4 **The x,y,z component of a force are 36 kN, -24 kN and 24 kN respectively. Find the component of this force along the line joining A(1,2,-3) and B(-1,-2,2).**
BTL4 (May 2016)

$$F_x = 36kN\ ; \quad F_y = -24kN \quad ; \quad F_z = 24kN$$

$$\vec{F} = 36\vec{i} - 24\vec{j} + 24\vec{k}\ ; \quad |F| = \sqrt{36^2 + (-24)^2 + 24^2} = 49.48kN$$

$$\vec{\lambda} = \frac{\vec{F}}{|F|} = \frac{36\vec{i} - 24\vec{j} + 24\vec{k}}{49.48}$$

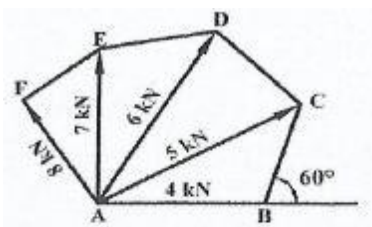
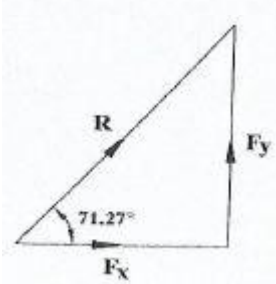
$$\vec{\lambda} = 0.728\vec{i} - 0.485\vec{j} + 0.485\vec{k}$$

$$\text{Position vector} \quad \overrightarrow{AB} = (-1-1)\vec{i} + (-2-2)\vec{j} + (2-(-3))\vec{k}$$

$$= -2\vec{i} - 4\vec{j} + 5\vec{k}$$

$$\text{Unit vector } AB = \vec{\mu} = \frac{-2\vec{i} - 4\vec{j} + 5\vec{k}}{\sqrt{(-2)^2 + (-4)^2 + 5^2}} = \frac{-2\vec{i} - 4\vec{j} + 5\vec{k}}{6.708}$$

$$\vec{\mu} = -0.298\vec{i} - 0.596\vec{j} + 0.75\vec{k}$$

	component of $\vec{F}$ along $\overrightarrow{AB}$ is, $\Rightarrow \vec{F} \cdot \mu$ $= 49.48 \times (0.728\vec{i} - 0.485\vec{j} + 0.485\vec{k}) \times (-0.298\vec{i} - 0.596\vec{j} + 0.75\vec{k})$ $= 49.48 \times ((0.728 \times -0.298) + (-0.485 \times -0.596) + (0.485 \times 0.75))$ $= 21.567 kN$
5	**A system of five forces of magnitude 4 kN, 5kN, 6kN, 7kN and 8 kN acts at one of the angular points of a regular hexagon and the forces pass through the other angular points as shown in Fig. Find the magnitude and direction of the resultant of the system of forces.**  **BTL4 (Nov. 2015)** Sum of the six interior angles of a hexagon $= (2n - 4) \times 90°$ $= (2 \times 6 - 4) \times 90$ $= 720°$ Interior angle BAF $= \frac{720°}{6} = 120°$ The angle between the consecutive forces $= \frac{120°}{4} = 30°$ $\Sigma F_x = 4 + 5\cos 30 + 6\cos 60 + 7\cos 90 - 8\cos 60 = 7.33$ kN $\Sigma F_y = 0 + 5\sin 30 + 6\sin 60 + 7 + 8\sin 60 = 21.62$ kN Resultant $= \sqrt{(\Sigma F_x^2 + \Sigma F_y^2)} = \sqrt{(7.33^2 + 21.62^2)} = 22.83$ kN Inclination of the resultant with the horizontal $= \tan^{-1}\left[\frac{\Sigma F_y}{\Sigma F_x}\right]$ 

$$\theta = \tan^{-1}\left[\frac{21.62}{7.33}\right]$$

$\theta = 71.27°$

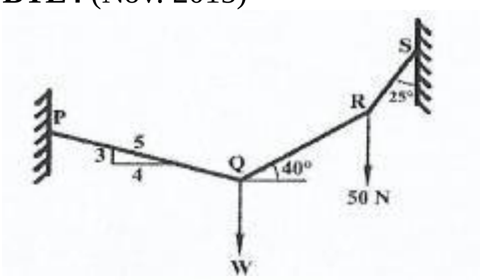
The resultant lies in the first quadrant. Hence 71.27° is measured from the positive x - axis.

Answers:

1. The magnitude of the resultant = 22.83 kN

2. The inclination of the resultant = 71.27°

6 Three links PQ,QR and RS connected as shown in Fig. support loads W and 50 N. Find the weight W and the force in each link if the system remains in equilibrium.
BTL4 (Nov. 2015)



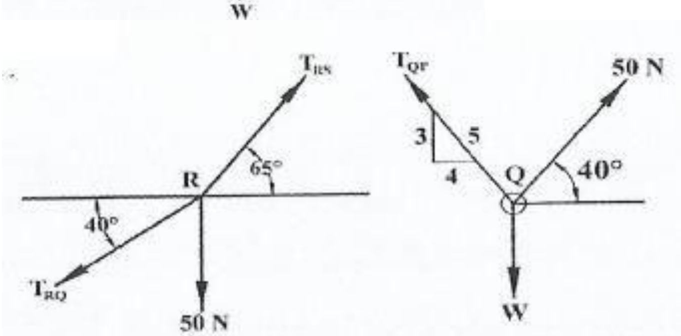


Fig. (i) shows the free body diagram of ring at R.

$\Sigma F_x = 0$; $T_{RS} \cos 65° - T_{RQ} \cos 40° = 0$ $\rightarrow (1)$

$\Sigma F_y = 0$; $T_{RS} \sin 65° - 50 - T_{RQ} \sin 40° = 0$ $\rightarrow (2)$

Eqn. (1) $T_{RS} = T_{RQ} \times \dfrac{\cos 40°}{\cos 65°}$

$T_{RS} = 1.813\ T_{RQ}$

Substituting T_{RS} value in Eqn (2),

$1.813\ T_{RQ} \times \sin 65° - 50 - T_{RQ} \sin 40° = 0$

$\boxed{T_{RQ} = 50N}$

	$\therefore T_{RS} = 1.813 \times T_{RQ} = 1.813 \times 50$ $\boxed{T_{RS} = 90.65N}$ Fig. (ii) shows the free body diagram of ring at Q. $\Sigma F_x = 0$; $50 \cos 40° - T_{QP} \times \frac{4}{5} = 0$ $\boxed{T_{QP} = 47.88N}$ $\Sigma F_y = 0$; $50 \sin 40° - T_{QP} \times \frac{3}{5} - W = 0$ $W = 50 \times \sin 40 + (47.88 \times \frac{3}{5})$ $\boxed{W = 60.87N}$ **Answers:** $T_{QP} = 47.88N$; $T_{RQ} = 50N$; $T_{RS} = 90.65N$; $W = 60.87N$
7	**(i) The magnitude of the resultant of two concurrent forces including an angle of 90º between them is $\sqrt{13}$ kN. When this included angle is changed to 60º, the magnitude of the resultant becomes $\sqrt{19}$ kN. Find the magnitude of the two forces. (8)** **BTL4 (May 2015)** *Let F_1 and F_2 be the two concurrent forces and R be their resultant.* $R^2 = F_1^2 + F_2^2 + 2F_1 F_2 \cos \theta$ $\theta = 90°$; $\left(\sqrt{13}\right)^2 = F_1^2 + F_2^2 + 2F_1F_2 \cos 90°$ $F_1^2 + F_2^2 = 13 \quad \rightarrow (1) \quad [\because \cos 90° = 0]$ $\theta = 60°$; $\left(\sqrt{19}\right)^2 = F_1^2 + F_2^2 + 2F_1 F_2 \cos 60°$ $F_1^2 + F_2^2 + F_1F_2 = 19 \quad \rightarrow (2) \quad [\because \cos 60° = 0.50]$ *Eqn (2)* $\Rightarrow$ $13 + F_1 F_2 = 19 \quad [\because F_1^2 + F_2^2 = 13]$ $F_1 F_2 = 19 - 13 = 6$ $F_1 F_2 = 6$ $(F_1 + F_2)^2 = F_1^2 + F_2^2 + 2F_1 F_2 = 13 + 2 \times 6 = 25$ $F_1 + F_2 = \sqrt{25} = 5 \quad \rightarrow (3)$ $(F_1 - F_2)^2 = F_1^2 + F_2^2 - 2F_1F_2 = 13 - 2 \times 6 = 1$ $F_1 - F_2 = \sqrt{1} = 1 \quad \rightarrow (4)$ *Eqn (3) + Eqn (4)* $\Rightarrow$ $2F_1 = 6$ $F_1 = 3 \ kN$ *Eqn (3)* $\Rightarrow 3 + F_2 = 5 \Rightarrow \quad F_2 = 2kN$

Answer : The magnitudes of the two concurrent forces are 3kN and 2kN.

(ii) A force of magnitude 3.5 kN makes 30º, 50º and 100º with x,y and z axes respectively. Find the force vector and determine its components along x,y,z axes. (5)
BTL5 (May 2015)

$$F_x = F \, Cos \, \theta_x = 3.5 \times Cos \, 30^o = 3.03kN$$
$$F_y = F \, Cos \, \theta_y = 3.50 \times Cos \, 50^o = 2.25kN$$
$$F_z = F \, Cos \, \theta_z = 3.50 \times Cos \, 100^o = -0.61kN$$

Force vector:

Vectorially, the force is written as $\vec{F} = F_x \vec{i} + F_y \vec{j} + F_z \vec{k}$

$$\vec{F} = 3.03\vec{i} + 2.25\vec{j} - 0.61\vec{k}$$

Answers :

1. **x, y and z scalar components are 3.03 kN, 2.25 kN and – 0.61 kN.**
2. **The vector components along the x, y and z axes are $3.03\vec{i} + 2.25\vec{j} - 0.61\vec{k}$ respectively.**

8 **ght of 8 kN is suspended by three cables PA, PB and PC. The co-ordinates of the points are: P (1.5,1.5,-2) A (0,3,4) B(2.5,3,2.5) C(1,3,0)**
BTL5 (May 2015)

$$R = \sum_F = \vec{F}_{PA} + \vec{F}_{PB} + \vec{F}_{PC} + \vec{W} = 0$$

Force in cable PA:

$$d_x = -1.5m; \; d_y = +1.5m \; ; \; d_z = +2m \; ;$$

$$d = \sqrt{(-1.5)^2 + 1.5^2 + 2^2} = 2.92m$$

$$\vec{F}_{PA} = \frac{F_{PA}}{2.92}(-1.5\vec{i} + 1.5\vec{j} + 2\vec{k})$$

$$= -0.51 \, F_{PA} \, \vec{i} + 0.51 \, F_{PA} \, \vec{j} + 0.685 \, F_{PA} \, \vec{k}$$

Force in cable PB :

$$d_x = +1m \; ; \; d_y = 1.5m \; ; \; d_z = 0.50m$$

$$d = \sqrt{1^2 + 1.5^2 + 0.5^2} = 1.87m$$

$$\vec{F}_{PB} = \frac{F_{PB}}{1.87}\,(1\vec{i} + 1.5\vec{j} + 0.5\vec{k})$$

$$= 0.53\;F_{PB}\,\vec{i} + 0.80\;F_{PB}\,\vec{j} + 0.27\;F_{PB}\,\vec{k}$$

Force in cable PC :

$$d_x = -0.50m; d_y = +1.5m; \; d_z = -2m \; ;$$

$$d = \sqrt{(-0.50)^2 + 1.5^2 + (-2)^2} = 2.55m$$

$$\vec{F}_{PC} = \frac{F_{PC}}{2.55}\,(-0.5\vec{i} + 1.5\vec{j} - 2\vec{k})$$

$$= -\,0.20\;F_{PC}\,\vec{i} + 0.59\;F_{PC}\,\vec{j} + 0.78\;F_{PC}\,\vec{k}$$

$$W = -8kN\,\vec{j}$$

$$\Sigma\vec{F} = \vec{i}\;(\,-0.51\;F_{PA} + 0.53\;F_{PB} - 0.20\;F_{PC}\,) + \;\vec{j}$$

$$(\,0.51\;F_{PA} + 0.8\;F_{PB} + 0.59\;F_{PC} - 8\,)$$

$$+\vec{k}\;(\,0.685\;F_{PA} + 0.27\;F_{PB} - 0.78\;F_{PC}\,)$$

Equilibrium condition:

$$\Sigma F = 0$$

$$\Sigma F_x = -0.51\ F_{PA} + 0.53 F_{PB} - 0.20\ F_{PC} = 0 \rightarrow (1)$$

$$\Sigma F_y = 0.51\ F_{PA} + 0.80 F_{PB} + 0.59\ F_{PC} - 8 = 0 \rightarrow (2)$$

$$\Sigma F_z = 0.685\ F_{PA} + 0.27 F_{PB} - 0.78\ F_{PC} = 0 \rightarrow (3)$$

By using calculator,

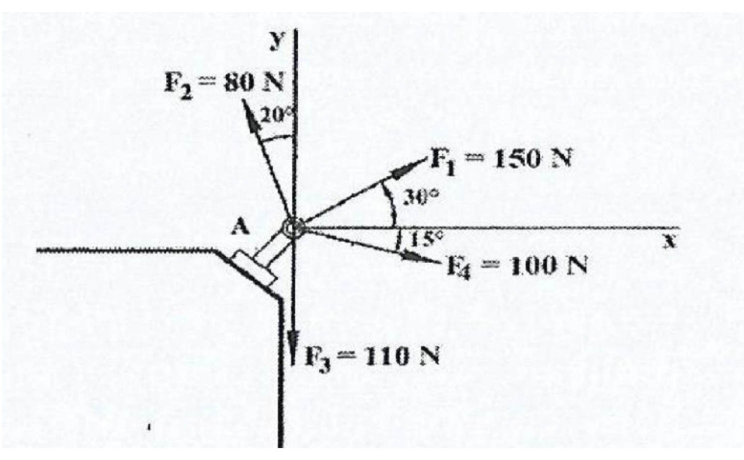
$$F_{PA} = 3.17\ kN;\ F_{PB} = 4.72kN;\ F_{PC} = 4.42kN$$

Answers:

1. **Tension in the cable PA = 3.20kN**
2. **Tension in the cable PB = 4.72kN**
3. **Tension in the cable PC = 4.42kN**

PART * C

1 **Four forces act on bolt A as shown in Fig. Determine the resultant of the forces on the bolt shown in Fig.**



BTL5 (Nov.2014)

The four system is coplanar concurrent.

Magnitude of Resultant force R = $\sqrt{(\Sigma H)^2 + (\Sigma V)^2}$

Resolving the forces horizontally,

$$\Sigma H = F_1 \cos 30^\circ - F_2 \cos 70^\circ + F_4 \cos 15^\circ$$
$$= 150 \cos 30^\circ - 80 \cos 70^\circ + 100 \cos 15^\circ$$

$$\boxed{\Sigma H = 199.13N}$$

Resolving the forces vertically,

$\Sigma_V = F_1 \sin 30^\circ + F_2 \sin 70^\circ - F_3 - F_4 \sin 15^\circ$

$= 150 \sin 30^\circ + 80 \sin 70^\circ - 110 - 100 \sin 15^\circ$

$\boxed{\Sigma V = 14.29N}$

Magnitude of resultant force:

$R = \sqrt{(\Sigma H)^2 + (\Sigma V)^2} = \sqrt{199.13^2 + 14.29^2}$

$\boxed{R = 199.64N}$

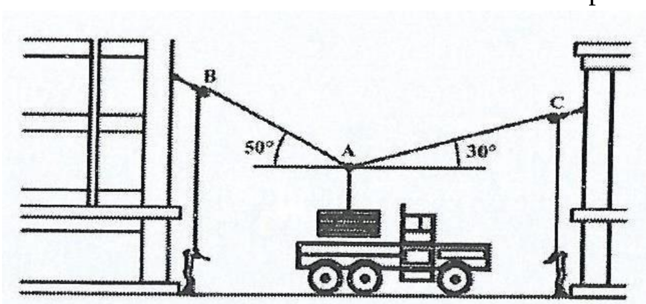
Direction of resultant : $\theta = \tan^{-1}\left[\frac{\Sigma V}{\Sigma H}\right] = \tan^{-1}\left[\frac{14.29}{199.13}\right]$

$\boxed{\theta = 4.10^\circ}$

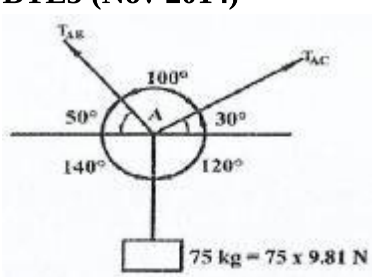
Answers:

$\Sigma H = 199.13N$
$\Sigma V = 14.29N$
$R = 199.64N$
$\theta = 4.10^\circ$

2 Consider the 75 kg crate shown in the space diagram of Fig. This crate was lying between two buildings and it is now being lifted on to a truck, which will remove it. The crate is supported by a vertical cable, which is joined at A to two ropes which pass over pulleys attached to the buildings at B and C. It is desired to determine the tension in each of the ropes AB and AC.



BTL5 (Nov 2014)

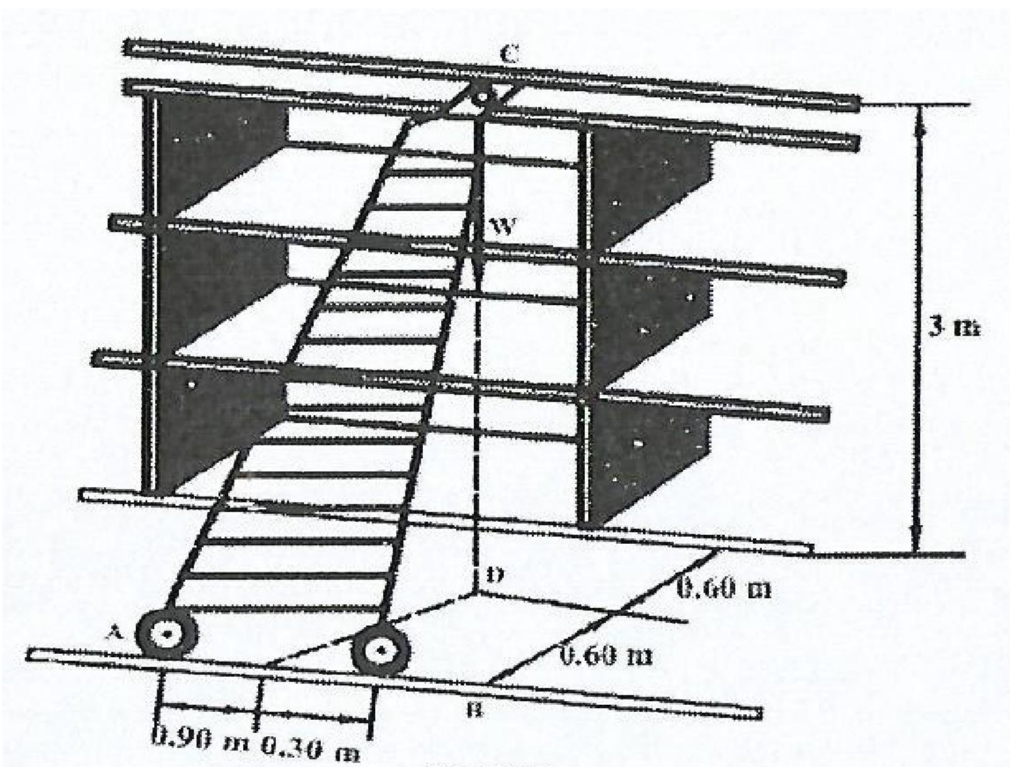


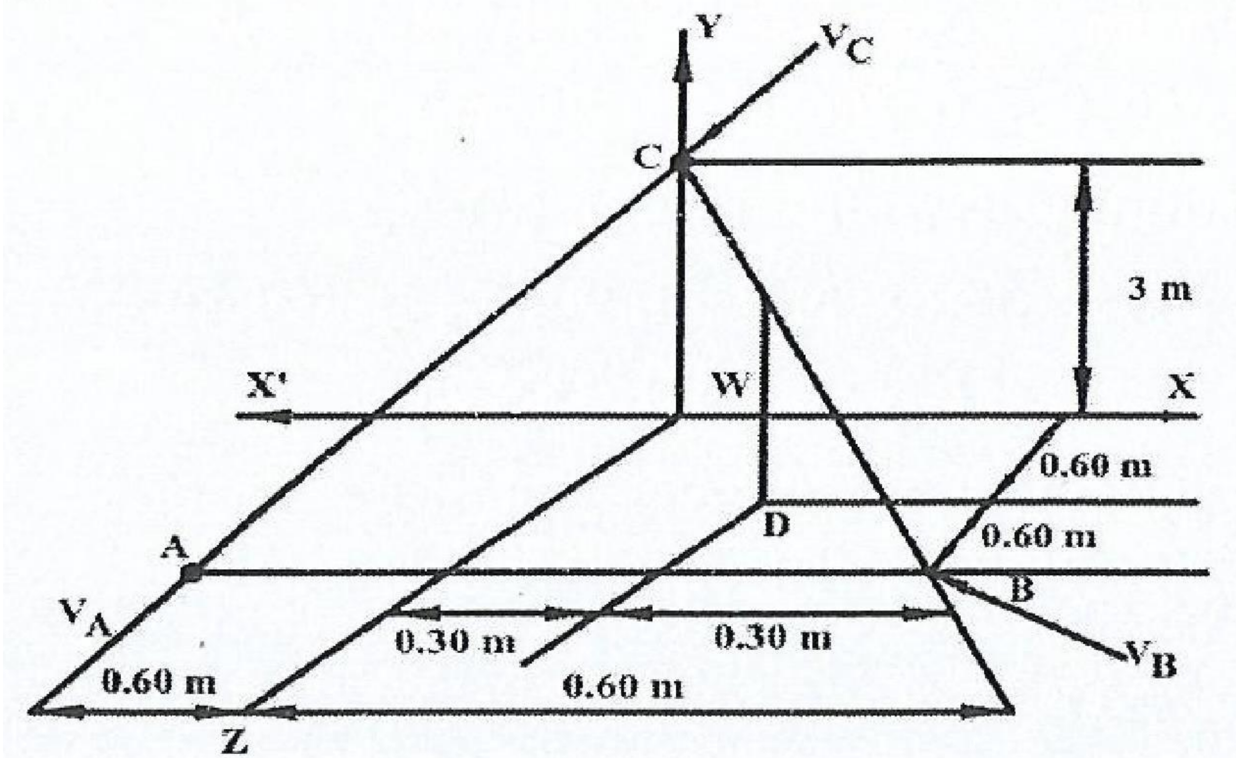
Free body diagram at A

T_{AB} = Tension in the rope AB, from A to B

T_{AC} = Tension in the rope AC, from A to C

From the geometry of the Fig. (i), the angle between T_{AC} and 75kg is $(30^\circ+90^\circ) = 120^\circ$.

