JEPPIAAR INSTITUTE OF TECHNOLOGY

Self Belief | Self Discipline | Self Respect

QUESTION BANK

ACADEMIC YEAR : 2019-2020

REGULATION: 2013

IV YEAR – 08th SEMESTER

DEPARTMENT OF MECHANICAL ENGINEERING

INSTITUTION VISSION

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.

INSTITUTION MISSION

- 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 VISSION

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

DEPARTMENT MISSION

- To provide innovative solutions for industrial problems which 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 motivate lifelong learning.

PROGRAM OUTCOMES (POs) (Given in SAR)

Engineering Graduates will be able to:

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

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.

Program Educational Objectives (PEOs):

PEO 1: Have a successful career in Mechanical Engineering and allied industries.

PEO 2: Have expertise in the areas of Design, Thermal, Materials and Manufacturing.

PEO 3: Contribute towards technological development through academic research and industrial practices.

PEO 4: Practice their profession with good communication, leadership, ethics and social responsibility.

PEO 5: Graduates will adapt to evolving technologies through life-long learning.

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.

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OBJECTIVES:

To enable students to understand the fundamental economic concepts applicable to engineering and to learn the techniques of incorporating inflation factor in economic decision making.

UNIT I INTRODUCTION TO ECONOMICS 8

Introduction to Economics- Flow in an economy, Law of supply and demand, Concept of Engineering Economics – Engineering efficiency, Economic efficiency, Scope of engineering economics - Element of costs, Marginal cost, Marginal Revenue, Sunk cost, Opportunity cost, Break-even analysis - V ratio, Elementary economic Analysis – Material selection for product Design selection for a product, Process planning.

UNIT II VALUE ENGINEERING 10

Make or buy decision, Value engineering – Function, aims, Value engineering procedure. Interest formulae and their applications –Time value of money, Single payment compound amount factor, Single payment present worth factor, Equal payment series sinking fund factor, Equal payment series payment Present worth factor- equal payment series capital recovery factor - Uniform gradient series annual equivalent factor, Effective interest rate, Examples in all the methods.

UNIT III CASH FLOW 9

Methods of comparison of alternatives – present worth method Revenue dominated cash flow diagram, Future worth method Revenue dominated cash flow diagram, cost dominated cash flow diagram, Annual equivalent method Revenue dominated cash flow diagram, cost dominated cash flow diagram, rate of return method, Examples in all the methods.

UNIT IV REPLACEMENT AND MAINTENANCE ANALYSIS 9

Methods of comparison of alternatives – present worth method Revenue dominated cash flow diagram, Future worth method Revenue dominated cash flow diagram, cost dominated cash flow diagram, Annual equivalent method Revenue dominated cash flow diagram, cost dominated cash flow diagram, rate of return method, Examples in all the methods.

UNITV DEPRECIATION 9

Methods of comparison of alternatives – present worth method Revenue dominated cash flow diagram, Future worth method Revenue dominated cash flow diagram, cost dominated cash flow diagram, Annual equivalent method Revenue dominated cash flow diagram, cost dominated cash flow diagram, rate of return method, Examples in all the methods.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of this course, students will acquire the skills to apply the basics of economics and cost analysis to engineering and take economically sound decisions.

TEXTBOOKS:

1. Panneer Selvam, R, “Engineering Economics”, Prentice Hall of India Ltd, New Delhi,2001.

REFERENCES:

1. Chan S.Park, “Contemporary Engineering Economics”, Prentice Hall of India,2011.
2. Donald.G. Newman, Jerome.P.Lavelle, “Engineering Economics and analysis” Engg. Press, Texas, 2010.
3. Degarmo, E.P., Sullivan, W.G and Canada, J.R, “Engineering Economy”, Macmillan, New York,2011.
4. Zahid A khan: Engineering Economy, "Engineering Economy", DorlingKindersley,2012

Subject code:MG6863 Year/Semester :IV/08
Subject: ENGINEERINGECONOMICS Subject Handler:Mrs.I.SHARON MARISHKA

	UNIT I INTRODUCTIONTO ECONOMICS 8
	Introduction to Economics- Flow in an economy, Law of supply and demand, Concept of Engineering Economics – Engineering efficiency, Economic efficiency, Scope of engineering economics - Element of costs, Marginal cost, Marginal Revenue, Sunk cost, Opportunity cost, Break-even analysis - V ratio, Elementary economic Analysis – Material selection for product Design selection for a product, Process planning
	PART - A
Q.No	**Questions**
1.	**What is elasticity of demand?** BTL1 Elasticity of demand defined as the degree of responsiveness of quantity demanded to a change in price.
2.	**Define the term cost.** BTL1 Cost defined as a total of all expenses incurred, whether paid or outstanding, in the manufacture and sale of a product.
3.	**What is opportunity cost?** BTL1 Opportunity cost defined as the potential benefit that is given up as an alternative course of action is sought. In other words, the expected return of benefit for gone in rejecting one course of action for another.
4.	**What do you mean by marginal cost?** BTL1 The Institute of Costs and Works Accountants of India defined marginal cost as, "the amount at any given volume of output by which aggregate costs are changed, if the volume of output is increased or decreased by one unit".
5	**Explain marginal costing?** BTL1 Marginal costing is defined by the ICWA as, "the ascertainment by differentiating between fixed costs, and variable costs, of marginal costs and of the effect on profit of changes in volume or type of output".
6	**What is meant by marginal revenue?** BTL1 The revenue that can be obtained from selling one more unit of product is called marginal revenue.
7	**Give a short note on sunk cost.** BTL1,**M/J 2012** A cost which was incurred or sunk in the past and is not relevant to the decision-making is a sunk cost or sunk loss. It may be variable or fixed or both.
8	**List out the elements of cost.** BTL1 The elements of cost are • Materials • Labour • Expenses.
9	**Define the term costing**. BTL1 Institute of Costs and Management Accountants ICMA, London, has defined costing as the ascertainment costs. "It refers to the techniques and processes of ascertaining costs and studies the principles and rules concerning the determination of cost of products and services".
10	**Define break-even point.** BTL2 Level of sales at which total revenues, total costs are equal. It is a point at which the, profit is

	zero. It is also known as "no-profit **no-loss point".**
11	**What is fixed cost?** BTL1 Fixed cost means that the cost tends to be unaffected with the volume of output. Fixed cost depends upon the passage of time and does not vary directly with the volume of output. Example: rent and rates of factory buildings, insurance of buildings, depreciation of buildings, etc.
12	**Give a short note on variable cost.** BTL1 Variable cost tends to vary directly with the volume of output. It varies almost in direct proportion to the volume of production. If production increases, the costs will also increase and vice versa. Example: The cost of direct materials, direct labour, direct chargeable expenses such as power, repairs, etc,
13	**Define contribution.** BTL2 The difference between selling price and variable cost per unit is known as **contribution or contribution margin.** Contribution = Selling price(SP) - Variable cost(VC)
14	**What do you mean by margin of safety?** BTL2 Margin of safety is the difference between the existing level of output and the level of output at BEP. Greater value of margin of safety means higher profits to the firm. If the safety margin is low, then the firm runs the risk of incurring losses.
15	**Define P/V Ratio.** BTL2 P/V Ratio = Contribution Sales
	PART * B
1	**Explain in detail about flow in an economy? (13M)** BTL3 **Answer : Page 1.4 - Dr.S.Senthil** **Economics -** is a study of economic problems of the people concerning production, consumption, exchange and distribution of wealth. Economics is the science that deals with the production and consumption of goods and services and the distribution and rendering of these for human welfare. The following are the economic goals. • A high level of employment • Price stability • Efficiency • An equitable distribution of income (5M) **Flow in economy:** The flow of goods, services, resources and money payments in a simple economy • Households and businesses are the two major entities in a simple economy. • Business organizations use various economic resources like land, labour and capital which are provided by households to produce consumer goods and services which will be used by them. • Business organizations make payment of money to the households for receiving various resources. • The households in turn make payment of money to business organizations for receiving consumer goods and services.