	Angle between T_{AB} and 75kg is $(50°+90°) = 140°$ Angle between T_{AB} and T_{AC} is $(180°–50°–30°) = 100°$ Applying Lami's equation at A, $\frac{T_{AB}}{Sin120°} = \frac{T_{AC}}{Sin\,140°} = \frac{75 \times 9.81}{Sin100°}$ $\frac{T_{AB}}{Sin120°} = \frac{75 \times 9.81}{Sin100°}$ $\boxed{T_{AB} = 647N}$ $\frac{T_{AC}}{Sin\,140°} = \frac{75 \times 9.81}{Sin100°}$ $\boxed{T_{AC} = 480.23N}$ **Answers:** $T_{AB} = 647N$ $T_{AC} = 480.23N$
3	**A 20 kg ladder (Fig) used to reach high shelves in a store room is supported by an un flanged wheels A and B mounted on a rail and by an un flanged wheel C resting against a rail fixed to the wall. An 80 kg man stands on the ladder and leans to the right. The line of action of the combined weight W of the man and ladder intersects the floor at point D. Determine the reactions at A,B and C.**  **BTL5 (Nov. 2014)**



From the geometry, the coordinates are,

A (–0.6, 0,1.2)

B (0.6, 0, 1.2)

C (0,3,0)

D (0.30,0,0.60)

Reaction forces and combined weight are written in vector form:

$$\vec{V}_A = V_A \ \lambda_{AC}$$

$$= V_A \left[\frac{-0.6\vec{i} + 3\vec{j} - 1.2\vec{k}}{\sqrt{(0.6)^2 + 3^2 + (-1.2)^2}}\right]$$

$$\vec{V}_A = V_A(0.183\vec{i} + 0.913\vec{j} - 0.365\vec{k}) \quad \rightarrow (1)$$

$$\vec{V}_B = V_B \ \lambda_{BC}$$

$$= V_B \left[\frac{-0.6\vec{i} + 3\vec{j} - 1.2\vec{k}}{\sqrt{(-0.6)^2 + 3^2 + (-1.2)^2}}\right]$$

$$\vec{V}_B = V_B(-0.183\vec{i} + 0.913\vec{j} - 0.365\vec{k}) \quad \rightarrow (2)$$

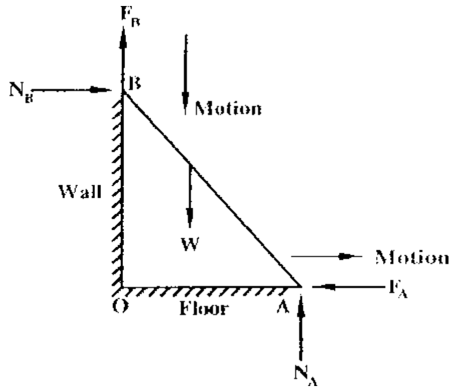
$$\vec{V} = V_C \ \vec{k} \quad \rightarrow (3)$$

$$\vec{W} = W(-\vec{j}) = 100 \times 9.81 \times (-\vec{j})$$

$$\vec{W} = -981\vec{j} \quad \rightarrow (4)$$

	Apply the condition of equilibrium $\Sigma F_x = 0$ $0.183V_A - 0.183\ V_B = 0 \quad \rightarrow (5)$ $\Sigma F_y = 0$ $0.913V_A + 0.913\ V_B - 981 = 0 \quad \rightarrow (6)$ $\Sigma F_z = 0$ $-0.365\ V_A - 0.365\ V_B + V_C = 0 \quad (7)$ Eqn. (5) $\Rightarrow$ $0.183\ V_A = 0.183\ V_B$ $\therefore$ $V_A = V_B$ Eqn. (6) $\Rightarrow$ $0.913V_B + 0.913V_B - 981 = 0$ $V_B = 537.24N$ $V_A = 537.24N$ Eqn. (7) $\Rightarrow$ $-0.365V_A - 0.365V_B + V_C = 0$ $(-0.365 \times 537.24) - (0.365 \times 537.24) + V_C = 0$ $\mathbf{V_C = 392.19N}$

UNIT II EQUILIBRIUM OF RIGID BODIES	
Free body diagram – Types of supports –Action and reaction forces – stable equilibrium – Moments and Couples – Moment of a force about a point and about an axis – Vectorial representation of moments and couples – Scalar components of a moment – Varignon's theorem – Single equivalent force -Equilibrium of Rigid bodies in two dimensions – Equilibrium of Rigid bodies in three dimensions	
PART * A	
Q.No.	**Questions**
1	**Differentiate between moment and couple. BTL2 (May 2017)** The couple is a pure turning effect which may be moved anywhere in its own plane, or into a parallel plane without change of its effect on the body, but the moment of a force must include a description of the reference axis about which the moment is taken.
2	**A uniform ladder of weight 'W' leans against a vertical wall. Assuming the contact surfaces as rough, draw the free body diagram of the ladder with necessary assumptions. BTL3 (May 2017)** A uniform ladder of Weight 'W' leans against a vertical wall. Assuming the contact surfaces as rough, draw the free body diagram of the ladder with necessary assumptions.

<table>
<tr><td></td><td>
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How free body diagram is constructed? BTL2 (May 2016)

- Identify the most significant single body to be analyzed.
- Isolate the significant portion thus identified from all other surrounding portions.
- Show this isolated body in a separate diagram.
- Mark all the applied forces, reactive forces, self weight and moments acting upon the isolated portion.
- Indicate the magnitudes and directions wherever known.

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<tr><td>4</td><td>

State Varignon's theorem. BTL1 (May 2016, Dec 2014,May 2013)

"The moment of the resultant of a number of concurrent forces about any point is equal to the algebraic sum of the moments of all the concurrent forces about the same point"

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Distinguish between the resultant and equilibrant. BTL2 (Dec. 2015)

Resultant is the single equivalent force of a system (group) of forces. Equilibrium is a single force that balances other forces. Thus, equilibrant can be said to be a single force which is equal, collinear and opposite to the resultant.

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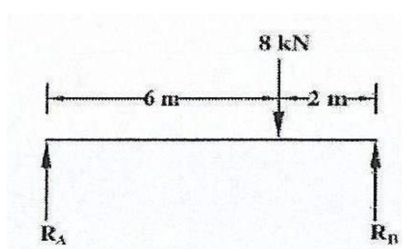
Find R_A and R_B of the beam shown in Fig. BTL3 (Dec. 2015)



$R_A + R_B$ = Total load

$R_A = \frac{wb}{l} = \mathbf{2\ kN}$; w = 8 kN; a = 6m; b =2 m

R_B = Total load – R_A = 8 – 2 = **6 kN**

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<tr><td>7</td><td>

List the different supports used to support structural components. BTL1 (May 2015)

- Roller (or) rocker support
- Hinged (or) pin—joint support
- Fixed (or) built in support

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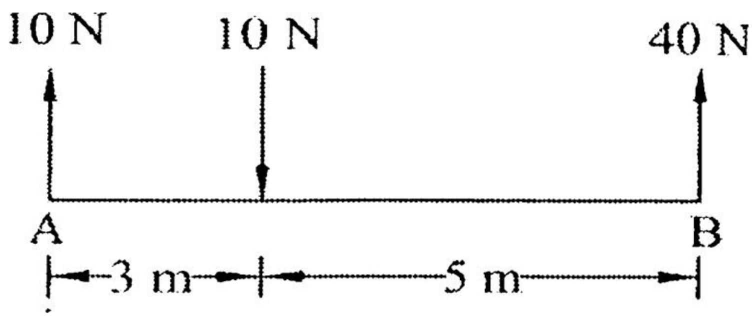
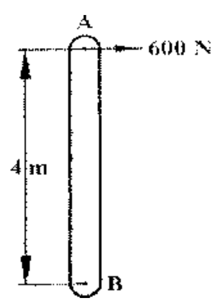
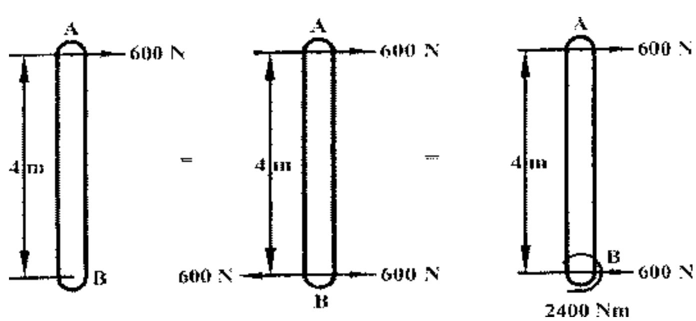
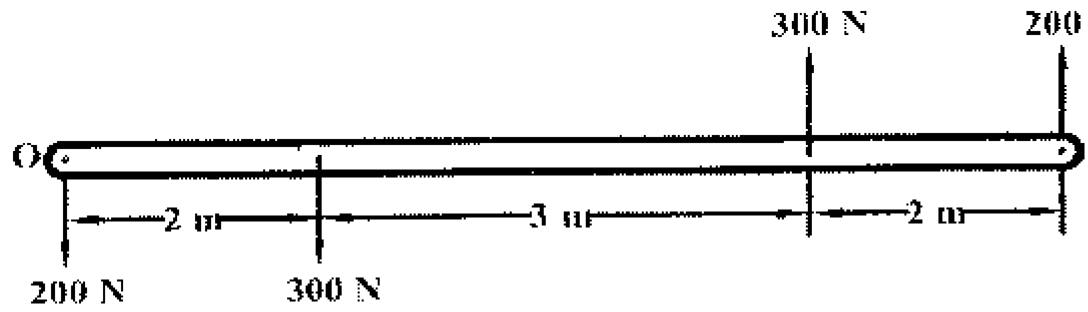
</table>

	• Smooth surface support (or) frictionless surface support.
8	**Find the magnitude and location of the single equivalent force for a beam AB of length 8 m having a point C at 3m from A subjected to the following forces:** **(i) An upward force of 10 N at A** **(ii) A downward force of 10 N at C** **(iii) An upward force of 40 N at B** **BTL3 (May 2015)**  Equivalent single force = 10 – 10 +40 = 40 N acting vertically 40 x X = 40 x 8 – 10 x 3 X = 7.25 m from A
9	**Define Couple. BTL2 (Dec. 2014)** Two parallel forces of equal magnitude having opposite senses are said to form a couple.
10	**Replace the force 600 N from A as shown in Fig by equivalent force and couple at B. BTL3 (May 2014)**  
11	**Find the resultant of the force system show in Fig. BTL3 (May 2014)**



Resultant force = 300+200 -200 – 300 = 0 N

12 **Write the equations of equilibrium of a rigid body in two dimensions. BTL2 (May 2013)**

$\sum F_x = 0; \sum F_y = 0; \sum M = 0$

Where,

$\sum F_X$ = Algebraic sum of horizontal components of all the forces.

$\sum F_Y$ = Algebraic sum of vertical components at all the forces.

$\sum M_Z$ = Algebraic sum of moments all the forces acting on the body

13 **A force F = (6i -3j-4k) N is acting at a point P whose position vector from the origin 'O' of the coordinate axes is (8i+6j-4k) mm. Find the moment of the force about the origin. BTL3 (Nov.2001)**

Given: F= (6i -3j-4k) N ; OP = 8i+6j-4k

Moment M = OP x F

M = (8i+6j-4k) x (6i -3j-4k)

$= \begin{bmatrix} i & j & k \\ 8 & 6 & -4 \\ 6 & -3 & -4 \end{bmatrix}$ = i[-24-(12)] –j [(-32)-(-24)]+k[(-24)-(36)]

= -36 I +8j – 60 k

M = $\sqrt{36^2 + (-8)^2 + 60^2}$ = **70.42 mm**

14 **Explain the concept of reducing a system of forces to an equivalent force couple system. BTL2 (May 2001)**

Any force F acting on a rigid body can be moved to an arbitrary point O provided that a couple is added whose movement is equal to the movement of F about O. The couple tends to impart to the rigid body the same rotational motion about O that the force F tended to produce before it was transferred to O. The couple vector is usually attached at O, together with F, and the combination obtained is referred as a force couple system.

15 **What are the types of supports? BTL1**

- Simple support
- Roller support
- Hinged support
- Fixed support

16 **Distinguish between particle and rigid body. BTL4**

S.No.	Particle	Rigid body
1	A body of infinitely small volume and is considered to be concentrated at a point.	Rigid body is the one which retain its shape and size, if subjected to some external forces.
2	Here mass is negligible.	Here mass is considered.

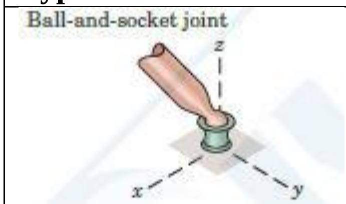
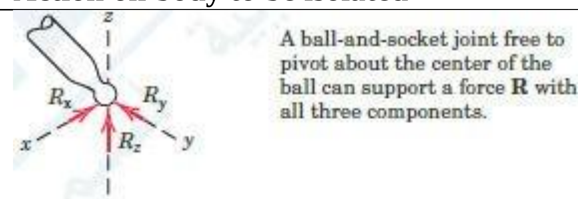
17 Explain what is meant by couple in space. BTL2

Two equal and unlike parallel forces, whose line of action are different from a couple. Generally they are coplanar forces.

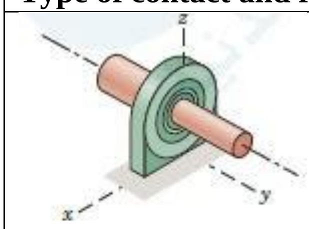
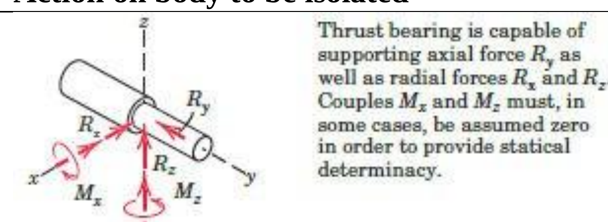
18 What is the difference between moment and couple? BTL1

The couple is a pure turning effect which may be moved anywhere in its own plane or in to a parallel plane without change of its effect on the body, but the moment of a force must include a description of the reference axis about which the moment is taken.

19 Draw the free body diagram for ball and socket joint. BTL3

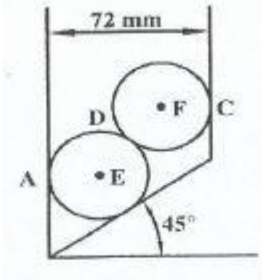
Type of contact and force origin	Action on body to be isolated
	

20 Draw the free body diagram for thrust bearing support. BTL3

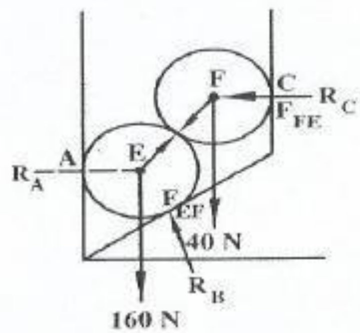
Type of contact and force origin	Action on body to be isolated
	

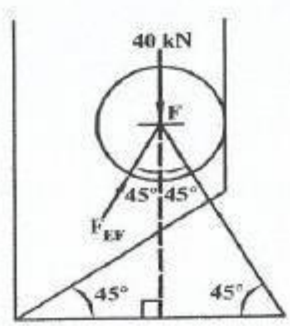
PART * B

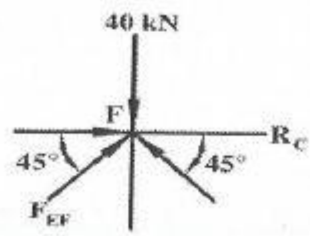
1 Two cylinders C,F of diameter 60 mm and 30 mm weighing 160 N and 40 N respectively are placed as shown in Fig. Assuming all the contact surfaces to be smooth, find the reactions at A,B and C. BTL3 (May 2017)



Solution:







Applying equilibrium equations at E, $\Sigma_H = 0$

$F_{EF} \cos 45° - R_c = 0 \quad \rightarrow (1)$

$\Sigma_V = 0; \; F_{EF} \sin 45° - 40 = 0 \rightarrow (2)$

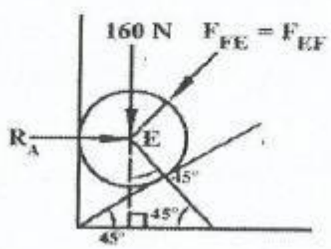
Solving the equations (1) and (2) F_{EF} and R_c can be determined.

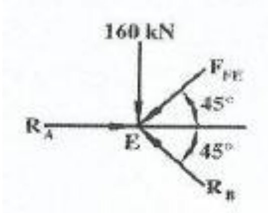
eqn (2) $\Rightarrow \quad F_{EF} \sin 45° = 40$

$$F_{EF} = \frac{40}{\sin 45°} \Rightarrow \boxed{F_{EF} = 56.57 \text{ N}}$$

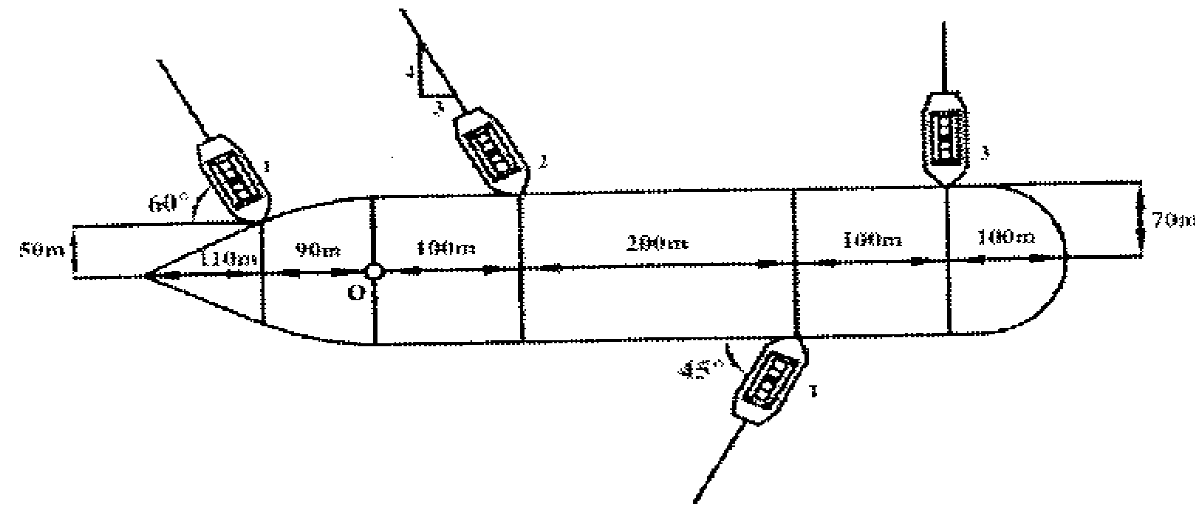
eqn (1) $\Rightarrow \quad (56.57 \times \cos 45°) - R_c = 0$

$$\boxed{\therefore R_c = 40 \text{ N}}$$





	$\theta = 180° - (90° + 45°) = 45°$ Free body diagram of cylinder E, Applying equilibrium equations at F, $\Sigma_H = 0$ $R_A - F_{FE} \cos 45° - R_B \cos 45° = 0$ $[\because F_{FE} = F_{EF} = 56.57N]$ $R_A - 56.57 \cos 45° - R_B \cos 45° = 0$ $R_A - R_B \cos 45° = 40 \rightarrow (3)$
2	**For tug boats are used to bring a large ship to its pier. Each tug boat exerts a 5000N force in the direction as shown in Fig. 12(a). Dtermine the equivalent force-couple system at point 'O', and the point on hull where a single more powerful tugboat should push to produce the same effect as the original four tugboats.**



BTL4 (May 2017)

$\Sigma F_x = 9.036$ kN

$\Sigma F_y = (-5\times\sin 60^\circ) - (5\times\frac{4}{5}) - 5 + (5\cos 45^\circ)$

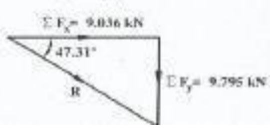
$\Sigma F_y = -9.795$ kN

Resultant $R = \sqrt{\Sigma F_x^{\,2} + \Sigma F_y^{\,2}} = \sqrt{9.036^2 + (-9.795^2)}$

$\boxed{R = 13.326 \text{ kN}}$

Direction of Resultant $R \Rightarrow \quad \theta = \tan^{-1}\left(\frac{\Sigma F_y}{\Sigma F_x}\right)$

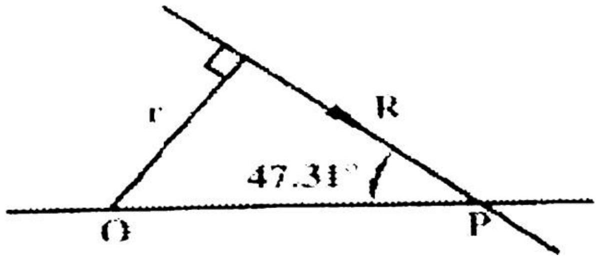
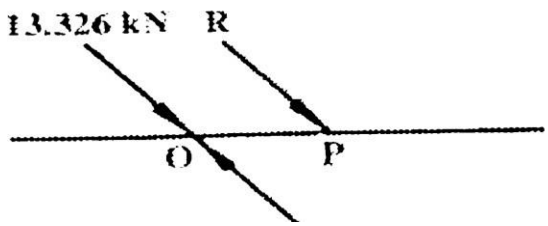
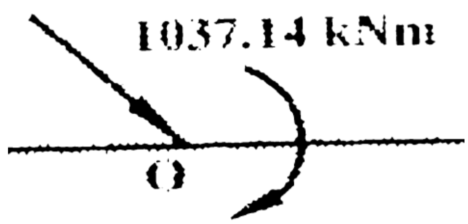
$= \tan^{-1}\left(\frac{9.795}{9.036}\right)$



$\boxed{\theta = 47.31^\circ}$

To find the equivalent force couple at O:

$$\Sigma M = (5\times\sin 60^\circ\times 90) - (5\times\cos 60^\circ\times 50)$$
$$-(5\times\frac{3}{5}\times 70) - (5\times\frac{4}{5}\times 100)$$
$$-(5\times 400) + (5\times\cos 45^\circ\times 70) + (5\times\sin 45^\circ\times 300)$$

	$\boxed{\Sigma M = -1037.14 \text{ kNm (or) } 1037.14 \text{ kNm (clockwise)}}$ The perpendicular distance between the line of action of the resultant and O $r = \frac{\Sigma_M}{R} = \frac{1037.14}{13.326} = 77.83m \Rightarrow \boxed{r = 77.83 \text{ m}}$  **To find the location of the resultant along the long longitudinal axis of the ship.** $\text{Sin } 47.31° = \frac{r}{OP}$  $\text{Sin } 47.31° = \frac{77.83}{OP}$  $\boxed{OP = 105.89 \text{ m}}$ Fig (iv) shows the equivalent force couple at O. **Answers:** **1. The magnitude of the single equivalent force = 13.326 kN** **2. The direction of the resultant = 47.31° measured clockwise direction from the positive x axis.** **3. The equivalent force couple at O is shown in fig 12a(iv). The moment of the couple at O = 1037.14 kNm (clockwise)**
3	**A bracket is subjected to a force as shown in Fig 12 (a). Determine : (i) an equivalent force couple system at A and B. (ii) an equivalent system consisting of 90kN force at B and another force at A.** **BTL4 (May 2016)**

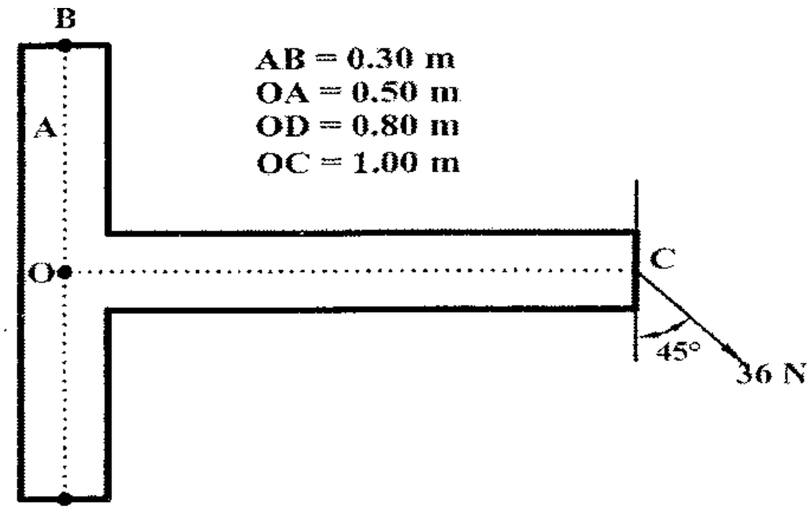


Fig. 12 (a)

(i) An equivalent force couple system at A and B

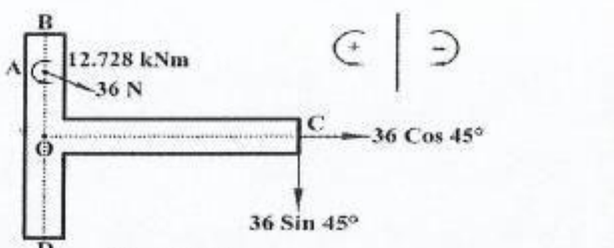


Fig. 12a (a)

$M_A = (+36 \text{ Cos } 45° \times 0.50) + (-36 \text{ Sin } 45° \times 1) = -12.728$ kNm

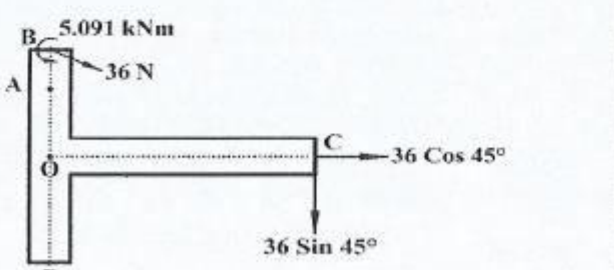


Fig. 12a (b)

$M_B = (+36 \text{ Cos} 45° \times 0.80) + (-36 \text{ Sin} 45° \times 1) = -5.091$kNm

(ii) Equivalent system of 90kN at B and another force at A

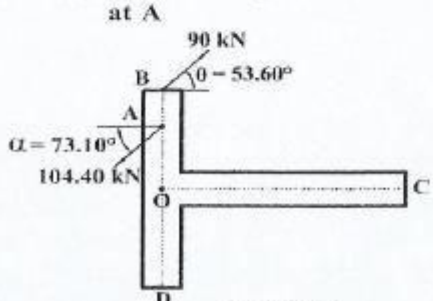


Fig. 12a (c)

4 A fixed crane has a mass of 1000 kg and is used to lift a 2400 kg crate as shown in Fig. It is

	held in place by a pin at A and a rocker at B. The centre of gravity of the crane is located at G. **Determine** the reactions at supports A and B.

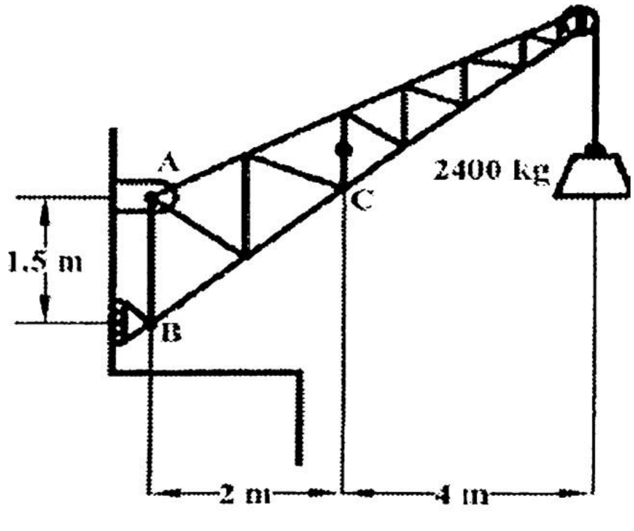


Fig. 12 (b)

BTL4 (May 2016)

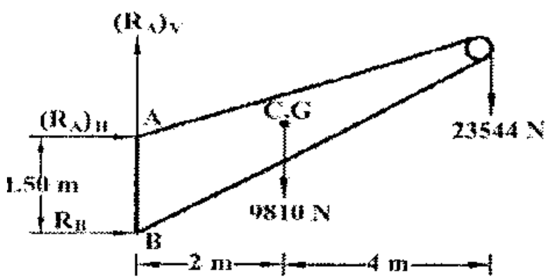


Fig. 12b (i)

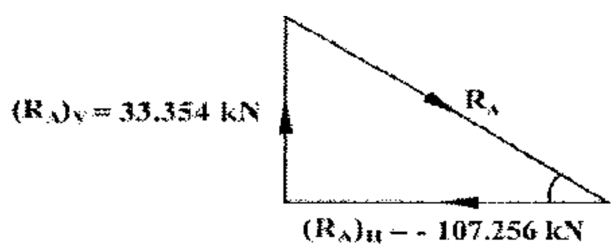


Fig. 12b (ii)

Weight of the container = 2400 kg×9.81m/s² = 23544 N

Weight of the crane = 1000 kg×9.81 m/s² = 9810N

$\Sigma F_x = R_B + (R_A)_H = 0 \quad \rightarrow (1)$

$\Sigma M_A = R_B \times 1.50 - 9810\times 2 - 23544\times 6 = 0$

$1.50 R_B = 19620 + 141264$

$\boxed{R_B = 107256N}$

$\Sigma F_y = (R_A)_V - 9810 - 23544 = 0$

$(R_A)_V = 9810 + 23544 = 33354N$

Eqn. (1) $(R_A)_H = -R_B = -107256N$

$R_A = \sqrt{(-107.256)^2 + (33.354)^2} = 112.322kN$

$\theta = \tan^{-1}\left(\frac{33.354}{107.256}\right) = 17.27°$

$\theta = 17.27°$

Answers :
1. The support reaction at A = 112.322kN
2. The support reaction at B = 107.256kN

5	**Find the support reactions of the truss loaded as shown in Fig.12 (b) BTL4 (Dec 2015)**

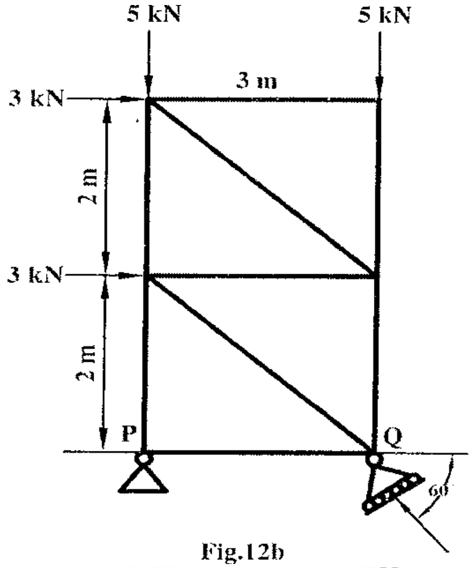


Fig.12b

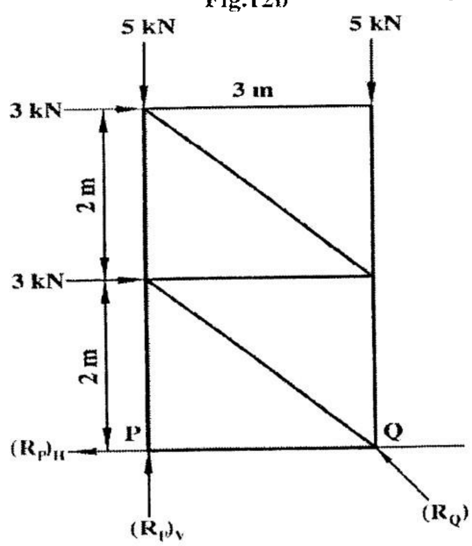


Fig.12b (i)

$\Sigma H = 3+3 - (R_P)_H - (R_Q) \cos 60^o = 0$

$(R_P)_H + R_Q \cos 60^o = 6 \quad \rightarrow \quad (1)$

$\Sigma V = (R_P)_V - 5 - 5 + R_Q \sin 60 = 0$

$(R_P)_V + R_Q \text{ Sin } 60 = 10 \quad \rightarrow \quad (2)$

$\Sigma M_P = -3\times2 - 3\times4 - 5\times3 + R_Q \sin 60\times3 = 0$

From Eqn (2),

$$(R_p)_V = 10 - 12.70 \times \sin 60 = 10 - 11 = -1 \text{ kN}$$

$$R_p = \sqrt{(R_P)_H^2 + (R_P)_V^2} = \sqrt{(10.35)^2 + (-1)^2} = 1.06\text{kN}$$

Inclination of R_p with the horizontal $\theta = \tan^{-1}\left(\frac{-1}{0.35}\right)$

$$\theta = \tan^{-1}(-2.857)$$

$$\theta = -70.71°$$

Answers:
1. **Support reaction at P = 1.06kN**
2. **Support reaction at Q = 12.70kN**

6 **A roller of radius 30 cm weighs 2.5 kN. It is to be pulled over a rectangular obstruction of height 10 cm by a horizontal force *F* passing through the centre of the roller. Find the magnitude if the force *F* passing through the centre of the roller. Find the magnitude if the force F required just to turn the roller over the corner of the obstruction. Also find the magnitude and direction of the minimum force required for the same. (16)**

BTL4 (May 2015)

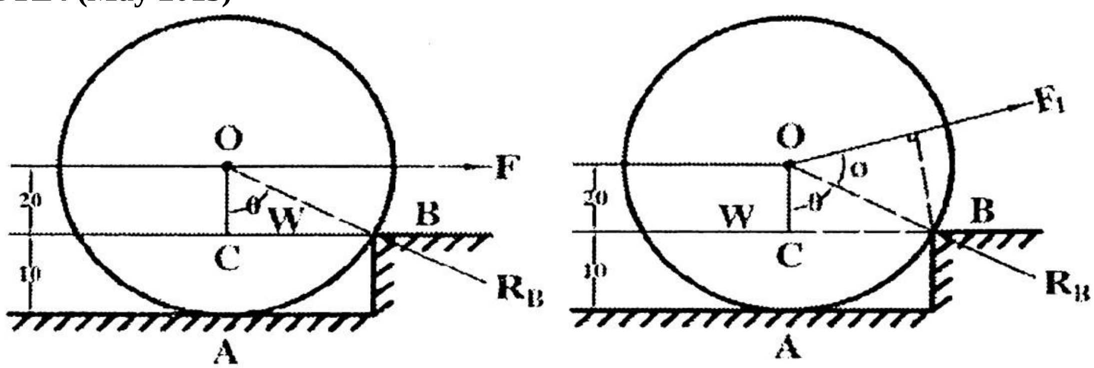


Fig.12a (a) **Fig.12a (b)**

The horizontal force $\vec{F}$; The weight of the roller W and the reaction at B must be concurrent. R_B should pass through O, where F and W meet. When the roller is just turned, the roller is not in contact with the surface at A.

The reaction at A is zero.

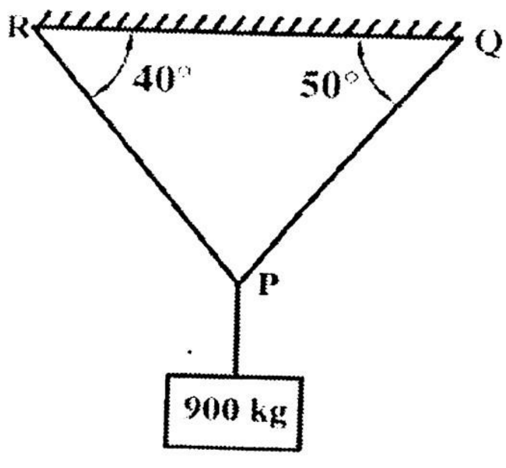
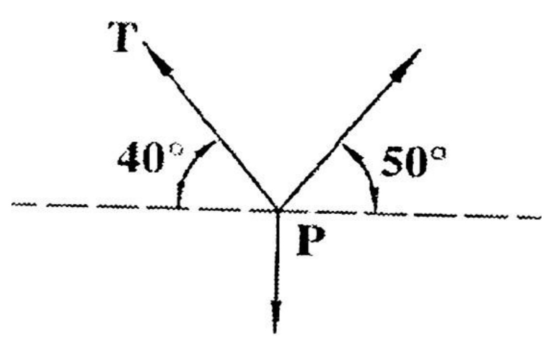
$$CB = \sqrt{(OB^2) - (OC^2)} = \sqrt{30^2 - 20^2} = \sqrt{500} = 22.36\text{cm}$$

$$\tan\theta = \frac{CB}{OC} = \frac{22.36}{20} = 1.118 \text{ (or) } \theta = 48.19°$$

$$\Sigma F_x = F - R_B \sin 48.19° = 0 \; ; \; \Sigma F_y = R_B \cos\theta \;\; 2.5 = 0$$

$$R_B = \frac{2.5}{\cos\theta} = \frac{2.50}{\cos 48.19} = 3.75\text{kN}$$

$$F = R_B \sin 48.19° = 3.75 \times 0.745 = 2.8kN$$

	To find the maximum force and its direction: Triangle OBD in Fig. (ii), $Sin\ \phi = \frac{BD}{OB} \Rightarrow BD = OB\ Sin\phi$ BD is the minimum distance line from B to the line of action of F_1. Moments of all the forces about B is zero. $M_B = W \times BC - F_1 \times BD = 0$ $W \times BC = F_1 \times BD = F_1 \times OB\ Sin\phi$ $F_1 = \frac{W \times BC}{OB \times Sin\ \phi} = \frac{2.50 \times 22.36}{30 \times Sin\ \phi} = 1.86\,kN$ The force F_1 will be minimum when $Sin\phi$ is maximum. $Sin\phi$ will be maximum when $\phi = 90°$. The magnitude of the minimum force $= \frac{2.50 \times 22.36}{30 \times Sin\ 90°}$ $= 1.86\ kN$ The minimum force makes an angle 90° with the line of action of the reaction at B **Answers:** **(i) The magnitude of the force required just to turn the roller = 2.8kN** **(ii) The magnitude of the minimum force = 1.86 kN** **(iii) The minimum force makes 90° with the line of action of R_B**
7	(I) A body of mass 900 kg is suspended by two cables PR and PQ making an angle of 40˚ and 50˚ respectively with the ceiling. Find the tension in the cables PQ and PR.(7) **BTL4 (May 2015)**  Fig.12b (i) (a) (a) Space diagram  Fig.12b (i) (b) (b) Free body diagram

Weight of 900 kg mass = 9.81 × 900 = 8829N Fig. (c) shows the corresponding force diagram. Applying law of sines (Lami's theorem),

$$\frac{T_{PR}}{\text{Sin }140°} = \frac{T_{PQ}}{\text{Sin }130°} = \frac{8829}{\text{Sin }90°}$$

Answers :
1. Tension in cable PR = 5675.17N
2. Tension in cable PQ = 6763.41N

(ii) A father and his son carry a block of mass 50 kg by using a uniform bar of length 3 m and mass 16 kg. The son can bear only half the load carried by the father. Find the location of the block on the bar. (6)

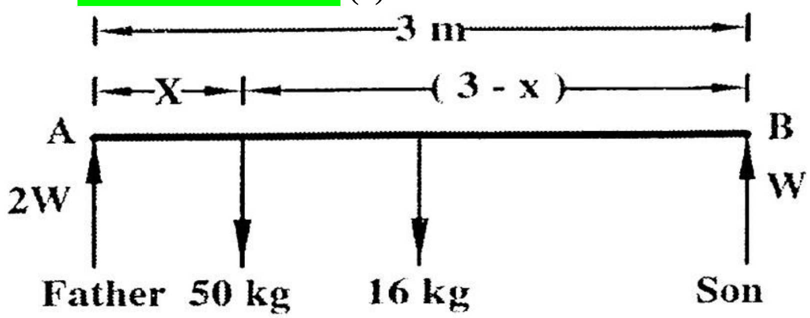


Fig.12b (ii) (a)

$\Sigma F_y = 0$

$2W - 50 \times 9.81 - 16 \times 9.81 + W = 0$

$3W = 647.46$ N

$W = 215.82$ N

$\Sigma M_A = 0$

$215.82 \times 3 - 16 \times 9.81 \times 1.5 - 50 \times 9.81 \times x = 0$

$490.50x = 412.02$

$\boxed{x = 0.840m}$

Answers :

The block should be suspended at 0.84m from the father so that the weight carried by the son is half the weight carried by his father

PART * C

1 Two cylinders, having weight W_A = 2000 N and W_B = 1000 N are resting on smooth inclined planes having inclination 60˚ and 45˚ with the horizontal respectively as shown in Fig. They are connected by weightless bar AB with hinge connections. The bar AB makes 15˚ angle with the horizontal. Find the magnitude of the force P required to hold the system in equilibrium.

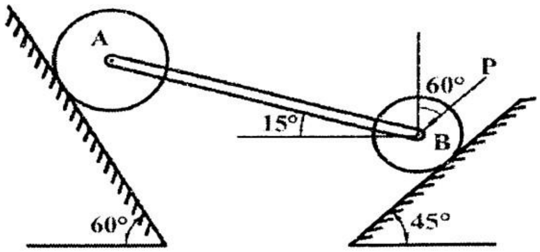


Fig.11a

	BTL4 (May 2014) **Solution:**

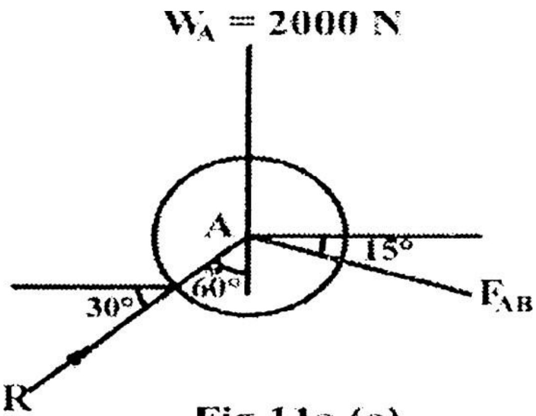


Fig.11a (a)

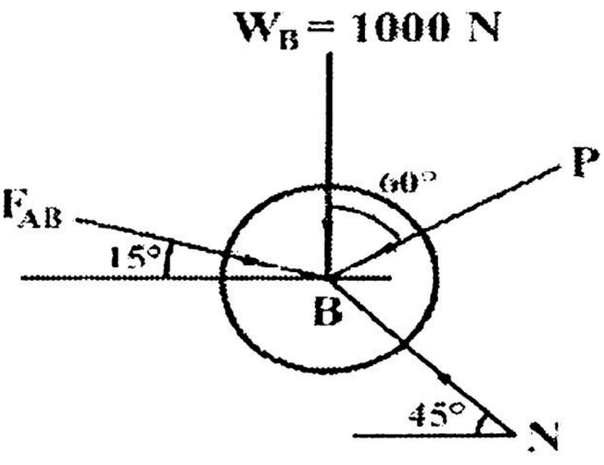


Fig.11a (b)

Lami's theorem :

$$\frac{F_{AB}}{\sin 120^\circ} = \frac{W_A}{\sin 135^\circ}$$

$$F_{AB} = \frac{\sin 120^\circ}{\sin 135^\circ} \times W_A$$

$$F_{AB} = \frac{\sin 120^\circ}{\sin 135^\circ} \times 2000 = 2449.49 \text{ N}$$

$$\boxed{F_{AB} = 2449.49 \text{ N}}$$

$\Sigma F_x = 0$ & $\Sigma F_y = 0$

$\Sigma F_x = 2449.49 \cos 15^\circ - P \cos 30^\circ - N \cos 45^\circ = 0$

$N \cos 45^\circ = 2449.49 \cos 15^\circ - P \cos 30^\circ \qquad \rightarrow (1)$

$\Sigma F_y = -1000 - P \cos 60^\circ - 2449.49 \cos 75^\circ + N \cos 45^\circ = 0$

$N \cos 45^\circ = 1000 + 2449.49 \cos 75^\circ - P \cos 60^\circ$

$N \cos 45^\circ = 1633.97 - P \cos 60^\circ \qquad \rightarrow (2)$

Eqn (2) – Eqn (1) $\Rightarrow$

$P(\cos 60^\circ + \cos 30^\circ) + 1633.97 - 2366 = 0$

$$P = \frac{732.03}{1.366}$$

$$\boxed{P = 535.89 \ N}$$

2	**Determine the tension in cable BC as shown in Fig.12.a. Neglect the self-weight of AB.**

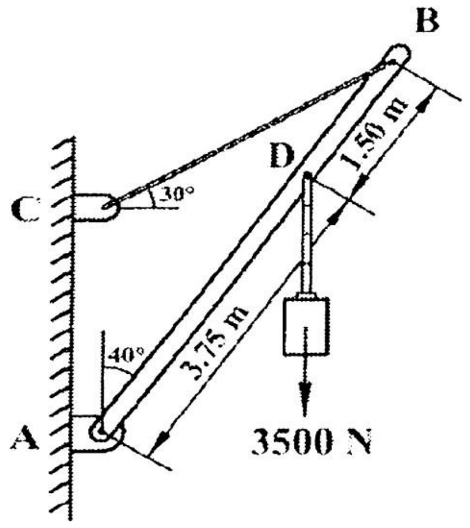
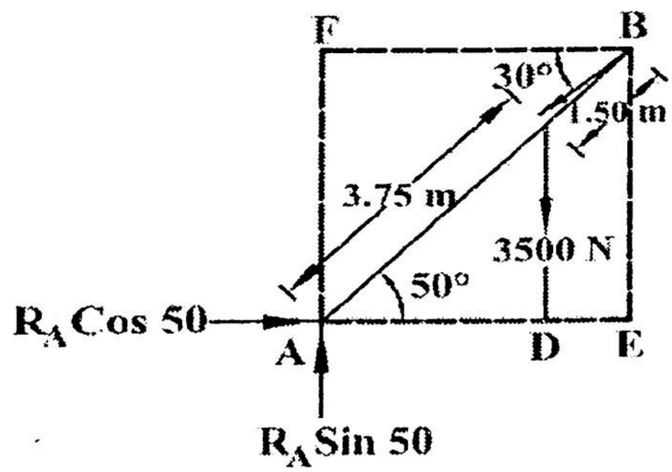


Fig.12a

BTL4 (May 2014)



Free body diagram of boom

$\Sigma M_A = 0$

$(3500 \times AD) + (F_{BC} \text{ Sin}30^\circ \text{ AE}) - (F_{BC} \text{ Cos } 30 \times BE) = 0$

$AD = 3.75 \times \text{Cos } 50^\circ = 2.410 \text{ m}$

$AE = 5.25 \times \text{Cos } 50^\circ = 3.375 \text{ m}$

$AF = BE = 5.25 \times \text{Sin } 50^\circ = 4.022 \text{ m}$

$(3500 \times 2.410) + (F_{BC} \text{ Sin } 30^\circ \times 3.375)$

$- (F_{BC} \text{ Cos } 30^\circ \times 4.022) = 0$

$8435 + 1.688 F_{BC} - 3.483 F_{BC} = 0$

$\boxed{F_{BC} = 4699.16 \text{ N}}$

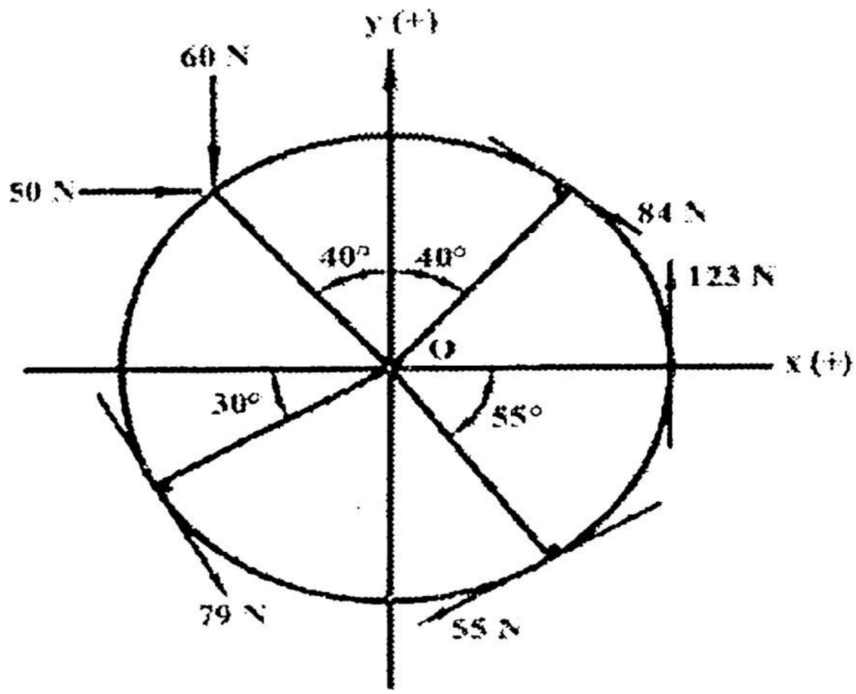
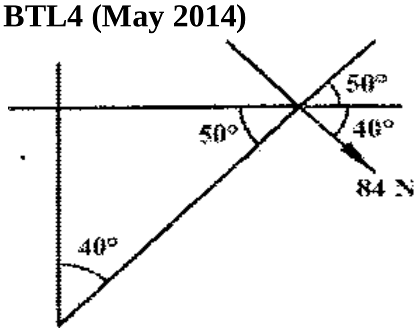
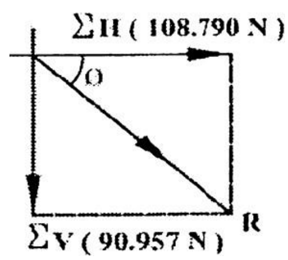
Reaction at A :

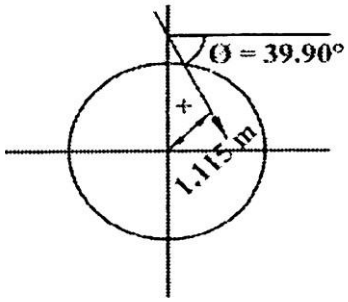
$\Sigma H = 0$

$H_A - F_{BC} \text{ Cos } 30 = 0$

$H_A = F_{BC} \text{ Cos}30^\circ = 4699.16 \times \text{Cos } 30^\circ$

$\boxed{H_A = 4069.59 \text{ N}}$

	$\Sigma V = 0$ $V_A - 3500 - F_{BC}\ \text{Sin}\ 30 = 0$ $V_A - 3500 - (4699.16\ \text{Sin}\ 30^\circ) = 0$ $\boxed{V_A = 5849.58\ N}$ $R = \sqrt{H_A^2 + V_A^2} = \sqrt{4069.59^2 + 5849.58^2}$ $\boxed{R = 7125.95\ N}$ $\alpha = \tan^{-1}\left(\frac{5849.58}{4069.59}\right)$ $\boxed{\alpha = 55.17^\circ}$
3	Find the resultant of the force system shown in Fig. Radius = 2.5 m.  **BTL4 (May 2014)**  



Force	Angle
50	0
60	90
84	40
123	90
55	35
79	60

ΣH = (50 Cos 0) + (60 × Cos 90) + (84 Cos 40)+(123 Cos 90) - (55 × Cos 35) + (79 × Cos 60)

$\boxed{\Sigma H = 108.79 \text{ N}}$

ΣV = 50 Sin 0 - 60 Sin 90 - 84 Sin 40 +123 Sin 90 -55 Sin 35 -79 Sin60

$\boxed{\Sigma V = -90.957 \text{ N}}$

$$R = \sqrt{\Sigma H^2 + \Sigma V^2} = \sqrt{108.79^2 + (-90.957)^2}$$

$\boxed{R = 141.80 \text{ N}}$

$$\alpha = \tan^{-1}\left(\frac{\Sigma_V}{\Sigma_H}\right) = \tan^{-1}\left(\frac{+90.957}{108.79}\right)$$