	• This cycle shows the interdependence between the two major entities in a simple economy. (8M)
2	**Explain the concept of law of supply and demand with suitable example. (13M)** BTL2 **Answer : Page1.6 - Dr.S. Senthil** **Laws of supply -** states that the quantity of a commodity supplied varies directly with the price, other determinants of supply remaining constant. **Factors influencing supply** The shape of the supply curve is affected by the following factors: • Cost of the inputs • Technology • Weather • Prices of related goods (3**M)** **Law of demand** states that other things being equal demand when price falls and contracts when price rises. **Market demand** is the total quantity demanded by all the purchasers together. **Elasticity of Demand** - Elasticity of demand may be defined as the degree of responsiveness of quantity demanded to a Change in price. • An interesting aspect of the economy is that the demand and supply of a product are interdependent and they are sensitive with respect to the price of that product. • Also, the product is more in demand and hence the demand of the product increases. • At the same time, lowering of the price of the product makes the producers restrain from releasing more quantities of the product in the market. • Hence, the supply of the product is decreased. The point of intersection of the supply curve and the demand curve is known as the equilibrium point.

	• At the price corresponding to this point, the quantity of supply is equal to the quantity of demand. Hence, this point is called the equilibrium point. **(5M)** **Factors influencing demand** The shape of the demand curve is influenced by the following factor • Income of the people • Prices of related goods • Tastes of consumers (5M)
3	**Classify and explain about element of cost. (13M)** BTL3 **Page 1.17- Dr.S.Senthil** **Elements of Costs** The cost classified into **variable cost and overhead cost**. Variable cost varies with the volume of production while overhead cost is fixed, irrespective of the production volume. Variablecostcanbefurtherclassifiedintodirectmaterialcost,directlabourcost, and direct expenses. The **overhead cost** classified into factory overhead, administration overhead, selling overhead, and distribution overhead. **Factory Overhead** cost is the aggregate of indirect material costs, indirect labour costs and indirect expenses. **Administration overhead** includes all the costs that are incurred in administering the business. **Selling overhead** is the total expense that is incurred in the promotional activities and the expenses relating to sales force. **Distribution overhead** is the total cost of shipping the items from the factory site to the customer sites**.** (7M) **Other Costs/Revenues** The following are the costs/revenues other than the costs which are presented in the previous section: 1. Marginal cost 2. Marginal revenue 3. Sunk cost 4. Opportunity cost **1. Marginal Cost** Marginal cost of a product is the cost of producing an additional unit of that product. Let the cost of producing 20 units of a product be Rs. 10,000, and the cost of producing 21 units of the same product be Rs. 10,045. Then the marginal cost of producing the 21st unit is Rs. 45. **2. Marginal Revenue** Marginal revenue of a product is the incremental revenue of selling an additional unit of that product. **3. Sunk Cost** The past cost of an equipment/asset. So, the purchase value of the equipment in the past is known as its sunk cost.

	4**. Opportunity Cost** In practice, if an alternative X is selected from a set of competing alternatives X,Y , then the corresponding investment in the selected alternative is not available for any other purpose. If the same money is invested in some other alternative Y , it may fetch some return. Since the money is invested in the selected alternative X , one has to forego the return from the other alternative Y. The amount that is foregone by not investing in the other alternative Y is known as the opportunity cost of the selected alternative X . So, the opportunity cost of an alternative is the return that will be foregone by not investing the same money in another alternative. (6M)
4	**Derive the selling prince in detail.(13M)** BTL4 **Page 1.18 -Dr.S.Senthil** The selling price of a product is derived as shown below: 1. Direct material costs + Direct labour costs + Direct expenses = Prime cost 2. Prime cost + Factory overhead = Factory cost 3. Factory cost + Office and administrative overhead = Costs of production **4.** Cost of production + Opening finished stock – Closing finished stock = Cost of goods sold **(8M)** 5. Cost of goods sold + Selling and distribution overhead = Cost of sales 6. Cost of sales + Profit =Sales 7. Sales/Quantity sold = Selling price per unit In the above calculations, if the opening finished stock is equal to the closing finished stock, then the cost of production is equal to the cost of goods sold. (**5M)**
5	**Explain the concept of breakeven analysis with clear diagram.(13M)** BTL4 **Page 1.31 -Dr.S.Senthil** **Break-Even Analysis** The main objective of break-even analysis is to find the cut-off production volume from where a firm will make profit. Let • s = selling price per unit • v = variable cost per unit • FC = fixed cost per period • Q = volume of production The total sales revenue S of the firm is given by the following formula: S=s Q The total cost of the firm for a given production volume is given as TC = Total variable cost + Fixed cost =v Q +FC The linear plots of the above two equations are shown in Fig. . The intersection point of the total sales revenue line and the total cost line is called the break-even point. The corresponding volume of production on the X-axis is known as the break-even sales

	quantity. At the intersection point, the total cost is equal to the total revenue. This point is also called the no-loss or no-gain situation. For any production quantity which is less than the break-even quantity, the total cost is more than the total revenue**.** (7M) Hence, the firm will be making loss. (6M)

For any production quantity which is more than the break-even quantity, the total revenue will be more than the total cost. Hence, the firm will be making profit.

Profit = Sales – (Fixed cost + Variable costs)

$= s \quad Q - (FC + v \quad Q)$

The formulae to find the break-even quantity and break-even sales quantity

$$\text{Break-even quantity} = \frac{\text{Fixed cost}}{\text{Selling price/unit} - \text{Variable cost / unit}}$$

$$= \frac{FC}{s\text{-}v} \text{ (inunits)}$$

$$\text{Break-even sales} = \frac{\text{Fixed cost}}{\text{Selling price/ unit} - \text{Variable cost / unit}} \times \text{Selling price/unit}$$

$$= \frac{FC}{s - v} \times s \text{ (Rs.)}$$

The contribution is the difference between the sales and the variable costs. The margin of safety (M.S.) is the sales over and above the break-even sales. The formulae to compute these values are

Contribution = Sales – Variable costs

Contribution/unit = Selling price/unit – Variable cost/unit

M.S. = Actual sales – Break-even sales

$$= \frac{\text{Profit}}{\text{Contribution}} \times \text{sales}$$

M.S. as a per cent of sales = (M.S./Sales) 100

(7M)

PART * C

1

Definition and Explain the Scope of Engineering Economics. (15M) BTL3

Page 1.13 - Dr.S.Senthil

Definition

Engineering economics deals with the methods that enable one to take economic decisions towards minimizing costs and/or maximizing benefits to business organizations. (3M)

Scope

The issues that are covered in this book are elementary economic analysis, interest formulae, bases for comparing alternatives, present worth method, future worth method, annual equivalent method, rate of return method, replacement analysis, depreciation, evaluation of public alternatives, inflation adjusted investment decisions, make or buy decisions, inventory control, project management, value engineering, and linear

programming.