$\boxed{\alpha = 39.90°}$

Location of Resultant force :

$\Sigma M = 0$ at centre

ΣM_O = (50 × r Cos 40) – (60 × r Sin 40) + (84 × r) – (123 × r) + (55 × r) – (79 × r)

r = 2.5 m

ΣM_O = (50 × 2.5 Cos 40) – (60 × 2.5 Sin 40) + (84 × 2.5) – (123 × 2.5) + (55 × 2.5) – (79 × 2.5)

= -158.163 Nm

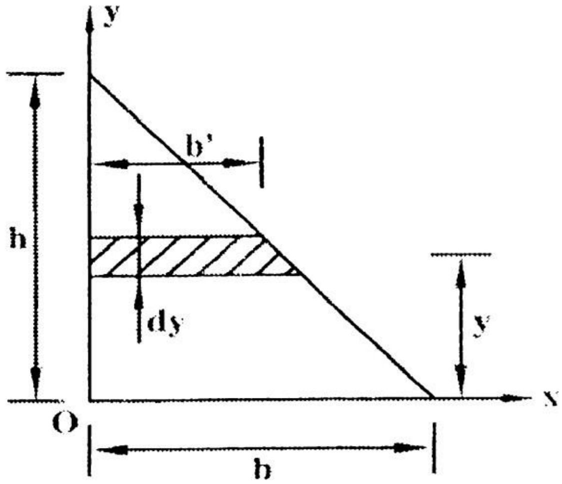
ΣM_O = –158.163 Nm (Anticlockwise)

	Using Varignon's Theroem, $\Sigma M_O = R \times X$ $X = \frac{\Sigma M_O}{R} = \frac{158.163}{141.80}$ $\boxed{X = 1.115 \text{ m}}$

UNIT III PROPERTIES OF SURFACES AND SOLIDS	
Centroids and centre of mass – Centroids of lines and areas - Rectangular, circular, triangular areas by integration – T section, I section, - Angle section, Hollow section by using standard formula –Theorems of Pappus - Area moments of inertia of plane areas – Rectangular, circular, triangular areas by integration – T section, I section, Angle section, Hollow section by using standard formula – Parallel axis theorem and perpendicular axis theorem – Principal moments of inertia of plane areas – Principal axes of inertia-Mass moment of inertia –mass moment of inertia for prismatic, cylindrical and spherical solids from first principle – Relation to area moments of inertia.	
PART * A	
Q.No.	**Questions**
1	**Differentiate between center of gravity and centroid. BTL4 (May 2017)** Centre of gravity is the physical property of a body like wire, rod, disc and solids. Centroid is the geometric property of geometrical figures line, area and volume.
2	**State parallel axis theorem as applied to area Moment of Inertia. BTL1 (May 2017, Dec 2014)** If states that the moment of inertia of a plane area about any axis is the sum of the moment of inertia of the area about the axis passing through the Centroid of the area parallel to the given axis and the product of the area of the plane and the square of the perpendicular distance of its centroid from the axis. $I_{XX} = I_{GG} + Ah^2$
3	**State Pappus-Guldinus theorem. BTL1 (May 2016)** Theorem I: The area of surface of revolution obtained by revolving a line or curve is equal to the length of the generating line or curve multiplied by the distance travelled by the centroid of the generating line/curve when it is being rotated. Theorem 2: The volume of a body obtained by revolving an area is equal to the generated area multiplied by the distance travelled by the centroid of the generating area when it is being rotated.
4	**When will the product of inertia of an area become zero? BTL2 (May 2016)** • Product of inertia “I” is zero when x axis or y axis or both the x and y axes are axes of symmetry for the given area. • Product of inertia of the given area with respect to its principal axes is zero.
5	**A right angled triangle of base 3 m and height 4 m is revolved about its 4 m vertical edge. Compute the volume of the solid generated. BTL3 (Dec. 2015)** Volume generated = $(\frac{1}{2} \times 3 \times 4) \times 2 \times \pi \times 1 =$ **37.7 m^3**
6	**Write an expression for the radius of gyration of an area. BTL2 (Dec. 2015)**

	A gyration means rotation. Hence, radius of gyration means radius of rotation. Radius of gyration 'k' is the distance from the axis of rotation to the point where the entire area may be assumed to be concentrated. $I = Ak^2$; $k = \sqrt{\frac{I}{A}}$
7	**Find the radius of gyration of a rectangular area of MI about its base 9 x 10^4 cm^4 and cross sectional area 300 cm^2. BTL3 (May 2015, May 2013)** $k = \sqrt{\frac{I}{A}} = \sqrt{\frac{9\times10^4}{300}} =$ 17.32 cm
8	**State perpendicular axis theorem. BTL2 (May 2015)** It states that moment of inertia of a plane area about an axis perpendicular to the area is equal to the sum of the moments of inertia of the area about two mutually perpendicular axes passing through the point where the perpendicular axis meets the plane area. $I_z = \sum m(x^2 + y^2) = \sum mx^2 + \sum my^2 = I_x + I_y$
9	**Define principle moments of inertia. BTL1 (Dec. 2014)** The maximum moment of inertia I_{max} and the minimum moment of inertia I_{min} of an area about a given point are called the principal moments of inertia of the area about the given point. These maximum and minimum moment of inertia values correspond to the principal axes of the area about the give point.
10	**Define centroid. BTL1 (May 2014)** Centroid is the point at which the entire area of the figure is assumed to be concentrated.
11	**Define Polar moment of inertia. BTL1 (May 2014)** Moment of inertia of an area about an axis perpendicular to the area through a pole point in the area is called polar moment of inertia. $I_P = I_{xx} + I_{yy}$
12	**When will the centroid and centre of mass coincides? BTL2 (May 2013)** Centriod and centre of mass coincide if the density of the material is uniform throughout the body.
13	**Given that the volume of hemisphere of radius r as 2/3 πr^3, find the position of the C.G. of a quarter circle by using Pappus – Guildinus theorem. BTL3** Volume generated = Area of quarter circle x distance travelled by its C.G. while being revolved. $\frac{2}{3}\pi r^3 = \frac{\pi r^2}{4} \times 2\pi \times x$ $x = \frac{2}{3}\frac{\pi r^3}{2\pi} \times \frac{4}{\pi r^2} = \frac{4r}{3\pi}$

14	**Using the theorem of Pappus, find the volume of a right circular cone of base radius r and height h. BTL3** Volume of the cone = Area $\times 2\pi\bar{y} = \left(\frac{1}{2} \times h \times r\right) \times 2\pi \times \frac{r}{3} = \frac{1}{3}\pi r^2 h$
15	**By using the Pappus theorem, determine the volume of sphere having radius r. BTL3 (May 2001)** $V = 2\pi\bar{y}A = 2\pi\left(\frac{4r}{3\pi}\right) \times \frac{\pi r^2}{2} = \frac{4\pi r^3}{3}$
16	**Knowing that the surface area of a sphere of radius 'r' is equal to $4\pi r^2$, determine the centroid of a line in the form of semicircular arc. BTL3 (Nov 97, May 99)** $4\pi r^2 = \pi r \times \bar{x} \times 2\pi$ $\bar{x} = \frac{4\pi r^2}{\pi r \times 2\pi} = \frac{2r}{\pi}$
17	**When centroid and centre of mass coincide? BTL2** Centroid and centre of mass coincide when the density of the material is uniform throughout the body.
18	**Write the expressions to find centroid of a composite plane figure? BTL2** X = sum of first moment of the area about y axis/Total area $= a_1 x_1 \pm a_2 x_2 \pm / a_1 \pm a_2$ y = sum of first moment of the area about y axis/Total area $= a_1 y_1 \pm a_2 y_2 \pm / a_1 \pm a_2$
19	**State the methods of determining the centre of gravity? BTL1** • By Geometrical considerations • Graphical method • Integration method • Method of moments
20	**Define moment of inertia of a body. BTL1** Moment of inertia (I) about an axis is the algebraic sum of the products of the elements of mass and the square of the distance of the respective element of mass from the axis.
	PART * B
1	**Determine the location of centroid for the right angle triangle from the first principles and find the volume of cone using Pappus – Guildness theorem. BTL4 (May 2018)**



Consider a right angled triangle with height 'h' and base 'b'.

To find $\bar{y}$**:** Consider a strip 'b' at a distance y from the x axis.

Let 'dy' be its elemental height.

$$dA = b'\ dy$$

$$\frac{b}{h} = \frac{b'}{(h-y)}$$

$$\therefore b' = \frac{b}{h}(h-y)$$

$$dA = \left(\frac{b}{h}\right)(h-y)\,dy$$

$$A = \int_0^h \left(\frac{b}{h}\right)(h-y)\,dy = \left(\frac{b}{h}\right)\left(hy - \frac{y^2}{2}\right)_0^h = \left(\frac{bh}{2}\right)$$

Total first moment of area about x-axis.

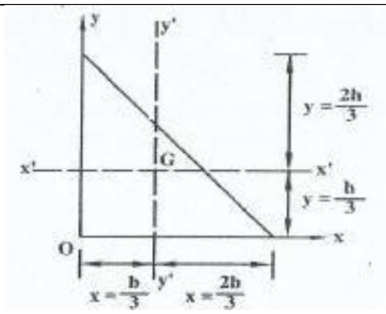
$$\int_0^h y.dA = \int_0^h \left(\frac{b}{h}(h-y)\,dy\right)$$

$$= \left(\frac{b}{h}\right)\int_0^h (hy - y^2)dy = \left(\frac{b}{h}\right)\left(\frac{hy^2}{2} - \frac{y^3}{3}\right)_0^h = \frac{bh^2}{6}$$

$$\therefore \bar{y} = \frac{\int dAy}{\int dA} = \left(\frac{bh^2/6}{bh/2}\right) = \frac{h}{3}$$

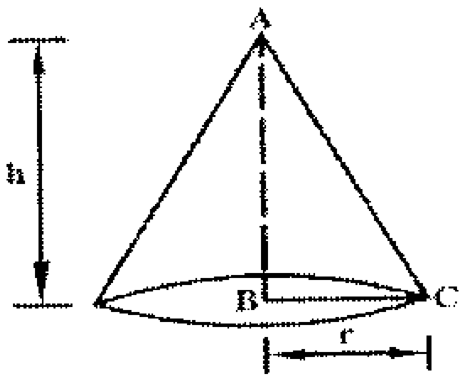
$$\boxed{\bar{y} = \frac{h}{3}}$$

Similarly we can find out the $\boxed{\bar{x} = \frac{b}{3}}$



Solution 2:

Let 'r' and 'h' be the base and height of right angled triangle.



$\therefore$ Generating area $= = \frac{1}{2}rh$

Distance of centroid from fixed axis $= \bar{x} = \frac{r}{3}$

Distance travelled by centroid $= 2\pi\bar{x} = 2\pi \times \left(\frac{r}{3}\right) = \frac{2}{3}\pi r$

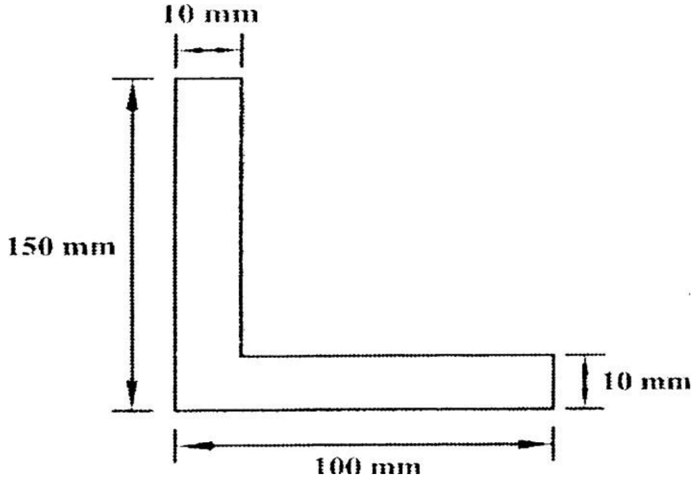
Applying Pappus – Guldinus theorem II,

Volume generated = Distance travelled by centroid of area $\times$ Generating area

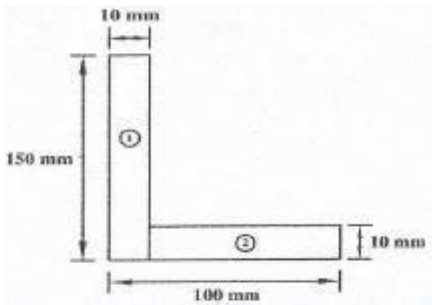
$$= \left(\frac{2}{3} \times r\right) \times \left(\frac{1}{2} rh\right)$$

$$\boxed{v = \frac{1}{3}\pi r^2 h}$$

2 **Calculate the moment of inertia of the section shown in Fig. about "x" and "y" axes through the centroid.**



BTL4 (May 2018)



$$a_1 = 150\times 10 = 1500 \text{ mm}^2$$

$$a_2 = 90\times 10 = 900 \text{ mm}^2$$

$$x_1 = \frac{10}{2} = 5\text{mm} \quad ; \qquad y_1 = \frac{150}{2} = 75\text{mm}$$

$$x_2 = 10 + \frac{90}{2} = 55\text{mm}; \quad y_2 = \frac{10}{2} = 5\text{mm}$$

$$\bar{x} = \frac{a_1x_1 + a_2x_2}{a_1 + a_2} = \frac{(1500\times 5)+(900\times 55)}{1500+900} = \frac{57000}{2400} = 23.75\text{mm}$$

(from left end)

$$\bar{x} = \frac{a_1y_1 + a_2y_2}{a_1 + a_2} = \frac{(1500\times 75)+(900\times 5)}{1500+900} = \frac{117000}{2400} = 48.75\text{mm}$$

(from bottom)

$$I_{xx} = \left(\frac{10\times 150^3}{12}\right) + 1500\times(75 - 48.75)^2 + \left(\frac{90\times 10^3}{12}\right)$$

$$+ 900\times(5 - 48.75^2)$$

$$= 2.813\times 10^6 + 1.034\times 10^6 + 7500 + 1.723\times 10^6$$

$$\boxed{I_{xx} = 5.578\times 10^6 \text{ mm}^4}$$

$$I_{yy} = \left(\frac{150\times10^3}{12}\right) + 1500\times(5-23.75)^2$$

$$+\left(\frac{10\times90^3}{12}\right) + 900\times(55-23.75)^2$$

$$= 12.5\times10^3 + 527.34\times10^3 + 607.5\times10^3 + 878.91\times10^3$$

$$\boxed{I_{yy} = 2.026\times10^6\ \text{mm}^4}$$

Answers:

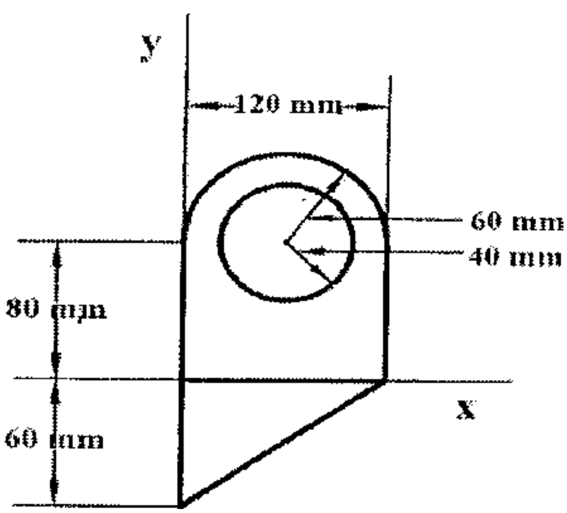
1. **Moment of inertia about xx axis of given L section**

   $I_{xx} = 5.578\times10^6\ \text{mm}^4$

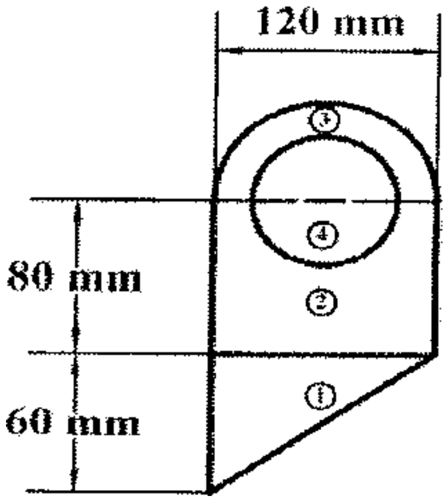
2. **Moment of inertia about yy axis of given L section**

   $I_{yy} = 2.026\times10^6\ \text{mm}^4$

3 **Locate the centroid for the area shown in Fig.**



BTL4 (May 2016)



For Triangle:

$$a_1' = \tfrac{1}{2}\, bh = \tfrac{1}{2} \times 120 \times 60 = 3600 mm^2$$

$$y_1 = \frac{2}{\cancel{3}} \times \overset{20}{\cancel{60}} = 40mm \quad ; \quad x_1 = \frac{1}{\cancel{3}} \times \overset{40}{\cancel{120}} = 40mm$$

For Rectangle:

$$a_2 = 120 \times 80 = 9600 mm^2$$

$$y_2 = 60 + \frac{80}{2} = 100mm \quad ; \quad x_2 = \frac{120}{2} = 60mm$$

For Semicircle :

$$a_3 = \frac{1}{2} \times \frac{\pi}{4} \times 120^2 = 5654.88 mm^2$$

$$y_3 = 60 + 80 + \left(\frac{4}{3\pi} \times 60\right) = 165.46mm \; ; \; x_3 = \frac{120}{2} = 60mm$$

For circle:

$$a_4 = \frac{\pi}{4} \times 80^2 = 5026.56 mm^2$$

$$y_4 = 60 + 80 = 140mm \quad ; \quad x_4 = 20+40 = 60mm$$

$$\bar{x} = \frac{a_1y_1 + a_2y_2 + a_3y_3 - a_4y_4}{a_1 + a_2 + a_3 - a_4}$$

$$= \frac{((3600\times40) + (9600\times100) + (5654.88\times165.46) - (5026.56\times140))}{3600+9600+5654.88-5026.56}$$

$$\bar{x} = \frac{1.3359\times10^6}{13.828\times10^3}$$

$$\boxed{\bar{x} = \textbf{96.608 mm (from bottom)}}$$

$$\bar{x} = 200 - 96.608 = 103.392 \text{ mm (from top)}$$

$$\bar{y} = \frac{a_1x_1 + a_2x_2 + a_3x_3 - a_4x_4}{a_1 + a_2 + a_3 - a_4}$$

$$= \frac{(3600 \times 40) + (9600\times60) + (5654.88\times60) - (5026.56\times60)}{3600+9600+5654.88-5026.56}$$

$$\bar{y} = \frac{757.699\times10^3}{13.828\times10^3}$$

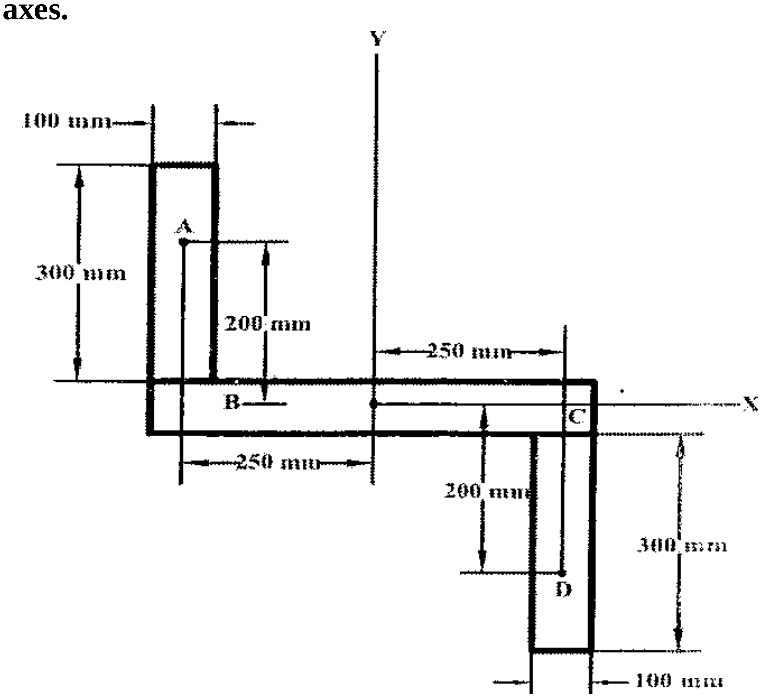
$$\boxed{\bar{y} = 54.793 \text{ mm (from left)}}$$

$$\bar{y} = 120 - 54.793 = 65.207 \text{ mm (from right)}$$

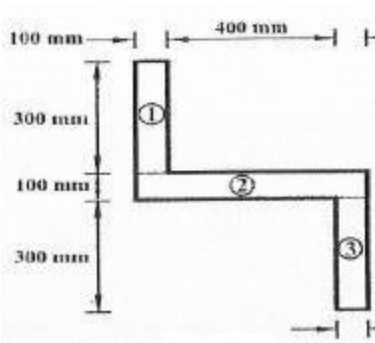
Answers

1. Distance of the centroid $\bar{x}$ = 96.608mm (from bottom)
2. Distance of the centroid $\bar{y}$ = 54.793mm (from left)

4 **Determine the moment of inertia for the area shown in Fig. about the centroidal x and y axes.**



BTL4 (May 2016, Nov 2015)



$$\bar{x} = \frac{600}{2} = 300mm$$

$$\bar{y} = \frac{700}{2} = 350mm$$

MI about the x centroidal axis:

MI = (1) + (2) + (3)

$$= \frac{(100\times300)^3}{12} + (100\times300\times(350-150)^2) +$$

$$\frac{(600\times100^3)}{12} + (600\times100\times0)$$

$$+ \frac{(100\times300^3)}{12} + (100\times300\times(350-150)^2)$$

$$\boxed{MI_X = 2.90\times10^9\ mm^4}$$

MI about the y centroidal axis:

$$MI = (1)+(2)+(3) = \frac{(300\times100^3)}{12} + (100\times300\times(300-50)^2) +$$

$$\frac{(100\times600^3)}{12} + (600\times100\times0) +$$

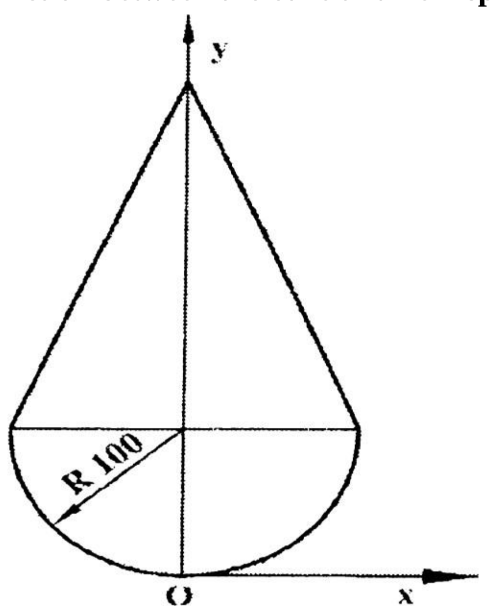
$$\frac{(300\times100)^3}{12} + (100\times300\times(300-50)^2)$$

$$\boxed{MI_y = 5.60\times10^9\ mm^4}$$

Answers :

1. MI about centroidal x axis = 2.90×10^9 mm^4
2. MI about centroidal y axis = 5.60×10^9 mm^4

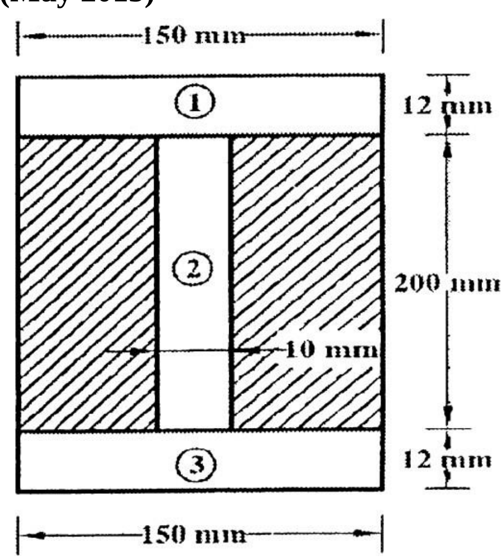
5 **A cone of base diameter 200 mm is fitted to a hemisphere of diameter 200 mm centrally. What should be the height of cone so that the centroid of the solid combination lies at the junction between the cone and hemisphere?**

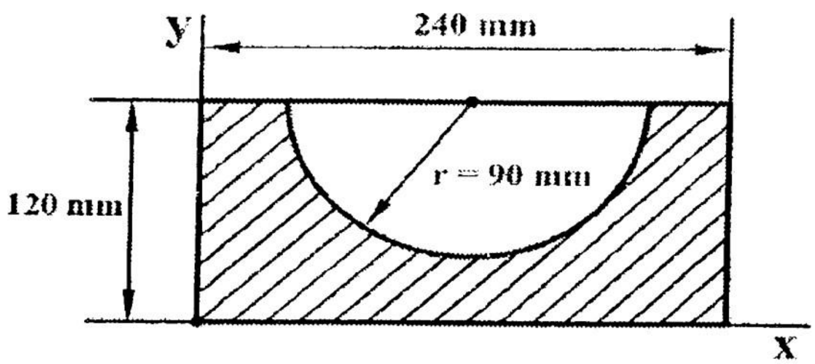
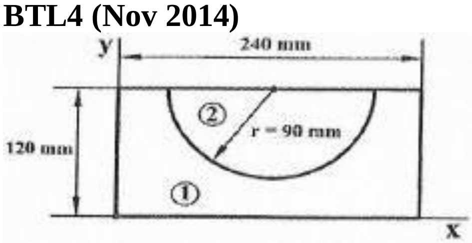


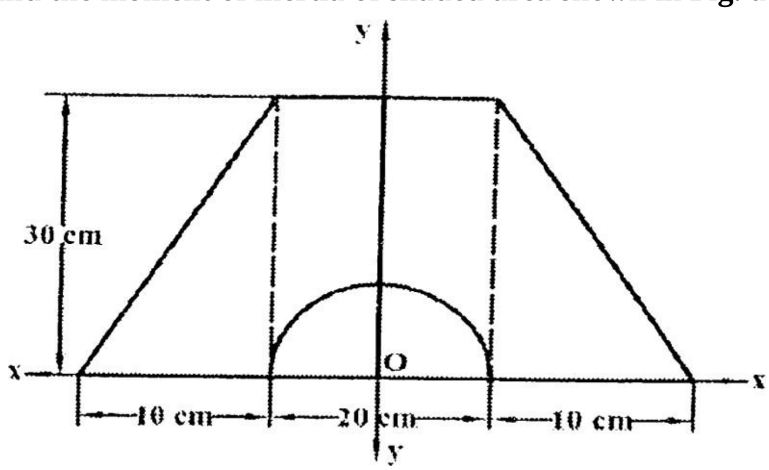
BTL4 (Nov 2015)

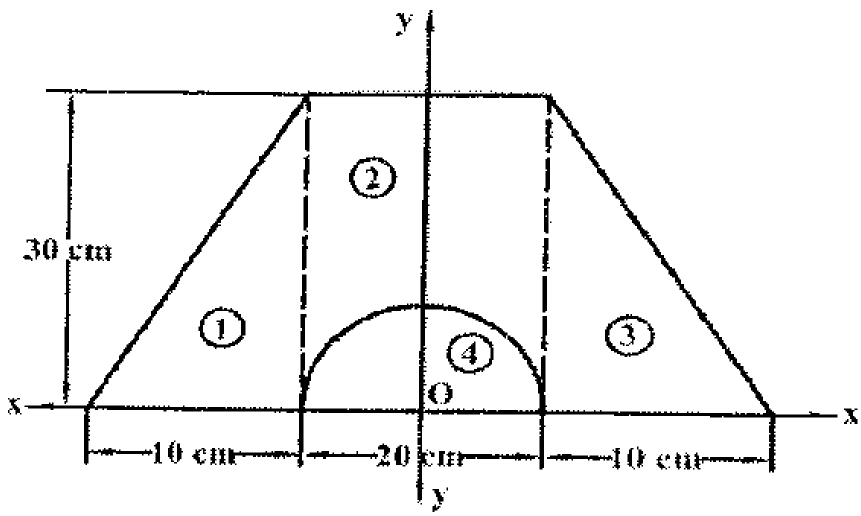
It is given that the height of the centroid above

$$O_X = \bar{y} = 100\ mm$$

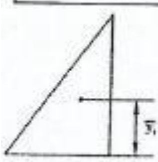
	First moment of volumes : First moment of hemisphere $O_X = \frac{2}{3} \times \pi \times r^3 \times (100 - \frac{3}{8} \times 100)$ $= \frac{2}{3} \times \pi \times 100^3 \times 62.50$ $= 130.90 \times 10^6 \text{ mm}^4$ First moment of cone about $O_X = \frac{1}{3} \pi r^2 h (100+\frac{h}{4})$ $= \frac{1}{3} \times \pi \times 100^2 \times h \times (100+\frac{h}{4})$ $= 10.472 \times 10^3 \times h \times (100+\frac{h}{4})$ $\overline{y} = 100\text{mm}$ $\therefore 100 = \frac{130.90 \times 10^6 + (10.472\times10^3) \times h \times (100+\frac{h}{4})}{(\frac{2}{3}\times\pi\times100^3) + (\frac{\pi}{3}\times100^2\times h)}$ $100 = \frac{130.90 \times 10^6 + (10.472\times10^3 \times h \times \frac{1}{4}(400+h)}{(2.094\times10^6) + (10.472\times10^3 \times h)}$ $(2.094 \times 10^8) + (10.472 \times 10^5 \times h) - (130.90\times10^6)$ $= 2.618 \times 10^3 \times h\ (400+h)$ $\frac{78.50\times10^6 + (10.472\times10^5 \times h)}{(2.618\times10^3)} = 400h + h^2$ $29.985 \times 10^3 + 400h = 400h + h^2$ $\therefore h^2 = (29.985 \times 10^3) + 400h - 400h$ $\boxed{h = 173.16\text{mm}}$
6	**Find the MI of an I section abut XX and YY axes through its centroid. Dimensions are: Top flange: 150 mm x 12 mm; Web: 200 mm x 10 mm, Bottom flange : 150 mm x 12 mm. BTL4 (May 2015)** 

	Given section is symmetrical about *xx* and *yy* axis. $\therefore \bar{x} = \frac{224}{2} = 112mm \; ; \; \bar{y} = \frac{150}{2} = 75mm$ $I_{xx} = \frac{150 \times 224^3}{12} - \frac{(150-10)\times 200^3}{12}$ $\mathbf{I_{xx} = 47.159\times10^6 \ mm^4}$ $I_{yy} = \frac{224\times150^3}{12} - \frac{200\times150^3}{12} + \frac{200\times10^3}{12}$ $\mathbf{I_{yy} = 6.767\times10^6 \ mm^4}$ (or) $I_{xx} = \frac{150\times12^3}{12} + (150\times12\times106^2) + \left(\frac{10\times200^3}{12}\right) + (10\times200\times0) + \left(\frac{150\times12^3}{12}\right) + (150\times12\times106^2)$ $\mathbf{I_{xx} = 47.159\times10^6 \ mm^4}$ $I_{yy} = \frac{12\times150^3}{12} + \frac{200\times10^3}{12} + \frac{12\times150^3}{12}$ $\mathbf{I_{yy} = 6.767\times10^6 \ mm^4}$ **Answers:** **1. I_{xx} of the given section = 47.159×10^6 mm^4** **2. I_{yy} of the given section = 6.766×10^6 mm^4**
7	**Determine the moment of inertia of the shaded area as shown in Fig with respect to the x-axis.**  **BTL4 (Nov 2014)** 

	Portion 1: Rectangle $A_1 = 120 \times 240 = 28800\ cm^2$ $x_1 = \frac{240}{2} = 120mm$ $y_1 = \frac{120}{2} = 60mm$ **Portion 2 : Semicircle** $A_2 = \frac{\pi r^2}{2} = \frac{\pi \times 90^2}{2}$ $A_2 = 12723.45mm^2$ $x_2 = 120mm$ $y_2 = 120 - \frac{4r}{3\pi} = 120 - \frac{4 \times 90}{3\pi}$ $\boxed{y_2 = 81.80mm}$ $\bar{x} = \frac{(28800 \times 120) - (12723.45 \times 120)}{28800 - 12723.45}$ $\bar{x} = 120mm$ $\bar{y} = \frac{(28800 \times 60) - (12723.45 \times 81.80)}{28800 - 12723.45}$ $\bar{y} = 42.75\ mm$ **Moment of inertia about *xx* axis:** $I_{xx} = I_{xx1} - I_{xx2}$ $I_{xx} = \left(\frac{240 \times 120^3}{12}\right) + (28800 \times (42.75 - 60)^2)$ $- (0.11 \times 90^4) - (12723.45 \times (42.75 - 81.80)^2)$ $\boxed{I_{xx} = 16.511 \times 10^6\ mm^4}$
8	**Find the moment of inertia of shaded area shown in Fig. about I_{xx} axis and I_{yy} axis.**  **BTL4 (May 2014)**



$\boxed{I_{xx1} = 22500\ \text{cm}^4}$; $\therefore\ I_{xx1} = I_{xx3}$

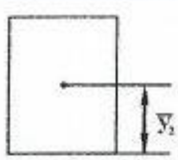


$\bar{y}_1 = 30/3 = 10$ cm

$$I_{xx2} = \left(\frac{bh^3}{12}\right) + A_2\,\bar{y}_2^{\,2}$$

$$= \left(\frac{20\times 30^3}{12}\right) + (20 \times 30 \times 15^2)$$

$$\boxed{I_{xx2} = 180 \times 10^3\ \text{cm}^4}$$



$\bar{y}_2 = 30/2 = 15$ cm

$$I_{xx4} = 0.0068\text{d}^4 + A_4\,\bar{y}_4^{\,2}$$

$$= (0.0068 \times 20^4) + \left(\frac{\pi}{4} \times 20^2 \times \tfrac{1}{2} \times 4.244^2\right)$$

$$I_{xx4} = 3.917 \times 10^3\ \text{cm}^4$$

$$I_{xx4} = 22500 + 180 \times 10^3 + 22500 - 3.917 \times 10^3$$

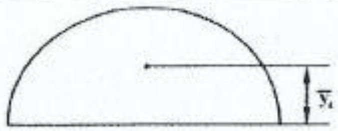
$$\boxed{Ixx = 221.083 \times 10^3\ \text{cm}^4}$$

$I_{yy} = (I_{yy})_1 + (I_{yy})_2 + (I_{yy})_3 - (I_{yy})_4$

$I_{yy1} = \frac{(hb^3)}{36} + A_1 \bar{x}_1^2$; $\bar{x}_1 = 20 - (2/3 \times 10) = 13.33\text{cm}$

$= \left(\frac{30 \times 10^3}{36}\right) + (½ \times 30 \times 10 \times 13.33^2)$

$\boxed{I_{yy1} = 27.487 \times 10^3 \text{ cm}^4}$ $\therefore I_{yy1} = I_{yy3}$



$I_{yy2} = \left(\frac{bh^3}{12}\right) + A_2 \bar{x}_2^2$; $\bar{x} = 20 - (10 + \frac{20}{2}) = 0$

$= \left(\frac{30 \times 20^3}{12}\right) + 0$

$\boxed{I_{yy2} = 20000 \text{ cm}^4}$

PART * C

1 **(i)** **A solid hemisphere of density 2 ρ is attached centrally to a solid cylinder of density ρ. Find the height of the cylindrical portion to have the CG of the solid combination on the axis of symmetry at the junction between the hemisphere and the cylinder. Take the cylinder diameter as 100 mm. (11)**

(ii) **Find the polar moment of inertia of a hollow circular section of outer diameter 80 mm and inner diameter 40 mm about an axis through its centroid. (4) BTL4 (May 2015)**

Weight of the hemisphere

$= \frac{2}{3} \pi r^3 \times 2\rho \times g$

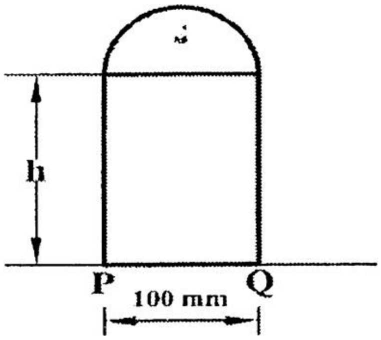
$= \frac{4}{3} \times \pi \times 50^3 \rho g$

First moment of the weight of the hemisphere about PQ

$= \frac{4}{3} \times \pi \times 50^3 \rho g \left[h + \frac{3}{8} \times 50\right]$

Weight of the cylinder = $\pi r^2 h \rho g$

$= \pi \times 50^2 \times h \rho g$



First moment of the weight of the cylinder about PQ

$$= \frac{\pi}{2} \times 50^2 \times h^2 \rho g$$

$$h = \frac{\Sigma \text{ First moment about } PQ}{\Sigma \text{ Weight}}$$

$$h = \frac{\frac{4}{3}\pi \times 50^3 \rho g \left[h + \frac{150}{8}\right] + \frac{\pi}{2} \times 50^2 \times h^2 \rho g}{\frac{4}{3} \times \pi\, 50^3 \rho g + \pi \times 50^2 \times h \times \rho g}$$

$$\frac{4}{3}\pi \times 50^3 \rho g\, h + \pi \times 50^2 \times h^2 \rho g =$$

$$\frac{4}{3}\pi \times 50^3 \rho g\, h + \frac{4}{3}\pi \times 50^3 \rho g \times \frac{(3\times 50)}{80}$$

$$+ \frac{\pi \times 50^2 \times h^2 \rho g}{2}$$

$$\frac{\pi \times 50^2 \times h^2 \rho g}{2} = \frac{4}{3}\pi \times 50^3 \rho g \times \frac{3\times 50}{8}$$

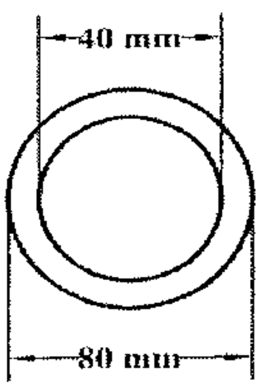
$$h^2 = 50^2$$

$$\boxed{h = 50\text{mm}}$$

Answer :

The limiting height of the cylinder is 50mm when the C.G lies at the junction between the hemisphere and the cylinder.

(ii)



$J_{centroid} = I_{x\ centroid} + I_{y\ centroid}$

$I_x = I_y = \frac{\pi}{64} \times (80^4 - 40^4)$

$= 1.885 \times 10^6\ mm^4$

$J_{centroid} = 2 \times 1.885 \times 10^6 = 3.77 \times 10^6 mm^4$

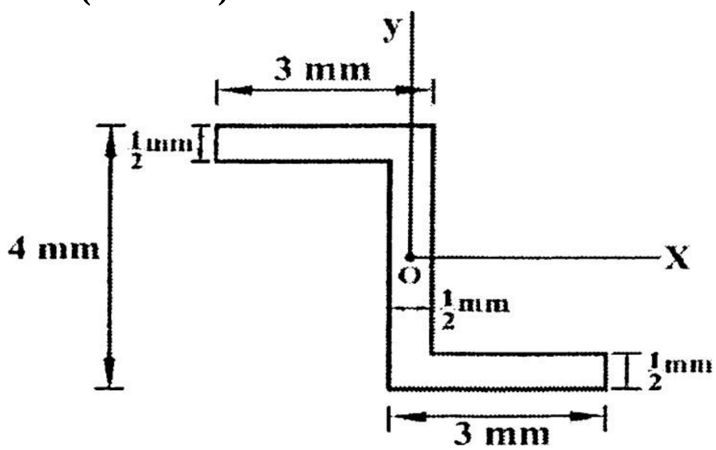
Answer : Polar moment of inertia of the hollow circular section = $3.77 \times 10^6\ mm^4$

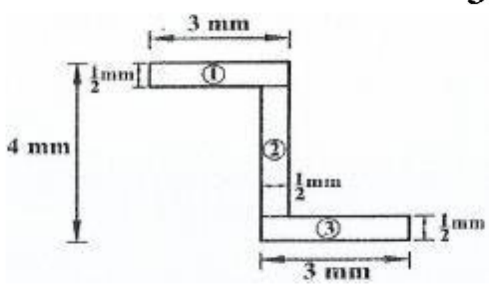
2 **For the section shown in Fig., the moment of inertia with respect to the x and y axes have been computed and are known to be Ix = 10.38 mm^4, Iy = 6.97 mm^4. Determine:**

(i) The orientation of the principal axes of the section about O. (8)

(ii) The values of the principal moments of inertia of the section about O. (7)

BTL4 (Nov.2014)





$I_{xx} = 10.38 mm^4$; $I_{yy} = 6.97 mm^4$

The given section is symmetry about x and y axis

$\bar{x} = 2.75mm$; $\bar{y} = 2mm$

Rectangle	A (mm^2)	X_1 (mm)	y_1 (mm)	$\bar{x}$ (mm)	$\bar{y}$ (mm)	$A\bar{x}\bar{y}$ mm^4
1	1.50	1.50	3.75	−1.25	1.75	−3.281
2	1.50	2.75	2.00	0	0	0
3	1.50	4.00	0.25	1.25	−1.75	−3.281
						−6.562

Product of inertia of the section with respect to x and y axes,

$I_{xy} = -6.562 mm^4$

(i) The orientation of the principle axes of the section about O:

$$\tan 2\theta = \frac{-2 I_{xy}}{I_{xx} - I_{yy}}$$

$$\tan 2\theta = \frac{-2 \times (-6.562)}{10.38 - 6.97} = 3.8486$$

$$2\theta = 75.43^\circ$$

$$\boxed{\theta = 37.72^\circ}$$

(ii) The values of the principal moments of intertia of the section about O :

$$I_{max,\ min} = \left[\frac{I_{xx} + I_{yy}}{2}\right] \pm \sqrt{\left(\frac{I_{xx} - I_{yy}}{2}\right)^2 + I_{xy}^{\ 2}}$$

$$= \left[\frac{10.38 + 6.97}{2}\right] \pm \sqrt{\left(\frac{10.38 - 6.97}{2}\right)^2 + (-6.562)^2}$$

$$= 8.675 \pm \sqrt{2.907 + 43.06}$$

$$I_{max,\ min} = 8.675 \pm 6.78$$

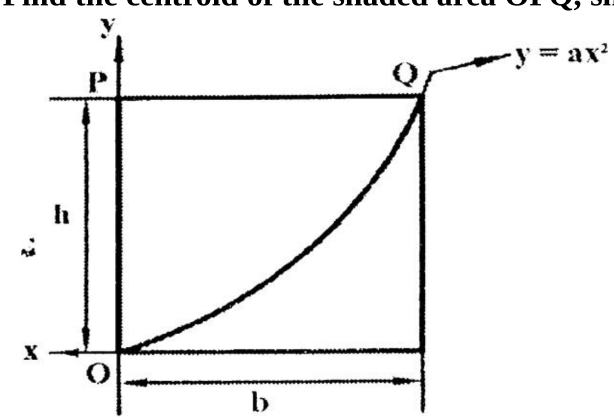
$$I_{max} = 8.675 + 6.78 = 15.455 mm^4$$

$$I_{min} = 8.675 - 6.78 = 1.895 mm^4$$

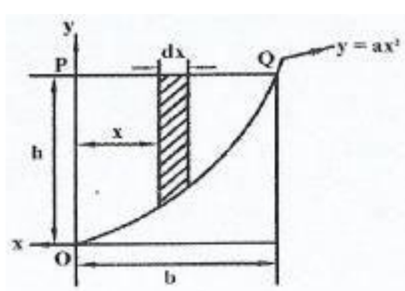
Answers:

1. $\theta = 37.72^\circ$
2. $I_{max} = 15.455 mm^4$
3. $I_{min} = 1.895\ mm^4$

3 **Find the centroid of the shaded area OPQ, shown in Fig. The curve OQ is parabolic.**



BTL4 (May 2014)



$y = ax^2$

$x = b \; ; \; y = h;$

$\therefore \quad h = ab^2; \boxed{a = \frac{h}{b^2}}$

$y = ax^2 \Rightarrow y = \frac{h}{b^2} x^2$

Consider a vertical rectangular strip of thickness dx and height y at a distance of x from oy axis.

Area of the strip, $dA = dx\,(h - y)$

$$A = \int_0^b dA = \int_0^b dx.(h-y) = \int_0^b (h - ax^2)\,dx$$

$$= \left[hx - \frac{ax^3}{3}\right]_0^b$$

$$\boxed{A = hb - \frac{ab^3}{3}}$$

$$\bar{x} = \frac{\int x_g\,dA}{\int dA} = \frac{\int x.dA}{A}$$

$x_g = x + \frac{dx}{2} \Rightarrow$ x since dx is very small.

$$\bar{x} = \frac{\int_0^b x.(h-y).dx}{\left[hb - \frac{ab^3}{3}\right]} \quad [\because dA = dx\,(h - y)]$$

$$= \frac{\int_0^b x.(h-ax^2).dx}{\left[hb - \frac{ab^3}{3}\right]} \quad [\because A = hb - \frac{ab^3}{3}]$$

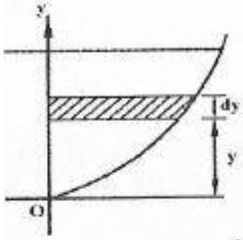
$$= \frac{\left[\frac{hx^2}{2} - \frac{ax^4}{4}\right]_0^b}{\left[hb - \frac{ab^3}{3}\right]}$$

$$= \left[\frac{hb^2}{2} - \frac{ab^4}{4}\right] \times \left[\frac{3}{3hb - ab^3}\right]$$

$$= \left[\frac{2hb^2 - ab^4}{4}\right] \times \left[\frac{3}{3hb - ab^3}\right]$$

$$= \frac{3b}{4b}\left[\frac{2hb - ab^3}{3h - ab^2}\right]$$

$$\boxed{\bar{x} = \frac{3b}{4}\left[\frac{2h - ab^2}{3h - ab^2}\right]}$$



$$\bar{y} = \frac{\int y_S . dA}{A}$$

$y_S = y + \frac{dy}{2} \Rightarrow y$ since dy is very small

$$y = ax^2$$

$$x = \sqrt{y/a} = \frac{1}{\sqrt{a}} \sqrt{y}$$

$$\bar{y} = \frac{\int_0^h y \frac{1}{\sqrt{a}} \sqrt{y} . dy}{\int_0^h \frac{1}{\sqrt{a}} \sqrt{y}\ dy} = \frac{\int_0^h y^{3/2} \frac{1}{\sqrt{a}}\ dy}{\int_0^h \frac{1}{\sqrt{a}} \sqrt{y}\ dy}$$

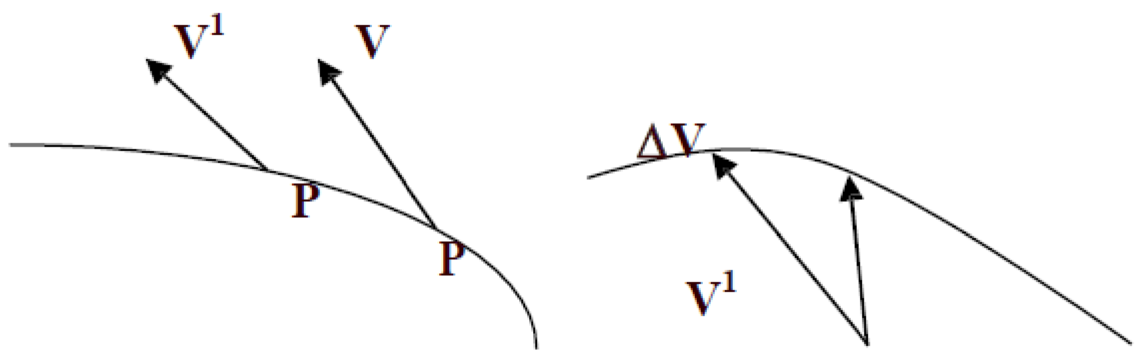
$$= \frac{\frac{1}{\sqrt{a}} \int_0^h y^{3/2}\ dy}{\frac{1}{\sqrt{a}} \int_0^h y^{1/2}\ dy} = \frac{\left[\frac{y^{5/2}}{5/2}\right]_0^h}{\left[\frac{y^{3/2}}{3/2}\right]_0^h} = \frac{(\frac{2}{5}) \times h^{5/2}}{(\frac{2}{3}) \times h^{3/2}}$$

$$= \left(\frac{3}{5}\right) \times \left[\frac{h^{3/2+1}}{h^{3/2}}\right] = \left(\frac{3}{5}\right) \times \left[\frac{h^{3/2}\ h^1}{h^{3/2}}\right]$$

$$\boxed{\bar{y} = \left(\frac{3}{5}\right) h}$$

UNIT IV DYNAMICS OF PARTICLES	
Displacements, Velocity and acceleration, their relationship – Relative motion – Curvilinear motion - Newton's laws of motion – Work Energy Equation– Impulse and Momentum – Impact of elastic bodies.	
PART * A	
Q.No.	**Questions**
1	**The displacement of a particle is given by S = 3 t^2 +2t meters. Where 't' is in seconds? Find the velocity and acceleration when t= 10 seconds. BTL3 (May 2017)** S = 3 t^2 +2t $$\frac{ds}{dt} = 6t + 2 \quad \frac{d^2s}{dt^2} = 6$$ Velocity = 6 x 10 +2 = 62 m/sec Acceleration = 6 m/sec^2
2	**State the principle of work-energy. BTL1 (May 2017)** The principle of Work and energy on work energy equation is written as Work done = Final Kinetic energy — initial Kinetic energy
3	**State D'Alembert's principle. BTL1 (May 2016)** The external forces including the self weight acting on any rigid body are equivalent to the effective forces of the various particular contained in the body.
4	**What happens if two perfectly elastic bodies are in impact? BTL1 (May 2016)** When two perfectly elastic bodies are in impact they repel each other without the loss of total momentum.
5	**A train running at 80 km/hr is brought to a standing halt after 50 seconds. Find the retardation. BTL3 (Dec. 2015)** v= u+at; 0 = 22.24+ (a x 50) ; **a = -0.445 m/s^2**
6	**What is dynamic equilibrium? BTL3 (Dec. 2015)** Dynamic equilibrium is an alternative to Newton's second law. It is written in the form of an equation $\sum F - ma = 0$. The vector "ma" is called inertia force or D' Alembert's force.
7	**A particle is projected in to space at an angle of 30^0 to the horizontal at a velocity of 40 m/s. Find the maximum height reached by the projectile. BTL3 (May 2015)** $v^2 = u^2 - 2gH$; v = 0; u = 40 sin 30^0; a =-g $$0 = 20^2 - 2 \times 9.81 \times H$$