Economic efficiency % = $\frac{\text{Output}}{\text{Input}} \times 100 = \frac{\text{Worth}}{\text{Cost}} \times 100$

Worth is the annual revenue generated by way of operating the business and cost is the total annual expenses incurred in carrying out the business.

For the survival and growth of any business, the economic efficiency should be more than 100%.Economic efficiency is also called productivity.

There are several ways of improving productivity. (7M)

Increased output for the same input

- Decreased input for the same output
- By a proportionate increase in the output which is more than the proportionate increase in the input
- By a proportionate decrease in the input which is more than the proportionate decrease in the output **(5M)**

2

Bring out the concept and types of efficiency of engineering economics. (15M) BTL3
Page 1.12 -Dr.S.Senthil

Concept of Engineering Economics

Science is a field of study where the basic principles of different physical systems are formulated and tested. Engineering is the application of science. It establishes varied application systems based on different scientific principles.

From the discussions in the previous section, price has a major role in deciding the demand and supply of a product.

Hence, from the organizations point of view, efficient and effective functioning of the organization would certainly help it to provide goods/services at a lower cost which in turn will enable it to fix a lower price for its goods or services. (5M)

Types of Efficiency

Efficiency of a system is generally defined as the ratio of its output to input. The efficiency can be classified into technical efficiency and economic efficiency.

Technical efficiency

It is the ratio of the output to input of a physical system. The physical system may be a diesel engine, a machine working in a shop floor, a furnace, etc.

Technical efficiency % = $\frac{\text{Output}}{\text{Input}} \times 100$

The technical efficiency of a diesel engine is as follows:

$$\text{Technical efficiency\%} = \frac{\text{Heat equivalent of mechanical energy produced}}{\text{Heat equivalent of fuel used}} \times 100$$

In practice, technical efficiency can never be more than 100%.

This is mainly due to frictional loss and incomplete combustion of fuel, which are unavoidable phenomena in the working of a diesel engine.

Economic efficiency

Economic efficiency is the ratio of output to input of a business system. (10M)

3

A part of a Machine has a yearly demand of 3000 units. The different costs in respect of make or buy are as given below.

	Buy	Make
Item cost/unit	**Rs10.00**	**Rs.8.00**
Procurement cost/order		**Rs.80.00**
Setup cost/Set-up	**Rs.2.00**	**Rs.1.50**
		10,000 units

Determine the best option.(15M) BTL3

Page 2.7 -Dr.S.Senthil

Buy option : given D = 3000 units/year

Co = Rs. 150/order

Cc = Rs.2.00/item/year

P = Rs.10/unit

Q_1 = root of(2 CoD/Cc) = 870.82 units

$TC = DP + DCo/Q_1 + Q_1Cc/2$

= 30000+670.82+670.82

=Rs.31341.64 (7M)

Make Option:

Co = Rs. 80/setup

R = 3000units/year

Cc = Rs.1.50 units/year

K = 10,000 units/year

P =Rs.8.00

Find : $TC= D*P+(DCo/Q_2 + Cc(k-r)Q_2/2*k$

Q_2 = root of (2 Cor)/Cc[1-(r/k)] =676.12

$Tc = D*P+(DCo/Q_2 + Cc(k-r)Q_2/2*k$

= 24,000+354.97 + 354.96 =Rs24,709.93 (8M)

Result: The cost of making the item is less than the cost of purchasing. Therefore, the option is to make the part of the machine.

Subject code:MG6863 **Year/Semester :IV/08**
SubjectENGINEERINGECONOMICS **Subject Handler:Mrs.I.SHARON MARISHKA**

	UNITII VALUE ENGINEERING	**10**
	Make or buy decision, Value engineering – Function, aims, Value engineering procedure. Interest formulae and their applications –Time value of money, Single payment compound amount factor, Single payment present worth factor, Equal payment series sinking fund factor, Equal payment series payment Present worth factor- equal payment series capital recovery factor - Uniform gradient series annual equivalent factor, Effective interest rate, Examples in all the methods.	
	PART * A	
Q.No	**Questions**	
1.	**What do you mean by, Make or Buy Decisions?** BTL1 Make or buy decision is a determination whether to produce a component part internally or to buy it from an outside supplier. The organization should evaluate the costs and benefits of manufacturing a product or product component against purchasing it and then select the alternative which results in the lower cost.	
2.	**What are the different approaches followed in make or buy decisions?** BTL1 • Simple cost analysis • Economic analysis • Break-even analysis.	
3.	**What is time value of money.** BTL1 The economic value of a sum depends on when it is received. Because money has earning power over time, a rupee received today has a greater value then a rupee received at some future time.	
4.	**What do you understand by value of a product?** BTL3 Value differs from both price and cost in the sense that it is the cost proportionate to the function. We can express value mathematically as Value= Function or utility /Cost.	
5	**Explain function.** BTL2 Function specifies the purpose of the product or what the product does, what is its utility etc.,	
6	**What are the various functions of a product?** BTL1 Functions can be classified into the following three categories: • Primary functions • Secondary functions • Tertiary functions..	
7	**What is Economic equivalence?**BTL1 It refers to the fact that a cash flow whether a single payment or a series of payments can be converted to an equivalent cash flow at any point of time.	
8	**What are the various types of values?** BTL1 • Cost value • Exchange value • Use value • Esteem value.	
9	**Write any four objectives of value analysis.** BTL1	

	Simplify the product, Use (new) cheaper and better materials and Modify and improve product design so as to make it acceptable to consumer.
10	**Differentiate value analysis and value engineering.** BTL1
11	**What is sinking fund factor?** BTL3 The factor $i/(1+i)^N - 1$ is called the equal payment series sinking fund factor or sinking fund factor, and is referred to by the notation (A/F, i, N). A sinking fund is an interest-bearing account into which a fixed sum is deposited each interest period it is commonly established for replacing fixed assets.
12	**What is capital recovery factor?** BTL3 The factor $i(1+i)^N/(1+i)^N - 1$ is called the equal payment series capital recovery f actor, or simply capital recovery factor, which is designated (A/P, i, N). In finance this A/P factor is referred to as the annuity factor. The annuity factor indicates a series of payments of a fixed, or constant, amount for a specified number of periods.
13	**What is effective interest rate?** BTL3. The formula to compute effective interest rate is $R = (1+i/C)^C - 1$ Where i = the nominal interest rate C = the number of interest periods in a year.
14	**Explain the concept of Discounting?** BTL3 Finding the present worth of a future sum is simply the reverse of compounding and is known as discounting process. (P/F, i, N) is the factor notation for single payment present worth factor. The interest rate I and the P/F factor are also referred to as the discount rate and discount factor, respectively.
15	**What is uniform gradient conversion?** BTL4 The factor is called the uniform gradient factor or the gradient to equal payment series conversation factor and is designated (A/G, i, N). The future sum of annual equal payments at the end of every year for N years is equal to the total amount of gradient series at the end of N years.