	$H = \frac{20^2}{2\times9.81}$ = **20.39 m**
8	**Distinguish between perfectly plastic impact and perfectly elastic impact. BTL4 (May 2015)** In the case of perfectly plastic impact, e == O. This means that there is no period of restitution. The two colliding bodies join together and travel with the same velocity. In the case of perfectly elastic impact e = 1. This means that the relative velocity before the impact is equal to the relative velocity after the impact.
9	**Define Newton's law (second law) of motion. BTL1 (Dec. 2014)** The resultant force acting on a particle is proportional to the acceleration of the particle and this acceleration is in the direction of the resultant.
10	**Give the equation of work energy for a rectilinear motion. BTL2 (Dec. 2014)** Work done = Final Kinetic Energy - Initial Kinetic Energy $\sum F \times S = \frac{W}{2g} \times [v^2 - u^2]$
11	**A motorist is travelling at 90 kmph, when he observes a traffic light 250 m ahead of him turns red. The traffic light is timed in to stay red for 12 sec. If the motorist wishes to pass the light without stopping, just as it turns green, determine** **(a) the required uniform deceleration of the motor and** **(b)the speed of the motor as it passes the traffic light. BTL3 (May 2014)** u = 90 kmph = $\frac{90 \times 1000}{60 \times 60} = 25\ m/sec$ s = 250 m; t =12 sec; (a) The required uniform deceleration of the motor: S = ut + ½ at^2 By substituting the respecxtive values, a = -0.694 m/s^2 (b) The speed of the motor as it passes the traffic light: v = u +at v =16.67 m/s
12	**A car runs with an initial velocity of 30 m/s and uniform acceleration of 3 m/s^2. Find its velocity after 5 seconds. BTL3 (May 2013)** u =30 m/s; a = 3 m/s^2; t = 5 Sec; v = ? v = u + at = 30 + (3 x 5); **v = 45 m/s.**
13	**Write the equations of plane motion? BTL2** • v= u+at

	• $s = ut + ½ at^2$ • $v^2 = u^2+2as$ Where v=Final velocity; u =Initial velocity; a=acceleration; t=time taken for displacement; S=distance travelled.
14	**Write the equations of motion of a body under the force of gravity? BTL2** • $v = u+gt$ • $h = ut + ½ gt^2$ • $v^2=u^2+2gh$
15	**Write the equations of motion of a body against the force gravity? BTL2** • $v = u-gt$ • $h = ut – ½ gt^2$ • $v^2=u^2-2gh$
16	**What is the distance travelled by a body in the n^{th} second of its motion? BTL1** The distance travelled by a body in the n^{th} second of its motion is: u + a/2 (2n-1)
17	**Define Time of Flight? BTL1** The total time taken by a projectile to reach maximum height and return back to the ground is known as time of flight.
18	**State the law of conservation of energy? BTL1** It states that, "The energy can neither be created nor destroyed, though it can be transformed from one form into any of the form in which the energy can exist.
19	**State the principle of conservation of linear momentum. BTL1** It states that, if the resultant force acting on a particle is zero, then the linear momentum of the particle remains constant ie, Final momentum = Initial momentum.
20	**What is hodograph? BTL1**  **(a)** **(b)** Let a particle has a velocity V at time t and a velocity V' (= V + I:l V) at P and P' respectively as shown in fig (a). To study the time rate of change, the two velocity vectors are plotted such that their tails are located at the fixed point '0' and their arrow heads touch points on the dashed curve as shown in fig (b) This curve is called as **Hodograph**.
	PART * B
1	**A body moving with uniform acceleration is observed to travel 33 m in 8^{th} second and 53 m in 13^{th} second of its travel. Calculate the velocity at state and uniform acceleration. BTL4 (May 2017)** $S_8 = u + \frac{a}{2} \times (2 \times 8 - 1) = 33m$ $u + 7.5a = 33 \ m \quad \rightarrow (1)$

$$S_{13} = u + \frac{a}{2}(2\times 13 - 1) = 53$$

$$u + 12.5a = 53 \quad \rightarrow (2)$$

eqn (2) − eqn (1) $\Rightarrow$

$$\begin{array}{rl} u + 12.5a &= 53 \\ u + 7.5a &= 33 \\ (-)\ (-) & (-) \\ \hline 5a &= 20 \end{array}$$

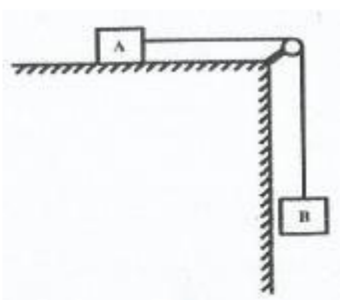
$$\boxed{a = 4 m / sec^2}$$

Substituting a = 4 in equation (1)

$$u + (7.5\times 4) = 33$$

$$\boxed{u = 3\ m/sec}$$

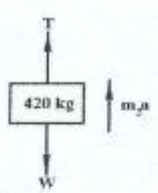
2 **Two blocks "A" and "B" of masses m_A = 280 kg and m_B = 420 kg are joined by an inextensible cable as shown in Fig. Assume that the pulley is frictionless and μ = 0.3 between block "A" and the surface. The system is initially at rest. Determine (i) acceleration of block A (ii) velocity after it has moved 3.5 m and (iii) velocity after 1.5 seconds.**



BTL4 (May 2017)

(i) Acceleration of block A:

m_1 = 280 kg ; m_2 = 420 kg ; μ = 0.30



$$T + m_2a = m_2g$$

$$T = 420\times 9.81 - 420a$$

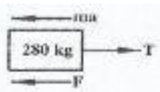
$$T = 4120.2 - 420a \quad \rightarrow (1)$$

$$T - ma - F = 0$$

$$T - 280a - \mu N = 0$$

$$T = 280a + (0.30\times 280\times 9.81)$$

$$T = 824.04 + 280a \quad \rightarrow (2)$$



eqn (1) $\Rightarrow$

$$T = 4120.2 - (420 \times 4.71)$$

$$\boxed{T = 2142 \text{ N}}$$

(ii) To find the acceleration:

$v^2 = u^2 + 2as$; $u = 0$; $s = 3.50$ m

$v^2 = 0 + (2 \times 4.71 \times 3.5)$; $v^2 = 32.97$

$$\boxed{v = 5.742 \text{ m/sec}}$$

Answers:

1. **Acceleration of block A = 4.71 m/sec²**
2. **Velocity after it has moved 3.5m v = 5.742 m/sec**
3. **Velocity after 1.5 seconds v = 7.065 m/s**

3 **A stone is projected with a speed of 30 m/s at an angle of elevation of 50º. Find its velocity (i) after 2 seconds, (ii) at the highest point of its path, (iii) at the height of 6 m. Find also the time interval between two points at which the stone attains a speed of 23 m/s.**
BTL4 (May 2016)

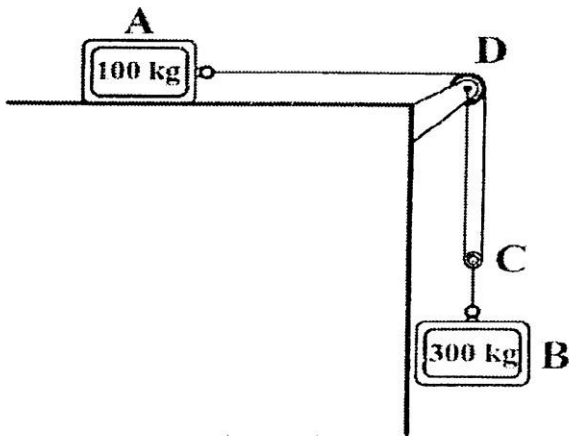
$u = 30$ m/s ; $\alpha = 50°$
$u_x = 30 \cos 50° = 19.28$ m/s
$u_y = 30 \sin 50° = 22.98$ m/s
$v_x = u_x = 1.9284$ m/s
$x = u_x.t = 19.284\, t$
$v_y = u_y - gt = 22.981 - (9.81 \times t)$
$y = u_y t - \frac{1}{2} gt^2$

(i) After 2 seconds

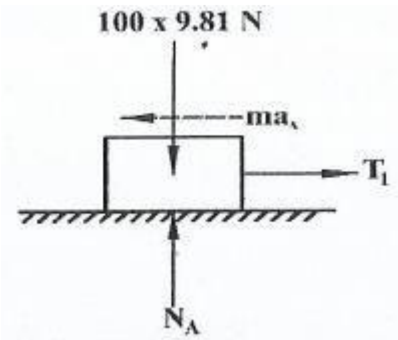
$V_x = 19.284$ m/s ; $V_y = 22.981 - (9.81 \times 2) = 3.361$ m/s

$$\therefore V = \sqrt{V_x^2 + V_y^2} = \sqrt{19.284^2 + 3.361^2} = 19.575\ m/s$$

	(ii) At highest point, $V_y = 0$; $V_y = 22.98 - (9.81 \times t) = 0$ $t = 2.343s$ $y_{max} = (22.981 \times 2.343) - ½ \times 9.81 \times 2.343^2$ $y_{max} = 26.918m$ **(iii) When Y=6m :** $y \Rightarrow 22.981t - 4.905\ t^2 = 6$ $t^2 - 4.685\ t + 1.223 = 0$ $t = 4.41s\ ;\ 0.28\ s$ When, $t = 0.28s$; $v = 20.234$ m/s $t = 4.41s$; $v = 20.281$ m/s **(iv) When the stone has a speed of 23m/s:** $V^2 = V_x^2 + V_y^2$; $23^2 = 19.281^2 + V_y^2$ $V_y = \pm\ 12.540$ m/s $V_y = 22.981 - 9.81\ t$ $\therefore +12.540 = 22.981 - 9.81\ t \Rightarrow t = 1.064s$ $-12.540 = 22.981 - 9.81\ t \Rightarrow t = 3.6214s$ $\boxed{\therefore \text{ Time interval , } t = 3.621 - 1.064 = 2.557s}$
4	**Two stones A and B are projected from the same point at inclinations of 45º and 30º respectively to the horizontal. Find the ratio of the velocities of projection of A and B if the maximum height reached by them is the same. BTL4 (Nov 2015)** At maximum height, velocity is zero. $V = 0$; $u_0 = u \sin\theta$; $a = -g$; maximum height $H = ?$ $V^2 = u_o^2 + 2as$ $0 = u^2 \text{Sin}^2\theta + 2 \times (-g) \times H$ $H = \dfrac{u^2 \text{Sin}^2\theta}{2g}$ Maximum height reached by A $= \dfrac{u_A^2\, Sin^2 45°}{2g} \rightarrow (1)$ Maximum height reached by B $= \dfrac{u_B^2\, Sin^2 30°}{2g} \rightarrow (2)$ Equating Eqn. (1) & Eqn (2) $\Rightarrow$ $\dfrac{u_A^2\, Sin^2 45°}{2g} = \dfrac{u_B^2\, Sin^2 30°}{2g}$ $\dfrac{u_A^2}{u_B^2} = \dfrac{Sin^2 30°}{Sin^2 45°}$ $\dfrac{u_A}{u_B} = \sqrt{0.50}$ $\dfrac{u_A}{u_B} = \mathbf{0.707}$ **Answer: The ratio of the velocities** $\dfrac{u_A}{u_B} = \mathbf{0.707}$
5	**The two blocks in Fig. start from rest. The horizontal plane and the pulley are frictionless, and the pulley is assumed to be of negligible mass. Determine the acceleration of each blocks and the tension in each cord.**



BTL4 (Nov 2014)



Free body diagram at A

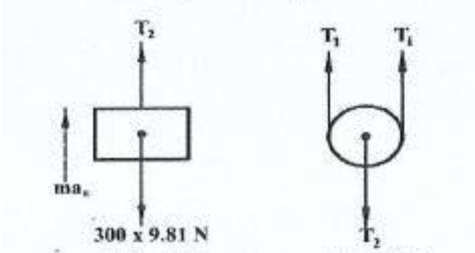
where, m = Mass of the block

a_A = Acceleration of the block A

$\Sigma H = 0$

$T_1 - ma_A = 0$

$T_1 = 100a_A \quad \rightarrow (1)$



At block B
Fig. 14a (b)

At pulley
Fig. 14a (c)

Free body diagram at B

a_B = Acceleration of block - B (300kg)

$a_B = \frac{a_A}{2}$ ($\therefore$ connects with two cable through pulley)

$\Sigma V = 0$

$T_1 + T_1 - T_2 = 0$

$2T_1 = T_2 \quad \rightarrow (3)$

Eqn. (2) $\Rightarrow \quad 2 \times 100\ a_A = 2943 - 150\ a_A$

$200\ a_A + 150\ a_A = 2943$

$350\ a_A = 2943$

$\boxed{a_A = 8.41\ m/s^2}$

$a_B = \frac{a_A}{2} = \frac{8.41}{2}$

$\boxed{a_B = 4.2\ m/s^2}$

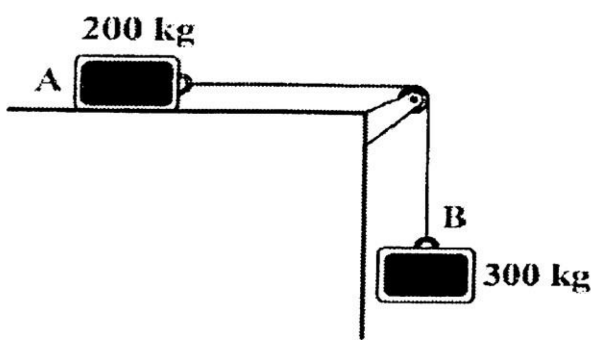
Eqn. (1) $\Rightarrow T_1 = 100 \times a_A = 100 \times 8.41 \Rightarrow T_1 = 841N$

Eqn. (1) $\Rightarrow T_2 = 2943 - 150\ a_A = 2943 - 150 \times 8.41 \Rightarrow T_2 = 1681.5N$

Answers:

1. $a_A = 8.41\ m/s^2$
2. $a_B = 4.20\ m/s^2$
3. $T_1 = T_{AD} = 841N$
4. $T_2 = T_{CB} = 1681.5N$

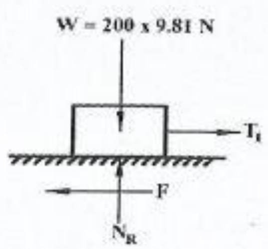
6 **Two blocks are joined by an inextensible cable as shown in Fig. If the system is released from rest, determine the velocity of block A after it has moved 2m. Assume that the coefficient of kinetic friction between block A and the plane is $\mu_k = 0.25$ and that the pulley is weightless and frictionless.**



BTL4 (Nov 2014)

Distance moved by block A, S = 2m

Coefficient of friction between block A and the plane $\mu = 0.25$



Free body diagram at block A

Force along the direction of movement.

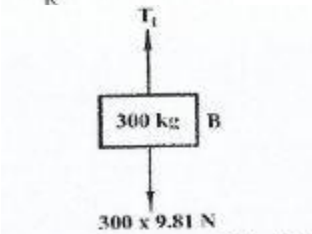
$F_x = (T_1 - F) = T_1 - \mu N_R = T_1 - (0.25 \times 1962)$

$F_x = T_1 = 490.50$

$\Sigma V = 0$

$N_R = 200 \times 9.81$

$N_R = 1962N$



Free body diagram at block B

Force along the direction of motion $= (300 \times 9.81 - T_1)$

$= 2943 - T_1$

Total workdone in the direction of motion

$= (T_1 - 490.50) \times S + (2943 - T_1) \times S$

$= 2452.5s$

Total change in K.E of the system

The system is released from rest $u = 0$

Final velocity of both the block is same, let it be V.

Change in K.E $= \frac{1}{2} \times 200 \times (v^2 - u^2) + \frac{1}{2} \times 300 \times (v^2 - u^2)$

$= 100v^2 + 150\ v^2$

$= 250\ v^2$

Apply work – Energy equation :

Total workdone = Total change in K.E.

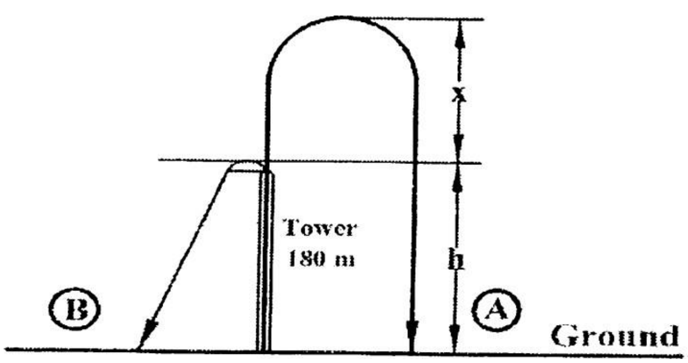
$2452.50 \times S = 250v^2$

$2452.50 \times 2 = 250v^2$

$4905 = 250\ v^2$

$\boxed{v = 4.429\ m/sec}$

7 **A body A is projected vertically upwards from the top of a tower with a velocity of 40 m/s, the tower being 180 m high. After t sec, another body B is allowed to fall from the same point. Both the bodies reach the ground simultaneously. Calculate t and the velocities of A and B on reaching the ground.**



BTL4 (May 2014)

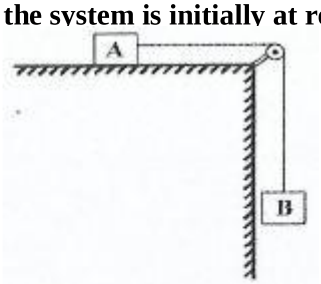
Projected vertically upwards, reacting its maximum height x and then starts moving downwards to strike the ground.

t_A = Total time taken to strike the ground

t_1 = time taken to reach maximum height x

t_2 = time taken to strike the ground from maximum height.

$t_A = t_1 + t_2$

	Consider the motion of A upto reaching the maximum height: $u = 40m/s$; time $= t_1$; $v=0$ (@max. height, velocity is zero) $v = u - gt$ $0 = 40 - (9.81 \times t_1)$ $\therefore t_1 = 4.077$ sec $\boxed{x = 81.55m}$ **Consider the downward motion (from maximum height to the ground of body A:** Total distance $= (h + x) = 180 + 81.55 = 261.55m$ Time $= t_A - t_1$ $t_2 = (t_A - 4.077)$ $h = ut + \frac{1}{2}gt^2$ $(\therefore u = 0)$ $(h + x) = ut_2 + \frac{1}{2}gt^2$ $261.55 = \frac{1}{2} \times 9.81 \times (t_A - 4.077)^2$ $(t_A - 4.077)^2 = 53.32$ $t_A - 4.077 = 7.302$ $\boxed{t_A = 11.379 \text{ sec}}$ $V = u + gt_2 = 0 + (9.81 \times (11.379 - 4.077))$ $\boxed{V = 71.633 \text{ m/s}}$
8	**Two blocks "A" and "B" of masses $m_A = 280$ kg and $m_B = 420$ kg are joined by an inextensible cable as shown in Fig. Assume that pulley is frictionless and $\mu = 0.3$ between block A and the surface. If the system is initially at rest, determine the velocity of the blocks after it has moved 3.5 m. Use work**  **BTL4 (May 2016)** $m_A = 280kg$ $m_B = 420kg$ $\mu = 0.30$

Consider 280 kg block (moving towards right):

Resolving the forces normal to the plane

$$N_R - (280 \times 9.81) = 0$$

$$N_R = 2746.80N$$

The net force along the direction of motion,

$$\Sigma F_x = (T-F) = T - (0.30 \times N_R)$$

$$= T - (0.30 \times 2746.80)$$

$$\Sigma F_x = T - 824.04$$

Applying work – Energy principle,

$$\Sigma F_x \times S = \frac{W}{2g}(v^2-u^2)$$

$$(T-824.04)s = \frac{280 \times 9.81}{2 \times 9.81}(v^2-u^2)$$

$u = 0$; $\therefore$ starts from rest $s = 3.50m$

$$(T-824.04) \times 3.50 = 140 \times (v^2-0)$$

$$T-824.04 = 40\ v^2 \rightarrow (1)$$

Consider 420 kg block (moving downwards):

Net force along the direction of motion,

$$\Sigma F_y = (420 \times 9.81) - T = 4120.2 - T$$

Applying Work Energy equation,

$$\Sigma F_y \times S = \frac{W}{2g}(v^2-u^2)$$

$$(4120.20 - T)s = \frac{420 \times 9.81}{2 \times 9.81}(v^2-0)$$

$$(4120.20-T) \times 3.50 = 210\ v^2$$

$$4120.20 - T = 60v^2 \rightarrow (2)$$

Solving the Equation (1) & (2) $\Rightarrow$

$$T - 824.04 = 40v^2$$

$$-T + 4120.02 = 60v^2$$

$$3295.98 = 100v^2$$

$$\boxed{V = 5.741m/s}$$

Eqn (1) $\Rightarrow T - 824.04 = 40 \times 5.741^2$

$$\boxed{T = 2142.40\ N}$$

Answers :

1. **Velocity V = 5.741 m/s**
2. **Tension T = 2142.40N**

PART * C

1 **Two smooth spheres 1 and 2 having a mass of 2 kg and 4 kg respectively collide with initial velocities as shown in Fig.14(b). If the coefficient of restitution for the spheres is e = 0.8, determine the velocities of each sphere after collision.**

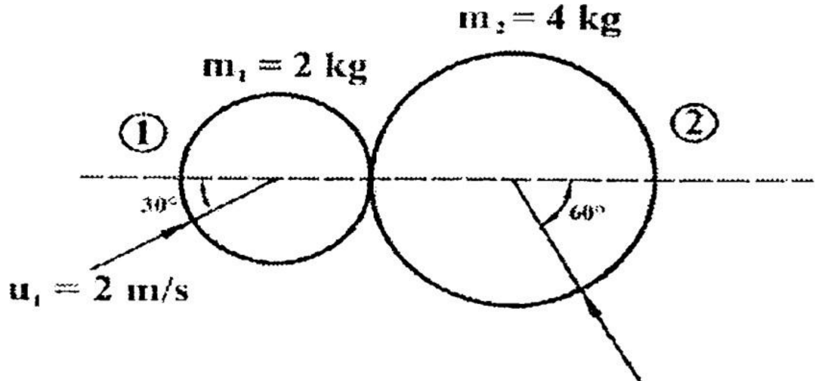


Fig.14b

BTL4 (May 2014)

$m_1 = 2kg$; $u_1 = 2m/s$; $\alpha_1 = 30^o$

$m_2 = 4kg$; $u_2 = -4m/s$; $\alpha_2 = 60^o$

$m_1u_1 \text{ Cos } \alpha_1 + m_2u_2 \text{ Cos } \alpha_2 = m_1V_1 \text{ Cos } \theta_1 + m_2V_2 \text{ Cos}\theta_2$

$(2\times2 \text{ Cos}30) + (4 \times -4 \text{ Cos}60) = (2V_1 \text{ Cos}\theta_1) + (4V_2\text{Cos}\theta_2)$

(– sign indicates u_2 acts in opposite direction)

$2V_1 \text{ Cos}\theta_1 + 4V_2 \text{ Cos}\theta_2 = -4.536 \quad \rightarrow (1)$

$(V_2 \text{ Cos}\theta_2 - V_1 \text{ Cos}\theta_1) = e\ (u_1 \text{ Cos } \alpha_1 - u_2 \text{ cos}\alpha_2)$

$(V_2 \text{ Cos}\theta_2 - V_1 \text{ Cos}\theta_1)$

$= 0.80 \times (2 \text{ Cos}30^o + 4 \text{ Cos } 60^o) = 2.986 \quad \rightarrow (2)$

Eqn (1) - Eqn (2) × (4) ⇒

$2v_1 \text{ Cos } \theta_1 + 4V_2 \text{ Cos } \theta_2 = -4.536$

$-4v_1 \text{ Cos } \theta_1 + 4V2 \text{ Cos}\theta_2 = 11.944$

(+) (–) (–)