	PART * B
1	**Explain in detail about criteria for make or buy decision and its approaches. (13M)** BTL2 **Answer : Page 2 - Dr.S.Senthil**
	CRITERIA FOR MAKE OR BUY In this section the criteria for make or buy are discussed. **Criteria for make** The following are the criteria for make: 1. The finished product can be made cheaper by the firm than by outside suppliers. 2. The finished product is being manufactured only by a limited number of outside firms which are unable to meet the demand. 3. The part has an importance for the firm and requires extremely close quality control. 4. The part can be manufactured with the firm's existing facilities and similar to other items in which the company has manufacturing experience. (5M) **Criteria for buy** The following are the criteria for buy: 1. Requires high investments on facilities which are already available at supplier's plant. 2. The company does not have facilities to make it and there are more profitable opportunities for investing company's capital. 3. Existing facilities of the company can be used more economically to make other parts. 4. The skill of personnel employed by the company is not readily adaptable to make the part. 5. Patent or other legal barriers prevent the company for making the part. 6. Demand for the part is either temporary or seasonal. (5M) **APPROACHES FOR MAKE OR BUY DECISION** Types of analysis followed in make or buy decision are as follows: 1. Simple cost analysis 2. Economic analysis 3. Break-even analysis (3M)

2	**What are all the functions, aims of value engineering? Discuss the value engineering procedure ? (13M)** BTL2 **Answer : Page 2.18 - Dr.S.Senthil** **INTRODUCTION** Value analysis is one of the major techniques of cost reduction and cost prevention. It is a disciplined approach that ensures necessary functions for minimum cost without sacrificing quality, reliability, performance, and appearance. According to the Society of American Value Engineers (SAVE), Value Analysis is the systematic application of recognized techniques which identify the function of a product or service, establish a monetary value for the function and provide the necessary function reliably at the lowest overall cost. It is an organized approach to identify unnecessary costs associated with any product, material part, component, system or service by analysing the function and eliminating such costs without impairing the quality, functional reliability, or the capacity of the product to give service (5M) **WHEN TO APPLY VALUE ANALYSIS** One can expect very good results by initiating a VA programme if one or more of the following symptoms are present: Company‘s products show decline in sales. Company ‘s prices are higher than those of its competitors. Raw materials cost has grown disproportionate to the volume of production. New designs are being introduced. The cost of manufacture is rising disproportionate to the volume of production. Rate of return on investment has a falling trend. Inability of the firm to meet its delivery commitments. **Value** The term value is used in different ways and, consequently, has different meanings. The designer equates the value with reliability; a purchase person with price paid for the item; a production person with what it costs to manufacture, and a sales person with what the customer is willing to pay**.** (4M) **Example** **Cost value**. It is the summation of the labour, material, overhead and all other elements of cost required to produce an item or provide a service compared to a base. **Exchange value**. It is the measure of all the properties, qualities and features of the product, which make the product possible of being traded for another product or for money. **Value analysis/value engineering** It is a special type of cost reduction technique. It critically investigates and analyses the different aspects of materials, design, cost and production of each component of the product in produce it economically without decreasing its utility, function or reliability. **Applications** The various application areas of value engineering are machine tool industries, industries making accessories for machine tools, auto industries, import substitutes, etc.(4M)

3	**A company has extra capacity that can be used to produce a sophisticated fixture which it has been buying for Rs. 900 each. If the company makes the fixtures, it will incur materials cost of Rs. 300 per unit, labour costs of Rs.250 per unit, and variable overhead costs of Rs. 100 per unit. The annual fixed cost associated with the unused capacity is Rs. 10,00,000. Demand over the next year is estimated at 5,000 units. Would it be profitable for the company to make the fixtures?(13M)**BTL2 **Answer : Page 2.51 - Dr.S.Senthil** We assume that the unused capacity has alternative use. Cost to make Variable cost/unit = Material + labour + overheads = Rs. 300 + Rs. 250 + Rs. 100 = Rs. 650 Total variable cost = (5,000 units) (Rs. 650/unit) =Rs.32,50,000 (5M) Add fixed cost associated with unused capacity + Rs. 10,00,000 Totalcost = Rs.42,50,000 Cost to buy Purchasecost = (5,000 units)(Rs.900/unit) = Rs. 45,00,000 Add fixed cost associated withunused capacity + Rs.10,00,000 Totalcost =Rs. 55,00,000 (8M) The cost of making fixtures is less than the cost of buying fixtures from outside. Therefore, the organization should make thefixtures.
4	**Mr. Senthil wished to realise Rs15,000 after 15 years. He plans to interest an equal amount in a bank 11% interest rate compounded annually. What would be the equal amount he should invest at the end of each year for the next 15 years. (13M)** BTL2 **Answer : Page 2.41-Dr.S.Senthil** Given : F = Rs 15,000 N = 20 years i = 11% The formula to get equal amount A is $A= F\left[\frac{i}{(l+i)N-1}\right]=F(A/F,I,N)$ (5M) A = 1500000(A/F,11%,20) = 15000000(0.0156) = Rs.23,400 (8M)
5	**Mr john deposits sum of Rs. 10,000 in a bank at a nominal interest rate of 12% for 10 years. The compounding is quarterly. Find the maturity amount of the deposit after 10 years.(13M)** BTL2 **Answer : Page 2.24 - Dr.S.Senthil** Given : F = Rs 10,000 N = 10 years i = 12%(nominal interest rate)

Number of interest periods per year = 4
Number of interest periods in 10 years = 10*4 = 40
N = 40
R = 12%/4
= 3% compounded quarterly
The formula to find maturity value (F) is =F =$P(1+R)^N$ (5M)
= $10000(1+0.03)^{40}$
=Rs.32,620.38 (8M)

PART *C

1

An item has a yearly demand of 2,000 unit.The different costs in respect of make and buy are as follows.Determinte the best option.(15M) BTL2
Answer : Page 2.4 -Dr.S.Senthil

(6M)

(9M)

2

There are three alternatives available to meet the demand of a product. They are as follows:

Particulars	**Manufacturing the product by Process A in Rs.**	**Manufacturing the product by Process B**	**Buy**
Fixed cost/year	**1,00,000**	**3,00,000**	
Variable cost/unit	**75**	**70**	
Purchase/Unit			**80**

	The annual demand of the product is 10,000 units. **A) Should the company make the product using process A or Process B or butit?** **B) At what annual volume should be company switch from buying to manufacturing the product by using processA?** **C) At what annual volume should the company switch from process A toB** **(15M)** BTL2 **Answer : Page 2.35 - Dr.S.Senthil** Annual cost of Process A: Given: FC = Rs. 1,00,000 VC Rs. 75/unit To find :TC Variable cost = 7,50,000(10000 units*75) Fixed cost =1,00,000 --- Totalcost = 8,50,000 --- Annual cost of ProcessB: Variable cost = 7,00,000 (10000 units*70) Fixed cost =3,00,000 --- Totalcost =10,00,000 --- (7M) **Annual cost of buy** **Given :** Annual Demand = 10,000 units Purchaseprice =Rs.80/Unit To find : TC Annual cost of buy = Purchase price /unit * Volume =80*10,000 B) Given FC = Rs.1,00,00, SP =Rs.80/Unit , VC =Rs.75/Unit To find :BEP = $\frac{FC}{SP-VC} = \frac{1,00,000}{80-75}$= 20,000Units Result: 20,000 Units is the point at which the company should select the make option by using process A C) Given FC = Rs.3,00,00, SP =Rs.80/Unit , VC =Rs.70/Unit To find :BEP = $\frac{FC}{SP-VC} = \frac{3,00,000}{80-70}$=30,000Units (8M) Result: 30,000 Units the company can switch from process A to B
3	**A person deposited a sum of Rs.2000 at the rate of 10% compounded annually for 8 years. Find the maturity value after 8 years. (15M)** BTL2 **Answer : Page 2.9 -Dr.S.Senthil** Given : P = Rs. 2000 I = 10% compounded annually N = 8 years To find: F The formula to obtain the future value (F) is