$6V_1 \text{ Cos } \theta = -16.48 \quad \rightarrow (3)$

$u_1 \text{ Sin } \alpha_1 = V_1 \text{ Sin } \theta_1 \quad \rightarrow (4)$

$u_2 \text{ Sin } \alpha_2 = V_2 \text{ Sin } \theta_2 \quad \rightarrow (5)$

Eqn. (4) $\Rightarrow V_1 \text{ Sin } \theta_1 = u_1 \text{ Sin } \alpha_1 = 2 \times \text{Sin } 30^o = 1$

$V_1 \text{ Sin } \theta_1 = 1 \quad \rightarrow (6)$

Eqn. (3) & Eqn (6) ⇒

$$\frac{V_1 \text{Sin}\theta_1}{6V_1 \text{ Cos}\theta_1} = \frac{1}{-16.48}$$

$$\frac{\tan\theta_1}{6} = \frac{1}{-16.48}$$

$\tan \theta_1 = -0.364$

$\boxed{\theta_1 = -20^o}$

Eqn. (6) $\Rightarrow$ $V_1 \text{ Sin } \theta_1 = 1$

$$V_1 \times \text{Sin } 20^\circ = 1$$

$$V_1 = \frac{1}{Sin\,20^\circ}$$

$$\boxed{V = -\ 2.924 \text{ m/s}}$$

Eqn. (2) $\Rightarrow$ $V_2 \text{ Cos } \theta_2 - V_1 \text{ Cos } \theta_1 = 2.986$

$$V_2 \text{ Cos } \theta_2 - (-2.924 \times \text{Cos} - 20) = 2.986$$

$$V_2 \text{ Cos } \theta_2 - (-2.748) = 2.986$$

$$V_2 \text{ Cos } \theta_2 = 0.238 \qquad \rightarrow (7)$$

Eqn. (5) $V_2 \text{ Sin}\theta_2 - u_2 \text{ Sin } \alpha_2 = -4 \times \text{Sin } 60^\circ = -3.464$

$$V_2 \text{ Sin } \theta_2 = -3.464 \qquad \rightarrow (8)$$

Eqn. (8) $\div$ Eqn (7) $\Rightarrow$

$$\frac{V_2 \text{ Sin}\theta_2}{V_2 \text{Cos}\theta_2} = \frac{-3.464}{0.238}$$

$$\tan \theta_2 = -14.555$$

$$\boxed{\theta_2 = -86.07^\circ}$$

Eqn (7) $\Rightarrow$ $V_2 \text{ Cos } \theta_2 = 0.238$

$$V_2 \text{ Cos } (-86.02) = 0.238$$

$$\boxed{V_2 = 3.429 \text{ m/s}}$$

2 **A block and pulley system is shown in Fig 14(b). The coefficient of kinetic friction between the block and the plane is 0.25. The pulley is frictionless. Find the acceleration of the blocks and the tension in the string when the system is just released. Also find the time required for 100 kg block to come down by 2m.**

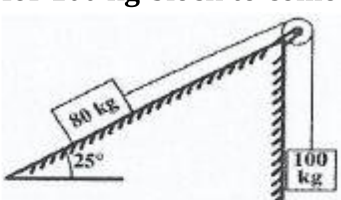
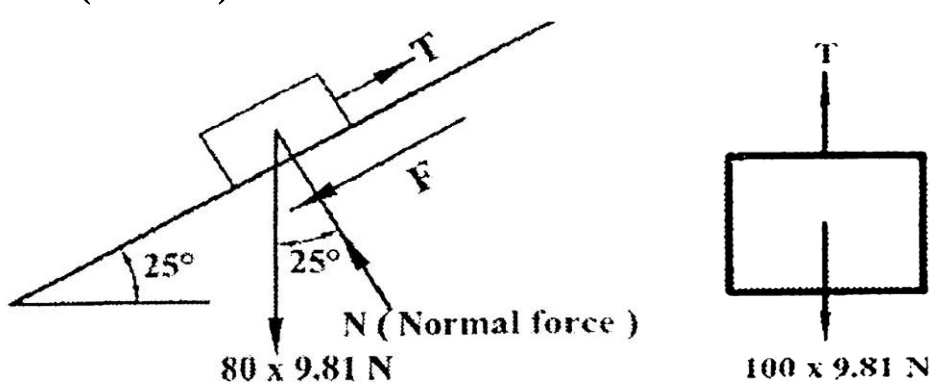
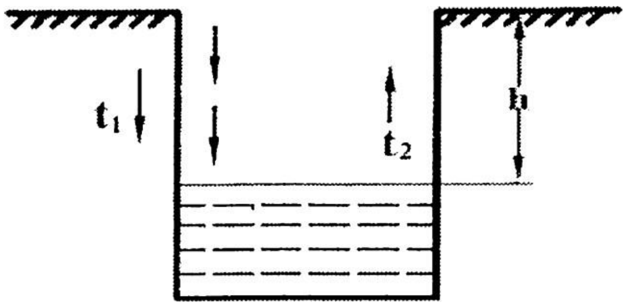


Fig.14b

BTL4 (Nov 2015)



	Total work done by the system = Total change in the kinetic energy of the system. T be the tension in the string Fig. (i) shows the free body diagram of 80 kg block $\Sigma F_y = N - 80 \times 9.81 \times \cos 25° = o$ $N = 711.27N$ Friction $F = \mu N = 0.25 \times 711.27 = 177.82N$ Algebric sum of the forces along the plane $\Sigma F_x = T - F - W \sin 25°$ Total work done in the direction of motion $= (T - 177.80 - 80 \times 9.81 \times \sin 25°)s$ $+ (100 \times 9.81 - T)s = 471.53s$ **Total change in K.E. of the system :** Final velocity (v) of both the blocks is the same. change in K.E. $= \frac{1}{2} \times 80 \times (V^2 - 0)$ $+ \frac{1}{2} \times 100 \times (V^2 - 0) = 90V^2$ Total work done = total change in K.E. $471.53s = 90V^2$ $\boxed{V = 5.24S}$ **To find the acceleration of the blocks :** $v^2 = u^2 + 2as$; $v^2 = 5.24s$; $u^2 = o$ $5.24s = 2as$ $\boxed{a = 2.62\ m/sec^2}$ **To find the tension in the string:** Work done by the forces acting on 100kg block $= (100 \times 9.81 - T)s$ Change in K.E. of 100 kg block $= \frac{100}{2} (v^2 - 0) = 50 \times 5.24s$ Equating work done to the change in K.E. $(981 - T)s = 50 \times 5.24s$ $T = 981 - 50 \times 5.24$ $\boxed{T = 719N}$ **To find the time required for 100kg block to drop by 2m:** $S = ut + \frac{1}{2} at^2$; S=2m ; u=0; a = 2.62m/s^2 ; t = ? $2 = 0 + \frac{1}{2} \times 2.62 \times t^2$ $\boxed{t = 1.236s}$ **Answers:** **1. Acceleration of the blocks = 2.62 m/s^2** **2. Tension in the string = 719N** **3. Time required for 100kg block to drop by 2m = 1.236s**
3	**(i) A boy drops a stone from the top of well vertically downwards into it. The splash is heard by him after 6 seconds. Find the well depth taking sound velocity as 400 m/s. (10) BTL4 (May 2015)**



Travel of stone :

t_2 = time taken by the stone to reach the water level.

t_1 = depth of water level from top surface.

$$h = ut_1 + \frac{1}{2} g t_1^2$$

$$h = (0 \times t_1) + \frac{1}{2} \times 9.81\, t_1^2 \quad (\therefore \text{Initial velocity } u = 0)$$

$$h = \frac{1}{2} \times 9.81\, t_1^2$$

$$h = 4.90\, t_1^2 \quad \rightarrow (1)$$

Travel of sound :

t_2 = time taken by the sound to reach the splash sound at top surface.

$$\text{Uniform velocity of Sound} = \frac{\text{Distance travelled by sound}}{\text{time taken}}$$

$$400 = \frac{h}{t_2}$$

$$h = 400 t_2 \quad \rightarrow (2)$$

$$t_1 + t_2 = 6$$

$$t_2 = (6 - t_1) \quad \rightarrow (3)$$

Eqn (2) & Eqn (3) $\Rightarrow$

$$h = 400 \times (6 - t_1) \quad \rightarrow (4)$$

Eqn (1) & Eqn (4) $\Rightarrow$

$$4.90 t_1^2 = 400 \times (6 - t_1)$$

$$4.90 t_1^2 + 400 t_1 - 2400 = 0$$

$$\boxed{t_1 = 5.60 \text{ sec}}$$

$$t_1 + t_2 = 6$$

$$5.6 + t_2 = 6$$

$$\boxed{t_2 = 0.40 \text{ sec}}$$

Eqn (4) $\Rightarrow h = 400 \times (6 - 5.60)$

$$\boxed{h = 160\text{m}}$$

Answer : Depth of well h = 160m

(ii) A car of mass 500 kg moving at a speed of 80 km/hr to the right collides with a lorry of mass 1,500 kg which is at rest. After the impact, the lorry moves at a speed of 36 km/hr to the right. Find the velocity of the car after impact. Also find the coefficient of restitution. (5)

BTL4 (May 2015)

Velocity of 500kg car after impact = v = ?

Velocity of the lorry after impact = 10 m/s

Applying the law of conservation of momentum

$500 \times 22.22 + 1500 \times 0 = 1500 \times 10 + 500 \times V$

$$V = \frac{11110-15000}{500} = -\frac{3890}{500}$$

$$V = -7.78 \text{ m/s}$$

To find co-efficent of restitution :

$$e = \frac{V'_{lorry} - V'_{car}}{V_{car} - V_{lorry}} = \frac{10.00-(-7.78)}{22.22-0} = \frac{17.78}{22.22}$$

$$\boxed{e = 0.80}$$

Answers :

1. **Velocity of the car after impact = -7.78 m/s. (that means, the velocity of the car is reversed after collision).**
2. **Coefficient of restitution = 0.800**

UNIT V FRICTION AND RIGID BODY DYNAMICS	
Friction force – Laws of sliding friction – equilibrium analysis of simple systems with sliding friction – wedge friction-. Rolling resistance -Translation and Rotation of Rigid Bodies – Velocity and acceleration – General Plane motion of simple rigid bodies such as cylinder, disc/wheel and sphere.	
PART * A	
Q.No.	**Questions**
1	**What is dry friction? BTL1 (May 2017)** It develops between dry surfaces or unlubricated Surfaces of bodies in contact.
2	**What is general plane motion? Given one example. BTL1 (May 2017)** It can be considered to be a sum of translation and rotation about an axis perpendicular to the plane of motion. Examples: (a) A cylinder rolling on a flat or a curved surface without slipping. (b) A rod one end of which slides along a horizontal track and the other end along a vertical track.
3	**What is angle of repose? BTL1 (May 2016, May 2015)** The angle of inclination of a plane with the horizontal when a body kept on the plane just starts moving down is called the angle of repose. Angle of repose is equal to the angle of static friction.
4	**A motor bike wheel of radius 80 cm is moving along the straight road with a speed of 60 km/hr. Find the angular speed of the wheel. BTL3 (May 2016)** $V = r\,\omega$; V = 60 km/hr; r = 80 cm = 0.8 m $\omega = V/r = (60 \times [1000/3600]) / 0.8 =$ **20.83 rad/sec**
5	**What is impulsive force? BTL1 (Dec. 2015)** When a large force acts on a particle for a short period of time and produces a definite change in its momentum, then such a force is called al1 impulsive force.
6	**State the principle of work and energy for the general plane motion of rigid-bodies. BTL1 (Dec. 2015)** Work done by a rigid body undergoing general plane motion = change in kinetic energy of the rigid body due to linear (or translational motion) from one point to another point + change in kinetic energy of the rigid body due to rotary motion from one position to another position.
7	**A wheel of radius 50 cm subjected to a load of 300 N rolls on a level ground at constant**

	speed. If the wheel is pushed by a tractive force of 60 N applied horizontally at the centre of the wheel, find the coefficient of rolling resistance. BTL3 (May 2015) Horizontal force = ws / r 60 = 300 s / 0.5 S = 0.1 m (or) **10 cm**
8	**Define limiting friction. BTL1 (Dec. 2014)** Friction force developed at the contact surfaces is maximum when one body just starts moving over the other. This maximum friction force is called the limiting friction. The limiting friction is actually the maximum static friction.
9	**Define instantaneous centre of rotation. BTL1 (Dec. 2014)** A rigid body in plane motion can be considered to rotate about a point that remains at rest at a particular instant. This point having zero instantaneous velocity is called the instantaneous centre of rotation.
10	**Define angle of friction. BTL1 (May 2014)** The angle of inclination of the resultant with the normal reaction is referred to as the angle of friction.
11	**What is general plane motion? BTL1 (May 2014, May 2013)** General plane motion can be considered to be a sum of translation and rotation about an axis perpendicular to the plane of motion.
12	**A flywheel has mass moment of inertia of 11 kg.m^2 about the axis of rotation. It runs at a constant angular velocity of 94.25 rad/s. Find the kinetic energy of the flywheel. BTL3 (May 2013)** Mass moment of inertia = 11 kg.m^2; Angular velocity : 94.25 rad/s Kinetic energy = ½ I ω^2 = 48856.84 N.m
13	**Define cone of friction. BTL1** It is defined as the right circular cone with vertex at the point of contact of the two bodies (or surface) axis in the direction of normal reaction (R) and semi vertical angle equal to angle of friction.
14	**Define Solid Friction or Dry Friction**. **BTL1** If between two surfaces, no lubrication (oil or grease) used, the friction that exists between two surfaces is called solid friction.
15	**What is the sliding friction? BTL1** It is the friction, experienced by a body when it slides over another body.
16	**What is Rolling Friction? BTL1** It is the friction, experienced by a body when it rolls over the other.
17	**State the Laws of static friction? BTL1** • The force of friction always acts in a direction opposite to that in which the body tends to move. • The Magnitude of the force of friction is equal to the force, which tends to move the body. • Limiting friction bears a constant ratio to the normal reaction between the two surfaces • The force of friction is independent of the area of contact between the two surfaces • The force of friction depends upon the roughness of the surfaces.

18 **State the laws of Dynamic friction? BTL1**

- The force of friction always acts in a direction, opposite to that in which the body is moving.
- The magnitude of the kinetic friction bears a constant ratio to the normal reaction between the two surfaces.
- For moderate speeds, the force of friction remains constant and it decreases with the increase of speed.

19 **Define Limiting Friction. BTL1**

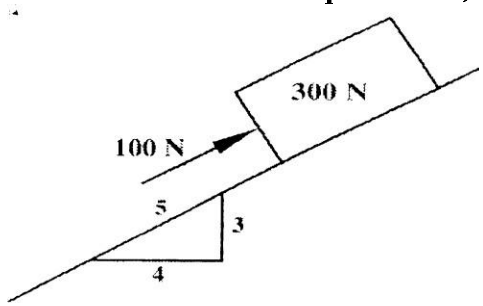
Limiting friction 'F' is the maximum value of static friction that occurs when motion is impending.

20 **What is impending motion? BTL1**

The motion is said to be impending if the applied forces are such that the body is just about to slide.

PART * B

1 **A 100 N force acts on a 300 N block placed on an inclined plane as shown in Fig. The coefficients of friction between the block and the plane are $\mu_s = 0.25$ and $\mu_k = 0.2$. Determine whether the block is in equilibrium, and find the value of the friction force.**

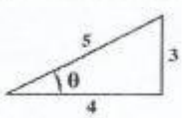


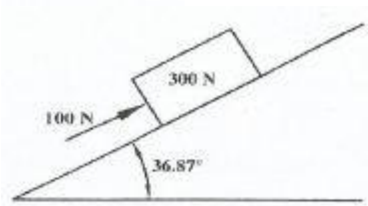
BTL4 (May 2017)

$$\tan\theta = \frac{3}{4}$$

$$\theta = \tan^{-1}\left(\frac{3}{4}\right)$$

$$\boxed{\theta = 36.87^\circ}$$





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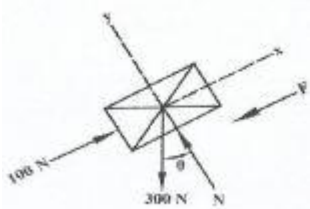

Equilibrium of the block:

Assume that the block just moves up.

Resolving all the forces in the x direction shown,

$100 - F - (300 \times \sin 36.87°) = 0$

$F = 100 - (300 \times \sin 36.78°)$

$F = -80$ N

The sense of the friction force assumed is to be reversed

Resolving the forces in the y direction shown,

$N - (300 \times \cos 36.78°) = 0$

$\boxed{N = 240 \text{ N}}$ (or) $\boxed{N = 0.24 \text{ kN}}$

A friction force of 80 N is required to maintain equilibrium.

Limiting friction force:

Limiting friction force developed $= \mu_s \times N = 0.25 \times 240$

$= 60$ N

Since the limiting friction force developed is less than the friction force required for equilibrium, the block will not be in equilibrium. The block will move down the plane.

Actual friction force developed:

Since the block slides down the plane, actual friction force developed is equal to the kinetic friction force.

Kinetic friction force $= \mu_k \times N = 0.20 \times 240 = 48$N

Answers:

1. The block is not in equilibrium. It slides down the plane.

2. Magnitude of the friction force = 48 N (kinetic friction force)
</td></tr>
<tr><td>2</td><td>A wheel is attached to the shaft of an electric motor of rated speed of 2000 rpm. When the power is switched on, the wheel attains the rated speed in 10 seconds and when the power is switched off, the unit comes to rest in 100 seconds. Assume uniformly accelerated motion and determine the number of revolutions the turns (i) to attain the rated speed and (ii) to come to rest.
BTL4 (May 2017)</td></tr>
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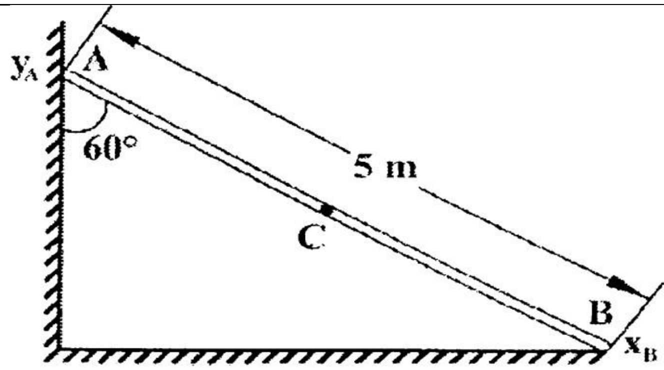
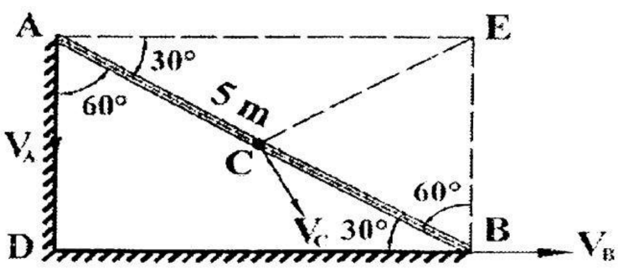
	Revolutions turned by the wheel to attain the rated speed: Angular velocity $= W \times \frac{N}{60} \times 2\pi = \frac{2000 \times 2\pi}{60} = 209.44\,rad/s$ (Here N refers to RPM) $W = W_0 + \alpha t$; $W = 209.44\,rad/s$; $W_0 = 0$; $t = 10s$; $\alpha = ?$ $209.44 = 0 + 10\alpha$ $\boxed{\alpha = 20.94\,rad/s^2}$ $\theta = W_0 \times t + \frac{1}{2}\alpha t^2 = 0 + \frac{1}{2} \times 20.94 \times 10^2 = 1047\,rad$ Number of revolutions turned $= \frac{\theta}{2\pi} = \frac{1047}{2\pi} = 166.64$ say 167 rpm **Revolutions turned for the unit to come to rest:** $W = 0$; $W_0 = 209.44$ rad/s ; $t = 100s$ $W = W_0 + \alpha t$ $0 = 209.44 + 100\alpha$ $\alpha = \frac{-209.44}{100}$ $\boxed{\alpha = -2.094\,rad/S^2}$; $t = 100s$ $\theta = (209.44 \times 100) + (\frac{1}{2} \times -2.094 \times 100^2)$ $= 20944 - 10470$ $\boxed{\theta = 10474\,rad}$ Number of revolutions turned $= \frac{\theta}{2\pi} = \frac{10474}{2\pi} = 1667\,rpm$ **Answers:** **1. The number of revolutions turned to attain rated speed = 167** **2. The number of revolutions turned to come to rest = 1667**
3	**A bar AB of length 5 m slides in the xy plane as shown in Fig. The velocity of point A is 10 m/s downwards and makes an angle 60˚vertical. Determine the velocity of point B and midpoint C.**



BTL4 (May 2016)



$$V_A = 10 \text{ m/s} = rw = w\,(AE)$$

$$\text{Sin } 30^\circ = \frac{AD}{AB} = \frac{AD}{5}$$

$$AD = 5 \times \text{Sin } 30^\circ = 2.50\text{m} = BE$$

$$\text{Sin } 60^\circ = \frac{DB}{AB} = \frac{DB}{5}$$

$$DB = 5 \times \text{Sin} 60^\circ = 4.33\text{m} = AE$$

$$w = \frac{V_A}{AE} = \frac{10}{4.33} = 2.31 \text{ rad/s}$$

$$V_B = w \times BE = 2.31 \times 2.50 = 5.775 \text{ m/s}$$

$$CE = \sqrt{\left(\frac{AD}{2}\right)^2 + \left(\frac{AE}{2}\right)^2} = \sqrt{\left(\frac{2.50}{2}\right)^2 + \left(\frac{4.33}{2}\right)^2}$$

$$CE = 2.50\text{m}$$

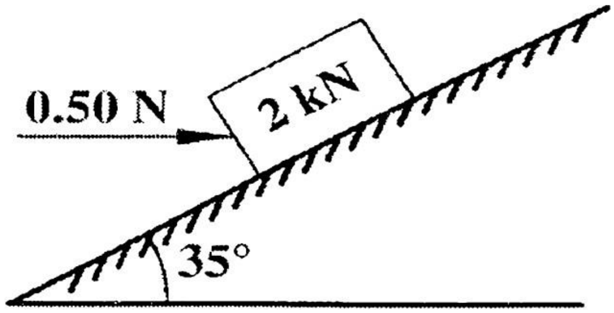
$$V_c = w \times CE = 2.31 \times 2.50 = 5.775 \text{ m/s}$$

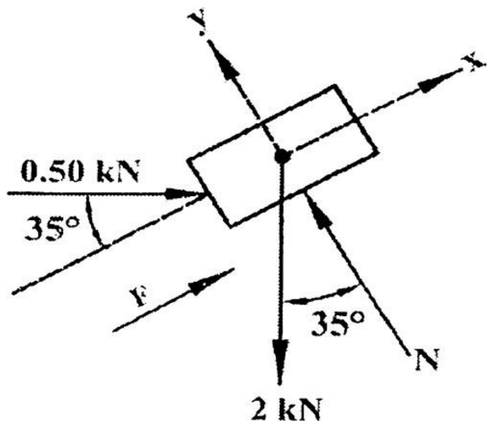
Answers:

1. **Angular velocity of rod AB = 2.31 rad/s**
2. **Velocity of end B = 5.775 m/s**
3. **Velocity of midpoint C = 5.775 m/s**

4 **A block of weight 2 kN kept on an inclined plane is acted upon by 0.5 kN horizontal force as shown in Fig. The coefficients of friction between the block and the plane are $\mu_s = 0.3$ and $\mu_k = 0.25$. Find whether the block is in equilibrium or not. Also find the magnitude and direction of the friction force.**

BTL4 (Nov 2015)





Equilibrium of the block:

Resolving all the forces in the x direction

$$F + 0.50 \text{ Cos } 35^\circ - 2 \text{ Sin } 35^\circ = 0$$

$$\mathbf{F = 0.74kN}$$

The assumed direction of friction is correct.

Resolving all the forces in the y direction

$$N - 2 \text{ Cos } 35^\circ - 0.50 \text{ Sin } 35^\circ = 0$$

$$\mathbf{N = 1.93kN}$$

Limiting friction force:

$$\begin{aligned} \text{Limiting friction force developed} &= \mu_s \times N \\ &= 0.30 \times 1.93 \\ &= 0.58 \text{ kN} \end{aligned}$$

Limiting friction force developed (0.58kN) is less than the friction force required for equilibrium (0.74kN) the block will not be in equilibrium. The block will move down the plane.

Actual friction force developed:

Actual friction force developed is equal to the kinetic friction force.

Kinetic friction force $= \mu_k N = 0.25 \times 1.93 = 0.48$kN

Answers:

1. The block is not in equilibrium. It slides down the plane.
2. Magnitude of the friction force = 0.48kN (kinetic friction force)
3. The friction force acts up the plane towards right opposing the motion.