	$F = P(1+i)^N$ $=P(F/P,I,N)$ $F = 2000(F/P,10\%,8)$ $= 2000(2.144) =$R.s 4289	(7M) (8M)

Subject code:MG6863 **Year/Semester :IV/08**
Subject: ENGINEERINGECONOMICS **Subject Handler: Mrs.I.SHARON MARISHKA**

	UNITIII CASH FLOW	**9**
	Methods of comparison of alternatives – present worth method (Revenue dominated cash flow diagram), Future worth method (Revenue dominated cash flow diagram, cost dominated cash flow diagram), Annual equivalent method (Revenue dominated cash flow diagram, cost dominated cash flow diagram), rate of return method, Examples in all the methods.	
	PART * A	
Q.No	**Questions**	
1.	**What is revenue dominated cash flow?** BTL1 The profit/revenue, salvage value of all inflows to an organization will be assigned with positive sign and the cost outflows will be assigned with negative sign and this is called revenue dominated cash flow.	
2.	**What is cash dominated cash flow?** BTL2 The cost outflows will be assigned with positive sign and the profit, revenue, salvage value, all inflows etc., will be assigned with negative sign and this is called cost dominated cash flow.	
3.	**What is annual equivalent method of comparing alternatives?** BTL1 In the case of revenue dominated cash flow, the corresponding annual equivalent revenues are to be computed and compared, then the alternative with the maximum annual equivalent revenue should be selected as the best alternative. In case of cost dominated cash flow the corresponding annual equivalent costs are to be computed and compared, then the alternative with the minimum annual equivalent cost should be selected as the best alternative	
4.	**Mention the various rate of return methods.** BTL2 • Internal rate of return(IRR) • Average rate of return(ARR) • Net present value method(NPV) • d. Pay-back period(PBP).	
5	**What is rate of return?** BTL1 Rate of return is the break-even interest rate, i, which equates the present worth of a project's cash outflows to the present worth of its cash inflows.	
6	**What is present worth method?** BTL3 The present worth measures the surplus in an investment project at time zero (0). The present worth of all cash inflows is computed against the present worth of all cash outflows associated with an investment of project is called present worth method.	
7	**What is future worth analysis?** BTL2 Net future worth measures the surplus at a time other than 0. Future worth analysis is particularly useful in an investment situation where we need to compute the equivalent with of a project at the end of its investment period.	
8	**What is annual equivalent method?** BTL1 The criterion provides a basis for measuring investment worth by determining equal payments on an annual basis is called annual equivalent method.	

9	**Write down the techniques for comparing the worthiness of a project.** BTL1 • Net present value methods • Rate of return methods • Ratio methods • Pay back methods • Annual equivalent methods • f. Future worth method.
10	**Define IRR.** BTL2 IRR (Internal Rate of the Return) is the rate of return at which total present value of Future cash inflow is equal to initial investment. The rate of return is generally found by trial and error method.
11	**Define MARR.** BTL1 MARR (Minimum Attractive Rate of Return) represents the required or minimum interval rate of return for a project. The MARR is a minimum return the company will accept on the money it invests.
12	**What are the advantages of Rate of Return method?** BTL1 The advantages of Rate of Return method are: • It is easy to understand and operate • It uses the entire earnings of an investment proposal, unlike the payback period method. • It gives a clear picture of the profitability of a project.
13	**What are the disadvantages of Rate of Return method?** BTL3 The disadvantages of Rate of Return method are: • Ignores the time value of the money and treats all incomes same irrespective of their time of receipt. • Reliability is affected due to the various concepts of investment. • Cash flow aspect of projects is not properly assessed. • Not useful to assess projects where investment is made in two or more installments at different times.
14	**What is the time value of money?** BTL1 The economic value of a sum depends on when it is received. Because money has earning power over time, (it can be put to work, earning more money for its owner), a rupee received today has a greater value than a rupee received at some future time.
	PART * B
1	**Explain the concept of cash flow and different methods of comparison of alternatives. List the merits and limitations of each method if any.(13M)** BTL2 **(May/June2013)** **Answer : Page 3 -Dr.S. Senthil** In most of the practical decision environments, executives will be forced to select the best alternative from a set of competing alternatives. Let us assume that an organization has a huge sum of money for potential investment and there are three different projects whose initial outlay and annual revenues during their lives are known. The executive has to select the best alternative among these three competing projects. There are several bases for comparing the worthiness of the projects. These bases are: 1. Present worth method 2. Future worth method 3. Annual equivalent method 4. Rate of return method**.** **(3M)**

	PRESENT WORTH METHOD In this method of comparison, the cash flows of each alternative will be reduced to time zero by assuming an interest rate *i*. Then, depending on the type of decision, the best alternative will be selected by comparing the present worth amounts of the alternatives. In a cost dominated cash flow diagram, the costs (outflows) will be assigned with positive sign and the profit, revenue, salvage value (all inflows), etc. will be assigned with negative sign. In a revenue/profit-dominated cash flow diagram, the profit, revenue, salvage value (all inflows to an organization) will be assigned with positive sign. The costs (outflows) will be assigned with negative sign. **(4M)** **Revenue-Dominated Cash Flow Diagram** A generalized revenue-dominated cash flow diagram to demonstrate the present worth method of comparison is presented in Fig. To find the present worth of the above cash flow diagram for a given interest rate, the formula is $PW(i)$ $= -P + R1[1/(1 + i)1] + R2[1/(1 + i)2] + ... + Rj\ [1/(1 + i)\ j] + Rn[1/(1 + i)n] + S[1/(1 + i)n]$ **Cost-Dominated Cash Flow Diagram** A generalized cost-dominated cash flow diagram to demonstrate the present worth method of comparison is presented in Fig. To compute the present worth amount of the above cash flow diagram for a given interest rate *i*, we have the formula $PW(i) = P + C1[1/(1 + i)1] + C2[1/(1 + i)2] + ... + Cj[1/(1 + i)\ j]$ $+ Cn[1/(1 + i)n] - S[1/(1+i)n]$ **(6M)**
2	**Alpha Industry is planning to expand its production operation. It has identified three different technologies for meeting the goal. The initial outlay and annual revenues with respect to each of the technologies are summarized in Table 1. Suggest the best technology which is to be implemented based on the present worth method of comparison assuming 20% interest rate, compounded annually.(13M)** BTL2 **Answer : Page 3.35 - Dr.S.Senthil**

In all the technologies, the initial outlay is assigned a negative sign and the annual revenues are assigned a positive sign.