5 **A flywheel is fixed to the shaft of a motor. The unit attains the rated speed of 1200 rpm in 4 seconds. But when it is switched off, the unit comes to rest in 70 seconds. Find the revolutions executed by the unit.**

(i) To attain the rated speed and

(ii) To come to rest after being switched off when the acceleration is uniform

BTL4 (Nov 2015)

Revolutions turned by the flywheel to attain rated speed:

Angular velocity $\omega = \frac{2\pi N}{60} = \frac{2\pi \times 1200}{60} = 125.66\ rad/s$

$\omega = 125.66$; $\omega_0 = 0$; t =4 sec

$\omega = \omega_0 + \alpha\, t$

125.66 = 0 + 4 α

$\alpha = {}^{125.6}/_{4}$ = 31.42 rad/s^2

$\theta = \omega_0 t + \frac{1}{2}\alpha t^2 = 0 + \frac{1}{2} \times 31.42 \times 4^2 = \frac{31.42 \times 4^2}{2}$

Number of revolutions turned = $\frac{\theta}{2\pi} = \frac{31.42 \times 4^2}{2 \times 2\pi}$ = 40

Unit to come to rest:

$\omega = 0$; $\omega_0 = 125.66$; t = 70 sec

$\omega = \omega_0 + \alpha\, t$

$0 = 125.66 + 70\,\alpha$

$\alpha = \frac{-125.66}{70}$= -1.795 rad/s^2

α = -1.795 rad/s^2 ; t =70 sec

$\theta = \omega_0 t + \frac{1}{2}\alpha t^2 = 125.66 \times 70 + \frac{1}{2} \times (-1.795) \times 70^2 = 8796.2 - 4397.75 = 4398.45\ rad$

Number of revolutions turned = $\frac{\theta}{2\pi} = \frac{4398.45}{2\pi}$ = 700

Answers:

1. The number of revolutions turned to attain rated speed = 40
2. The number of revolution turned to come to rest = 700

6 **A homogeneous sphere of mass m_1 and radius r_1 and a homogeneous cylinder of mass m_2 and radius r_2 roll along an incline without slipping. They start from rest at the top and reach the bottom at different times which of the two reaches the bottom earlier?**
BTL4 (May 2015)

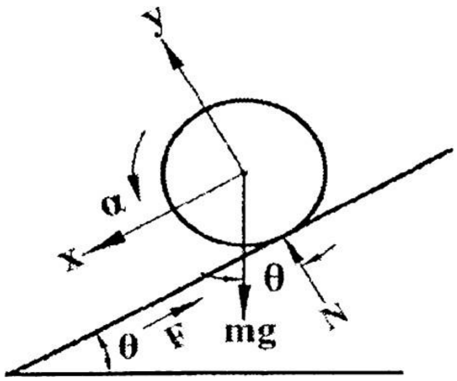


Fig (i) shows the free body diagram applicable to both sphere and cylinder.

$$\Sigma F_x = m_1 g \sin\theta - F_S = m_1 (a_x)_S$$

$$\Sigma F_y = N_S - m_1 g \cos\theta = 0$$

ΣM about the axis of rotation $= F_S r_1 = I_S \alpha_S$

$$= \frac{2}{5} m_1 r_1^2 \alpha_S$$

Substituting $r_1 \alpha_S = (a_x)_s$ in ΣM equation

$$F_S r_1 = \frac{2}{5} m_1 r_1 (a_x)_S$$

$$F_S = \frac{2}{5} m_1 (ax)_S$$

Substituting for F_S in ΣF_X equation,

$$m_1 g \sin\theta - \frac{2}{5} m_1 (a_x)_S = m_1 (a_x)_s$$

$$(ax)_S = \frac{5}{7} g \sin\theta$$

Note : α is the angular acceleration and a_x is the acceleration along the x - direction.

Cylinder :

$$\Sigma F_x = m_2 g \sin\theta - F_C = m_2 (ax)_c$$

$$\Sigma F_y = N_C' - m_2 g \cos\theta = 0$$

$$\Sigma M_o = F_c r_2 = I_C \alpha_c = \frac{1}{2} m_2 r_2^2 \alpha_c$$

Substituting $r_2 \alpha_C = (a_x)_C$ in ΣM_o equation

$$F_c r_2 = \frac{1}{2} m_2 r_2 (a_x)_c$$

$$F_c = \frac{1}{2} m_2 (a_x)_c$$

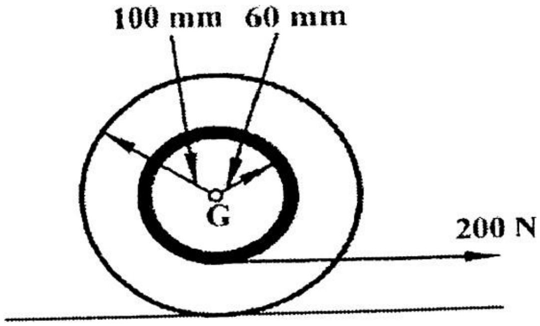
Substituting for F_c in ΣF_x equation

$$m_2 g \sin\theta - \frac{1}{2} m_2 (a_x)_c = m_2 (a_x)_c$$

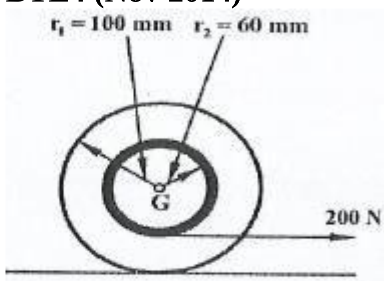
$$(a_x)_c = \frac{2}{3} g \sin\theta$$

Answer : $(a_x)_S$ is greater than $(a_x)_c$. Hence, the sphere reaches the bottom of the incline earlier than the cylinder.

7 **A cord is wrapped around the inner drum of a wheel and pulled horizontally with a force of 200 N as shown in Fig. The wheel has a mass of 50 kg and a radius of gyration of 70 mm. Knowing the μ_s = 0.2 and μ_k = 0.15, determine the acceleration of G and angular acceleration of the wheel.**



BTL4 (Nov 2014)



Mass of the wheel M = 50 kg

Radius of gyration r = 70mm = 0.07m

$\mu_s = 0.20$

$\mu_k = 0.15$

The rolling of wheel without slipping is possible only when the actual friction at the contact surface.

$F_{act} < \mu N_R$

If $F_{act} > \mu N_R$ then both rolling and slipping will occur.

$\Sigma F_X - ma_x = 0$

$-200 - F - 50\,a_x = 0$

$F = -200 - 50\,a_x \quad \rightarrow (1)$

$\Sigma M_G - I_G\,\alpha = 0 \quad \rightarrow (2)$

$\Sigma M_G = (200 \times 0.06) + (F \times 0.10)$

$$I_G = \frac{Mr^2}{2} = \frac{50\times0.07^2}{2} = 0.1225\ kg.m^2$$

Eqn. (2) $\Rightarrow (200 \times 0.06) + (F\times0.10) - 0.1225\,\alpha = 0 \quad \rightarrow (3)$

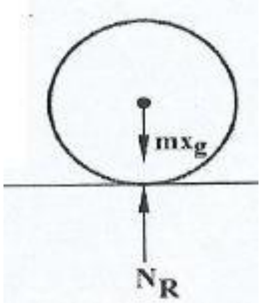
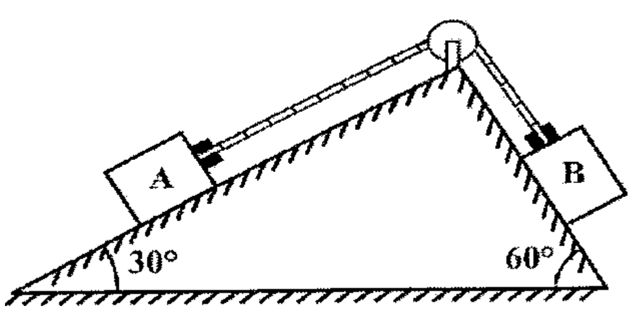
$$\alpha = \frac{a}{r}$$

$$\alpha = \frac{a}{0.10}$$

Eqn. (2) $\Rightarrow 12 + 0.10F = 0.1225 \times 10 \times a_x$

$0.10\,F = 1.225\,a_x - 12$

$10 \times \Rightarrow \quad F = 12.25\,a_x - 120$

	Eqn (1), Eqn (2) $\Rightarrow$ $-200 - 50a_x = 12.25\ a_x - 120$ $-200 + 120 = 12.25\ a_x + 50\ a_x$ $-80 = 62.25\ a_x$ $\boxed{a_x = -1.285\ m/s^2}$ Angular acceleration of the wheel $\alpha = \frac{a_x}{\gamma}$ $\alpha = \frac{-1.285}{0.10}$ $\alpha = -12.85$ rad/sec  **To check** : Whether the cylinder rolls without slipping. Eqn. (3) $\Rightarrow$ $F = 12.25\ a_x - 120 = -15.74 - 120$ $F_{act} = -135.74N$ $\Sigma v = 0$ $N_R = m \times g = 50 \times 9.81 = 490.50N$ $\therefore \mu N_R = 0.15 \times 490.50 = 73.58N$ $F_{act} < \mu N_R$, the wheel rolls without slipping. **Answers :** **1. Acceleration of G ; a_x $= -1.285\ m/s^2$** **2. Angular accelaration of wheel $\alpha = -12.85$ rad/sec**
8	**Two blocks A and B are placed on inclined planes as shown in Fig. The blocks A weighs 1000 N. Determine minimum weight of the block B for maintaining the equilibrium of the system. Assume that the blocks are connected by an inextensible string passing over a frictionless pulley. A coefficient of friction μ_A between the block A and the plane is 0.25. Assume the same value for μ_B.**  **BTL4 (May 2014)**

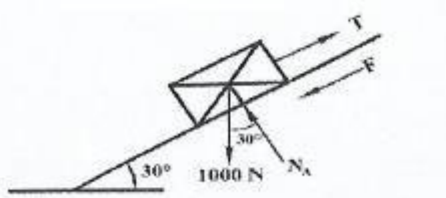
$\Sigma H = 0$; $N_A = 1000 \times \cos 30° = 866.025N$

$\Sigma V = 0$; $T - F - 1000 \sin 30° = 0$

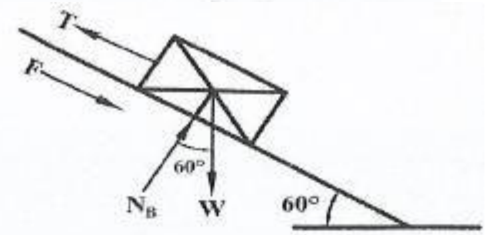
$F = \mu_A N_A = 0.25 N_A$

$T - (0.25 \times 866.025) = 1000 \times \sin 30°$

$\boxed{T = 716.51N}$



Free body diagram of block A



Free body diagram of block B

$\Sigma H = 0$; $N_B - W \cos 60° = 0$

$N_B = 0.50W$

$\Sigma V = 0$; $F + W \sin 60° - T = 0$

$(\mu_B \times N_B) + W \sin 60° - 716.50 = 0$

$(0.25 \times 0.50W) + 0.866W = 716.50$

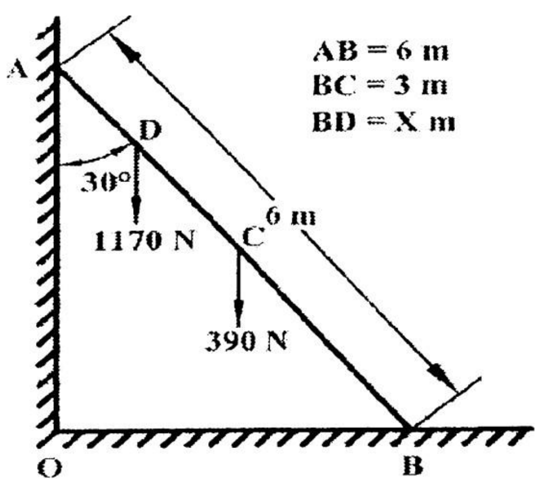
$0.125W + 0.866W = 716.50$

$\boxed{W = 723\ N}$

PART * C

1 **A ladder of weight 390 N and 6m long is placed against a vertical wall at an angle of 30° as shown in Fig.**

The co-efficient of friction between the ladder and the wall is 0.25 and between ladder and floor is 0.38. Find how high a man of weight 1170 N can climb without sliding.



BTL4 (May 2016)

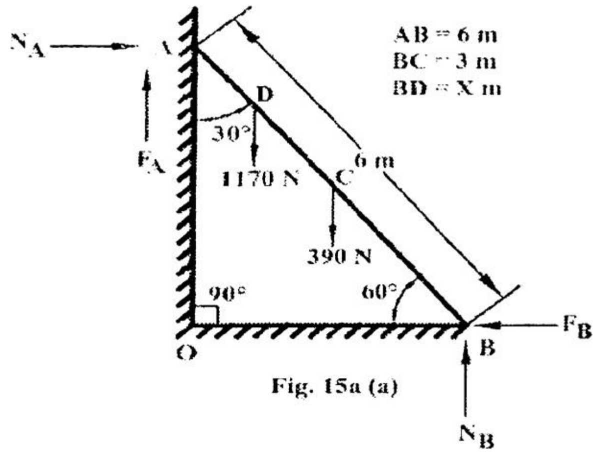


Fig. 15a (a)

$$\Sigma V = 0$$
$$N_B + F_A - 390 - 1170 = 0$$
$$N_B + F_A = 1560\ N \rightarrow (1)$$

$\Sigma H = 0$

$-F_B + N_A = 0$

$N_A = F_B \rightarrow (2)$

$\Sigma M_B = 0$

$\theta = 60^\circ$

$\text{Sin}60^\circ = \frac{OA}{AB} = \frac{OA}{6}$

$OA = 6 \times \text{Sin } 60^\circ = 5.196\text{m}$

$\text{Cos } 60^\circ = \frac{OB}{AB} = \frac{OB}{6}$

$OB = 6 \times \text{Cos } 60^\circ = 3\text{m}$

$$(-390\times3\times\text{Cos}60^\circ) + (-1170 \times x \times \text{Cos } 60^\circ)$$
$$+ (F_A \times 3) + (N_A \times 5.196) = 0$$
$$F_A = 0.25N_A$$
$$-585 - 585x + (0.25\times N_A\times3) + 5.196\ N_A = 0$$
$$-585 - 585x + 5.946\ N_A = 0 \rightarrow (3)$$

Eqn (1) $\Rightarrow$

$$N_B + F_A = 1560 \qquad (\because N_A = F_B)$$
$$\left(\frac{F_B}{0.38}\right) + (0.25\ N_A) = 1560$$
$$\left(\frac{N_A}{0.38}\right) + (0.25\ N_A) = 1560$$
$$2.882\ N_A = 1560$$
$$N_A = 541.29\text{N} \qquad \therefore N_B = 1424.68\text{N}$$

Eqn (3) $\Rightarrow F_A = 0.25N_A = 0.25\times541.29 = 135.34\text{N}$; $F_B = 541.29\text{N}$

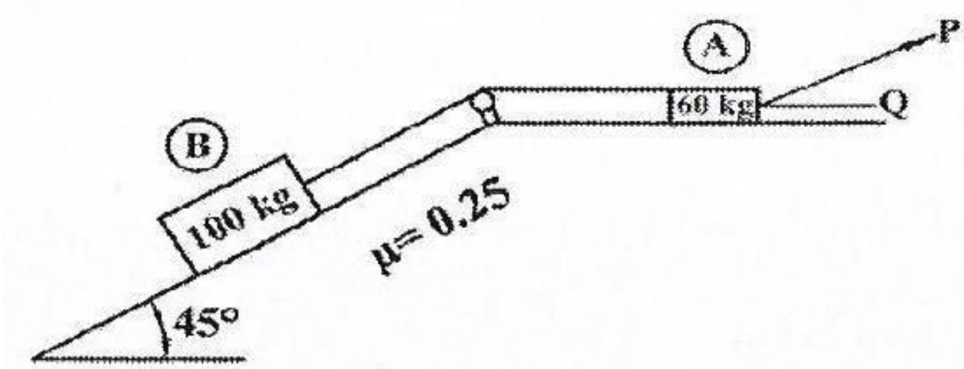
$$-585 - 585x + 5.946 \times 541.29 = 0$$
$$\mathbf{x = 4.502\ m}$$

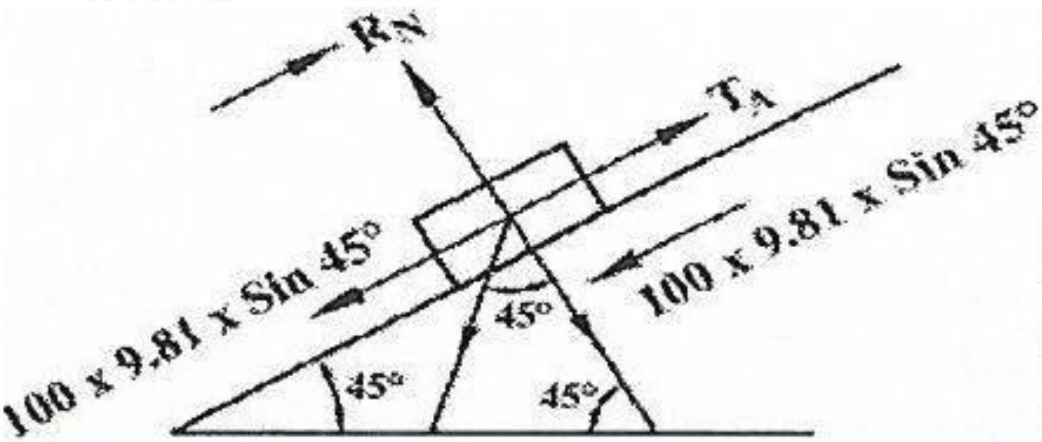
Answer : 1. The man can climb upto 4.502m from the foot of ladder.

2 **Two rough planes are joined together one of them is horizontal and the other is inclined at 45° to the horizontal. A 100 kg block is on the inclined plane and is connected to a 60 kg block on the horizontal plane through a cable passing over a smooth pulley at the junction of the planes. A dragging force of A is applied on 60 kg block at an angle of θ to the**

horizontal. Find the magnitude of the force and the value of ɵ for the motion is about to start. Assume μ = 0.25.

BTL4 (May 2015)





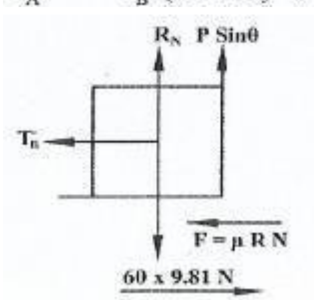
$\Sigma H = 0$

$T_A = 100 \times 9.81 \times \sin 45^\circ + \mu R_N$

$= 100 \times 9.81 \times \sin 45^\circ + 0.25 \times 693.67$

$T_A = 867.090$ N

$T_A = T_B$ ($\because$ *Pulley is smooth*)



Free body diagram of A

$T_B = 867.09$N

$\Sigma_H = 0$

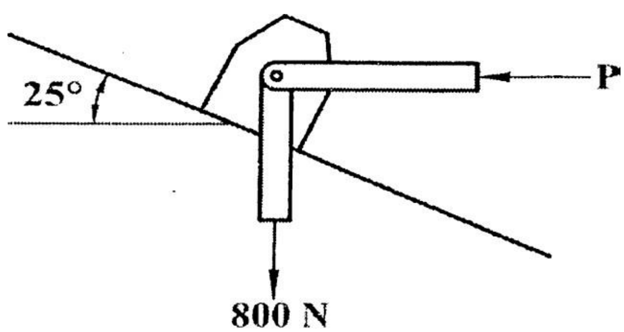
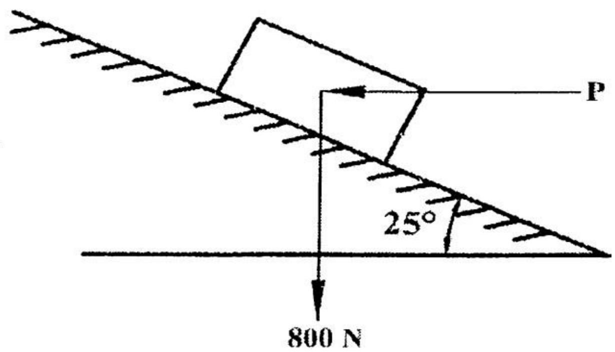
$T_B + \mu R_N = P \cos \theta$

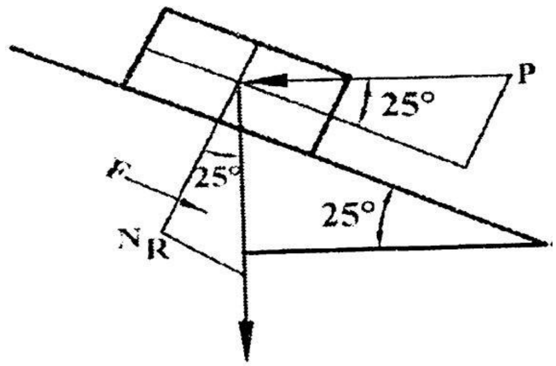
$\Sigma v = 0$

$R_N + P \sin\theta = 60 \times 9.81$

$R_N = (60 \times 9.81) - P \sin \theta$

$867.09 + 0.25 \times (60 \times 9.81 - P \sin\theta) = P \cos\theta$

	$867.090 + 147.15 - 0.25\ P\ Sin\theta = P\ Cos\theta$ $P\ Cos\theta + 0.25\ P\ Sin\theta = 1014.24$ $\frac{dP}{d\theta} = 0$ $-P\ Sin\theta + 0.25\ P\ Cos\ \theta = 0$ $P\ Sin\theta = 0.25\ P\ Cos\ \theta$ $tan\theta = 0.25$ $\boxed{\theta = 14.04°}$ $P\ Cos\ 14° + 0.25\ P\ Sin\ 14° = 1014.24$ $0.97\ P + 0.06\ P = 1014.24$ $\boxed{P = 984.70N}$
3	**A support block is acted upon by two forces as shown in fig. Knowing that the coefficients of friction between the block and the incline are μs = 0.35 and μk = 0.25, determine the force P required** **(i) To start the block moving up the incline (6)** **(ii) To keep it moving up (5)** **(iii) To prevent it from sliding down (4)**  **BTL4 (Nov 2014)**  **(i)** **The force P required to start the block moving up the incline FBD of Block:** $\Sigma F_x = 0$ $-P\ Cos\ 25° + 800\ Sin\ 25° + F = 0$ $F = P\ Cos\ 25° - 800\ Sin\ 25°$ $F = P\ Cos\ 25° - 338.09 \quad \rightarrow (1)$



$\Sigma F_y = 0$

$-P \text{ Sin } 25° - 800 \text{ Cos } 25° + N_R = 0$

$N_R = P \text{ Sin } 25 + 800 \text{ Cos } 25$

$N_R = P \text{ Sin } 25 + 725.05 \quad \rightarrow (2)$

But frictional force $F = \mu \times N_R$ where $\mu = \mu_s$

$F = \mu_s \times N_R = 0.35 \times N_R$

$\therefore N_R = \frac{F}{0.35}$

$\mathbf{N_R = 2.857\ F}$

Eqn (2) $\Rightarrow 2.857\ F = P \text{ Sin} 25° + 725.05 \quad \rightarrow (3)$

$$\frac{Eqn.(3)}{Eqn.(1)} \Rightarrow \frac{2.857 F}{F} = \frac{P\,Sin\,25° + 725.05}{P\,Cos\,25° - 338.09}$$

$2.857 \times (P \text{ Cos } 25° - 338.09) = P \text{ Sin } 25° + 725.05$

$2.589\ P - 965.92 = 0.423P + 725.05$

$2.166P = 1690.97$

$\boxed{P = 780.69N}$

(ii) The force P require to keep it moving up

$\Sigma F_x = 0$

$-P \text{ Cos } 25° + 800 \text{ Sin } 25° + F = 0$

$F = P \text{ Cos } 25° - 338.09 \quad \rightarrow (1)$

$\Sigma F_y = 0$

$-P \text{ Sin } 25° - 800 \text{ Cos } 25° + N_R = 0$

$N_R = P \text{ Sin } 25° + 725.05 \quad \rightarrow (2)$

$F = \mu_k x\ N_R = 0.25 \times N_R$

$\boxed{N_R = 4F}$

$\Sigma F_x = 0$

$-P \cos 25° + 800 \sin 25° - F = 0$

$F = -P \cos 25° + 338.09 \quad \rightarrow (1)$

$\Sigma F_y = 0$

$-P \sin 25° - 800 \cos 25° + N_R = 0$

$N_R = P \sin 25° + 800 \cos 25°$

$\therefore N_R = 2.857 F \quad \rightarrow (2)$

Eqn (2) $\Rightarrow 2.857 F = P \sin 25° + 725.05 \quad \rightarrow (3)$

$$\frac{Eqn.(3)}{Eqn.(1)} \Rightarrow \frac{2.857F}{F} = \frac{P \sin 25° + 725.05}{-P \cos 25° + 338.090}$$

$-2.589P + 965.92 = 0.423P + 725.05$

$-3.012 P = -240.87$

$\boxed{P = 79.97N}$

Answers:

1. To start the block moving up the include P = 780.69N
2. To keep it moving up P = 648.7N
3. To prevent it from sliding down P = 79.97N