TECHNOLOGY 1

Initial outlay, P = Rs. 12,00,000 Annual revenue, A = Rs. 4,00,000 Interest rate, i = 20%, compounded annually Life of this technology, n = 10 years

The cash flow diagram of this technology is as shown in Fig. 1

The present worth expression for this technology is

PW(20%)1 = –12,00,000+4,00,000 (P/A, 20%, 10) = –12,00,000 +4,00,000 (4.1925) = –12,00,000 + 16,77,000 =Rs. 4,77,000 **(6M)**

TECHNOLOGY 2

Initial outlay, P = Rs. 20,00,000 Annual revenue, A = Rs. 6,00,000 Interest rate, I = 20%, compounded annually Life of this technology, n = 10 years The cash flow diagram of this technology is shown in Fig.2

The present worth expression for this technology is

PW(20%)2 = – 20,00,000+6,00,000 (P/A, 20%, 10) = – 20,00,000 +6,00,000 (4.1925) = – 20,00,000 + 25,15,500 = Rs. 5,15,500

TECHNOLOGY 3

Initial outlay, P = Rs. 18,00,000 Annual revenue, A = Rs. 5,00,000 Interest rate, I = 20%,

compounded annually Life of this technology, n = 10 years The cash flow diagram of this technology is shown in Fig.3

The present worth expression for this technology is
PW(20%)3 = –18,00,000+5,00,000 (P/A, 20%, 10) = –18,00,000 +5,00,000 (4.1925) = –18,00,000 + 20,96,250 = Rs. 2,96,250
From the above calculations, the present worth of technology 2 is the highest among all the technologies. Therefore, technology 2 is suggested for implementation to expand the production. **(7M)**

3

RATE OF RETURN METHOD

The rate of return of a cash flow pattern is the interest rate at which the present worth of that cash flow pattern reduces to zero.

A In this method of comparison, the rate of return for each alternative is computed. Then the alternative which has the highest rate of return is selected as the best alternative.(13M) BTL2

Answer : Page 3.88 - Dr.S. Senthil

A generalized cash flow diagram to demonstrate the rate of return method of comparison is presented

(6M)

In the above cash flow diagram, *P* represents an initial investment, *Rj* the net revenue at the end of the *j*th year, and *S* the salvage value at the end of the *n*th year.

The first step is to find the net present worth of the cash flow diagram using the following expression at a given interest rate, *i*.

$PW(i) = -P + R1/(1 + i)1 + R2/(1 + i)2 + ... + Rj/(1 + i)\,j + ... + Rn/(1 + i)n + S/(1 + i)n$

(7M)

4

An engineer is considering two types of pressure sensors for a low-pressure steam line. The costs are shown below which should be selected based on a present worth comparison at an interest rate of 16% per year?

	Type X	**Type Y**
First cost	**Rs.76,000**	**Rs.1,29,000**
Maintenance cost/year	**Rs.12,000**	**Rs.9,000**
Salvage value	**0**	**20,000**

Life, years	**2**	**4**

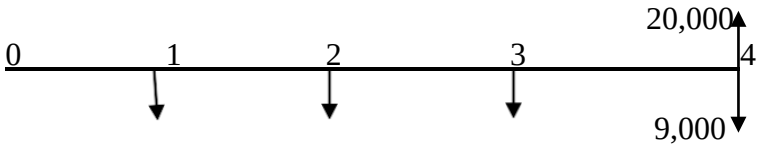
(13M) BTL2
Answer : Page 3.18 - Dr.S. Senthil
Type X:
First cost = Rs. 76,500
Maintenance cost/year = Rs.12,000
Salvage value =0
Interest rate = 16%

To find: PWx(16%)
The cash diagram of Type X is shown in Figure

12,000 12,000
75,000
Cash flow diagram for the plan

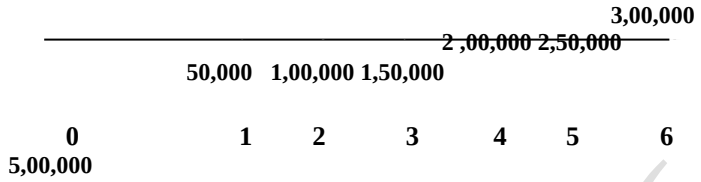
PWx(16%) = 76,000+12,000(P/A,16%.2)
= 76,000+12,000*19,262.40
= Rs.95,262.40
Type Y :
Given: First cost = Rs.1,29,000
Maintenance cost/year =Rs.9,000
Salvage value = 20,000
Life = 4years
Interest rate = 16%

To find: PW_Y (16%)
The cash flow of Type Y is shown is figure



Cash flow diagram for the plan

PW_Y(16%) = 1,29,000+(P/A,16%,4)–20,000(P?F,16%,4) **(7M)**
= 1,29,000+9,000*2.7982 – 20,000*0.5523
= 1,29,000 + 25183.8-11,046
= Rs.1,43,137.8
Result: The present worth of this optionisRs.1,43,137.8 **(6M)**

5	**For the given diagram, determine the future worth method assuming interest rate of 9% compounded annually and comment. (13M)** BTL2 **Answer : Page 3.37 - Dr.S. Senthil**  **Given: P =Rs.5,00,000** **A_1 = Rs.50,000** **G = Rs.50,000** **n = 6 years** **i= 9%** To find: FW(9%) FW(9%)=-P(F/P,9%,6)+[A_1+G(A/G,9%,6]*(F/A,9%,6) **(6M)** = 5,00,000(1.611)+[50,000+50,000(2,2498]*7.523 = -8,38,500 + 12,22,412.27 = Rs.3,83,912.27 Result: The future worth of the given diagram is feasible because it is more than 0. **(7M)**
	PART *C
1	**A company provides a car to its chief executive. The owner of the company is concerned about the increasing cost of petrol. The cost per litre of petrol for the first year of operation is Rs. 21. He feels that the cost of petrol will be increasing by Re.1 every year. His experience with his company car indicates that it averages 9 km per litre of petrol. The executive expects to drive an average of 20,000 km each year for the next four years. What is the annual equivalent cost of fuel over this period? If he is offered similar service with the same quality on rental basis at Rs.60,000 per year, should the owner continue to provide company car for his executive or alternatively provide a rental car to his executive? Assume i = 18%. If the rental car is preferred, then the company car will find some other use within the company.** **(15M)** BTL2 **Answer : Page 3.76-Dr.S. Senthil** Average number of km run/year = 20,000 km Number of km/litre of petrol = 9 km Therefore, Petrol consumption/year = 20,000/9 = 2222.2 litre Cost/litre of petrol for the 1st year = Rs. 21 Cost/litre of petrol for the 2nd year = Rs. 21.00 + Re. 1.00 = Rs. 22.00 Cost/litre of petrol for the 3rd year = Rs. 22.00 + Re. 1.00 = Rs. 23.00 Cost/litre of petrol for the 4th year = Rs. 23.00 + Re. 1.00 = Rs. 24.00 Fuel expenditure for 1st year=2222.2 21 = Rs. 46,666.20 **(7M)** Fuel expenditure for 2nd year=2222.2 22 = Rs. 48,888.40 Fuel expenditure for 3rd year=2222.2 23 = Rs.51,110.60

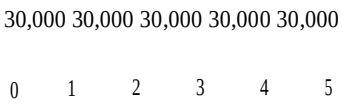
	Fuel expenditure for 4th year=2222.2 24 = Rs.53,332.80 The annual equal increment of the above expenditures is Rs.2,222.20 (G). **(8M)**
2	**A person is planning a new business. The initial outlay and cash flow pattern for the new business are as listed below. The expected life of the business is five years. Find the rate of return for the new business. (15M)** BTL2 **Answer : Page 3.78 -Dr.S. Senthil** **Period 0 1 2 3 4 5** **Cash flow –1,00,000 30,000 30,000 30,000 30,000 30,000 (Rs.)** **(13M)** BTL2 **Answer: Page - Dr.S.Senthil** Initial investment = Rs. 1,00,000 Annual equal revenue = Rs. 30,000 Life = 5 years The present worth function for the business is PW(i) = –1,00,000 + 30,000(P/A, i, 5) When i =10%, PW(10%) = –1,00,000 + 30,000(P/A, 10%, 5) = –1,00,000 + 30,000(3.7908) = Rs. 13,724. **(7M)** When i =15%, PW(15%) = –1,00,000 + 30,000(P/A, 15%,5) = –1,00,000 +30,000(3.3522) = Rs.566. When i = 18%, PW(18%) = –1,00,000 + 30,000(P/A, 18%, 5) = –1,00,000 +30,000(3.1272) = Rs. – 6,184 i = 15%+ 566 −0 566 − (– 6184) = 15% + 0.252% = 15.252% Therefore, the rate of return for the new businessis15.252%. **(8M)**
3	**Find the present worth of the following cash flow. Assume i=15% compounded annually**

End of year	0	1	2	3	4	5
Cash flow(Rs.)	-10000	30000	30000	30000	30000	30000

(15M) BTL2

Answer : Page 3.75 -Dr.S. Senthil

Initial outlay =10,000
Annual revenue = 30,000
Interest rate = 15%, compounded annually
Life = 5 years
To find: Present worth of 15%
The cash diagram for series is shown in figure



PW(15%)=-10000+30000*(P/A,15%,5) **(8M)**
= -10000+30000*3.3522
= -10000+1,00,566
= Rs.90,566
Result: The present worth of the given ash flow series is Rs.90,566 and it is feasible**.(7M)**

Subject code:MG6863 **Year/Semester :IV/08**
SubjectENGINEERINGECONOMICS **Subject Handler:Mrs.I.SHARON MARISHKA**

	UNIT IV REPLACEMENT ANDMAINTENANCE ANALYSIS 9
	Replacement and Maintenance analysis – Types of maintenance, types of replacement problem, determination of economic life of an asset, Replacement of an asset with a new asset – capital recovery with return and concept of challenger and defender, Simple probabilistic model for items which fail completely.
	PART - A
Q.No	**Questions**
1.	**What is replacement analysis?** BTL1 Replacement analysis involves the replacement of existing obsolete or worn-out assets to avoid failure in operations. The problems often faced by management of various industries are whether to replace the existing equipment with new and more efficient equipment or to continue to use existing equipment, and when existing equipment should be replaced with efficient equipment. This class of decision analysis is known as replacement analysis.
2.	**What is meant by gradual failure?** BTL2 Gradual failure is progressive in nature. It can be depicted in machine equipment, which is gradually depreciating or deteriorating with the time resulting in very high operating and maintenance costs and/or decreased residual value. It is easier to predict such type of failures and take the corrective measures by providing a replacement policy for such machine equipment.
3.	**Define economic service life of an asset?** BTL1 The economic service life of an asset is defined to be the period of useful life that minimizes the annual equivalent cost of owning and operating the asset.
4.	**What are the types of replacement problem?** BTL1 a.Replacement of assets that deteriorate with time (replacement due to gradual failure, or wear and tear of the components of the machine). This can be further classified into the following types: • Determination of economic life of an asset • Replacement of an asset with a new asset. b. Simple probabilistic model for assets that fails completely. (Replacement due to sudden failure)
5	**Explain capital recovery cost.** BTL1 Capital recovery cost computed from the first cost (Initial investment/purchase price) of the machine. As an asset becomes older, its salvage value becomes smaller. If the salvage value is less than the initial cost, the capital recovery cost is a decreasing function of the life of the asset. In other words, the longer we keep an asset, the lower the capital recovery cost becomes.
6	**Explain operating costs.** BTL1 The operating costs of an asset include operation and maintenance (O&M) costs, labour costs, material costs, and energy consumption costs. O&M costs tend to increase as a function of the age of the asset. Because of increasing trend of the O&M costs, the total operating costs of an asset usually increases as the asset ages. If the annual operating cost increases with the age of equipment, the annual equivalent operating cost is an increasing function of the life of the asset

7	**Explain annual equivalent total cost.** BTL1 Annual equivalent total cost of owning and operating an asset is a summation of the capital recovery cost (average first cost) and the annual equivalent operating costs of the asset.
8	**Explain sunk costs.** BTL2 The purchase costs of an equipment three years ago and repair cost of last year are called as sunk costs. A sunk cost is any past cost unaffected by any future investment decision. In a proper engineering economic analysis, only future costs should be considered; past sunk costs should be ignored.
9	**What is meant by maintenance?** BTL1 Maintenance is concerned with the day-to-day problem of keeping production facilities and equipment in proper operating condition. The machines and equipments should be continuously monitored for this efficient functioning. Otherwise, the quality of service will be poor, and the cost of operation and maintenance would increase with the passage of time.
10	**Name the types of maintenance.** BTL1 • Corrective or Breakdown maintenance • Scheduled maintenance • Preventive maintenance • Predictive maintenance.
11	**State the main causes of breakdown.** BTL1 • Failure to replace worn out parts • Lack of lubrication • c. Indifference towards min or faults.
12	**State any two disadvantages of breakdown maintenance.** BTL1 • Delays in production • Faster plant deterioration.
13	**What is the significance of timely maintenance?** BTL2 Timely maintenance makes more running time of machines and equipment's and helps in the continuous production thereby improving the productivity of the organisation.
14	**What is predictive maintenance?** BTL1 In predictive maintenance, equipment conditions are monitored and measured periodically or on continuous basis and this enables maintenance man to act such as equipment adjustment, repair or overhaul. This will extend the service life of equipment without fear of failure.
15	**Define preventive maintenance.** BTL1 Preventive maintenance is defined as any action performed to keep a machine in a specified operating condition by means of systematic inspection, detection, and prevention of incipient failures. It minimizes breakdown maintenance.
	PART * B
1	**Explain replacement in details.(13M)** BTL2 **Answer : Page 4 - Dr.S. Senthil** Replacement projects are decision problems involving the replacement of existing obsolete or worn-out assets. The contribution of operation is dependent on these assets. Failure to make an appropriate decision results in slowdown or shutdown of the operations. **(3M)**

	Causes/Reasons for Replacement • Deterioration • Increases maintenance costs, Reduces product quality, Decreases rate of production, causes loss in operating loss • Obsolescence • Reduces profit, Seriously impair the concern's competitive position in the market • Inadequacy • Working conditions **(4M)** **Factors to be considered for replacing equipment'sTechnical factor:** • Whether the present equipment has deteriorated? • Whether the present equipment has become obsolete? • Is the present equipment inadequate in meeting production rate? • Can the present equipment hold tight tolerances? • Can the present equipment provide required surface finish • Is the existing equipment hard on the workers **Financial workers:** • The initial cost of the challenger • Operating expenses, They include • Direct and Indirect labour cost • Direct and Indirect Material cost • Power • Maintenance cost • Cost of replacing parts • Insurance • Interest on invested capital **(6M)**
2	**Explain Maintenance analysis in detail.(13M)** BTL2 **Answer : Page 4.10 - Dr.S. Senthil** Maintenance is concerned with the day-to-day problem of keeping production facilities and equipment in proper operating condition. It is concerned with action taken by a user to maintain an existing facility in operating condition. **(2M)** Objectives: • To achieve minimum break-down • To keep plant in good working condition at the lowest possible cost. • To keep plant in good working condition at the lowest possible cost • To achieve efficient functioning of machines • To reduce operation and maintenance cost **(6M)Function of MaintenanceDepartment** • Inspection • Engineering • Maintenance • Repair • Overhaul • Construction

- Salvage
- Clerical job **(5M)**

List the types of Maintenance and Explain.(13M) BTL2

Answer : Page 4.11-Dr.S.Senthil

- Corrective or breakdown maintenance
- Scheduled maintenance
- Preventive maintenance
- Predictive maintenance **(2M)**

Corrective or breakdown maintenance:

It implies that repairs are made after the equipment is out of order and it can not perform its normal functions any longer. Under such conditions, production department calls on the maintenance department to rectify the defect.

Causes of equipment breakdown

- Failure to replace worn out parts
- Lack of lubrication
- Neglected cooling system
- Indifferent towards minor faults
- Indifferent towards equipment vibrations, unusual wrong fuel etc., **(3M)**

Scheduled Maintenance

Scheduled maintenance practice incorporated inspection, repair and overhaul of certain equipment's which if neglected can result in breakdown. Inspection, lubrication, servicing etc., of these equipment's are included in the predetermined schedule.

Preventive Maintenance

Is defined as any action performed to keep a machine in a specified operating condition by means of systematic inspection, detection, and prevention of incipient failures.

It locates weak spots in all equipment's, provides them with regular inspection and minor repairs and thereby reduces the danger of anticipated breakdown.

Objectives:

- To identify small problems in equipment's and to rectify it so that break down are minimized.
- To keep always the equipment available
- To maintain the value of the equipment by periodic inspection, repairs and overhauls etc.,
- To ensure safety of workers
- To reduce the work content of maintenance jobs.

Predictive Maintenance

It is comparatively a newer maintenance technique. It makes use of human sense or other sensitive instruments such as Audi gauges, vibration analysers, Amplitude meters, Pressure, Temperature and Resistance strain gauges etc., to predict trouble before the equipment fails. Unusual sounds coming out of a rotating equipment predicto trouble**.** **(8M)**

3	**A person deposits a sum of Rs.20,000 at the interest rate of 18% compounded annually for 10 years. Find the maturity value after 10 years.(13M)** BTL2 **Answer : Page 4.50 -Dr.S.Senthil** P = Rs. 20,000 i = 18% compounded annually n = 10 years F = P(1 + i)n = P(F/P, i, n) = 20,000 (F/P, 18%, 10) =20,000 5.234 = Rs.1,04,680 The maturity value of Rs. 20,000 invested now at 18% compounded yearly is equal to Rs. 1,04,680 after10years. **(6M)** **A person wishes to have a future sum of Rs. 1,00,000 for his son's education after 10 years from now. What is the single-payment that he should deposit now so that he gets the desired amount after 10 years? The bank gives 15% interest rate compounded annually.** F = Rs. 1,00,000 i = 15%, compounded annually n = 10 years P = F/(1 + i)n = F(P/F, i, n) = 1,00,000 (P/F, 15%, 10) =1,00,000 0.2472 = Rs. 24,720 The person has to invest Rs.24,720 now so that he will get a sum of Rs. 1,00,000 after 10 years at 15% interest rate compounded annually. **(7M)**
4	**A person is planning for his retired life. He has 10 more years of service. He would like to deposit 20% of his salary, which is Rs. 4,000, at the end of the first year, and thereafter he wishes to deposit the amount with an annual increase of Rs. 500 for the next 9 years with an interest rate of 15%. Find the total amount at the end of the 10th year of the above series.(13M)**BTL2 **Answer : Page 4.52 -Dr.S.Senthil** A_1 = Rs. 4,000 G = Rs. 500 i = 15% n = 10 years A = ? & F = ? The cash flow diagram is shown in Fig. i = 15% 0 1 2 3 4 4,000 4,000 + 500 4,000 +1,000 4,000 +1,500 4,000 +4,500 Fig. Cash flow diagram of uniform gradient series annual equivalent amount.

$A = A1 + G$

$(1 + i)n - in - 1$

$i(1 + i)n - i$

$= A1 + G(A/G, i, n)$

$= 4,000 + 500(A/G, 15\%, 10)$

$= 4,000+500 \quad 3.3832$

$=$Rs.5,691.60 **(6M)**

This is equivalent to paying an equivalent amount of Rs. 5,691.60 at the end of every year for the next 10 years. The future worth sum of this revised series at the end of the 10th year is obtained as follows:

$F = A(F/A, i, n)$

$= A(F/A, 15\%,10)$

$=5,691.60(20.304)$

= Rs. 1,15,562.25

At the end of the 10th year, the compound amount of all his payments will be Rs.1,15,562.25. **(7M)**

5

Due to increasing awareness of customers, two different television manufacturing companies started a marketing war. The details of advertisements of the companies started a marketed war. the details of advertisements of the companies are as follows

	Brand X	**Brand Y**
Selling price of a TV set	**Rs.15,000**	**Rs.10,000**
Amount returned to buyer after 5 years	**Rs.8,000**	**-**

Two years ago, a machine was purchased at a cost of Rs. 2,00,000 to be useful for eight years. Its salvage value at the end of its life is Rs. 25,000. The annual maintenance cost is Rs.25,000.

The market value of the present machine is Rs. 1,20,000. Now, a new machine to cater to the need of the present machine is available at Rs. 1,50,000 to be useful for six years. Its annual maintenance cost is Rs. 14,000. The salvage value of the new machine is Rs.20,000.

Using an interest rate of 12%, find whether it is worth replacing the present machine with the new machine. (13M) BTL2

Answer : Page4.26- Dr.S.Senthil

Present machine

Purchase price = Rs. 2,00,000

Present value (P) = Rs. 1,20,000

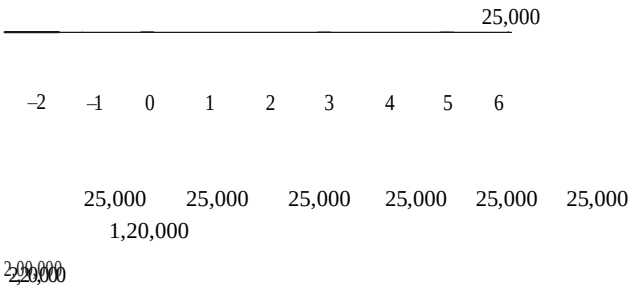
Salvage value (F) = Rs. 25,000

Annual maintenance cost (A) = Rs. 25,000

Remaining life = 6 years

Interest rate = 12%

The cash flow diagram of the present machine is illustrated in Fig.



(7M)

annual maintenance cost for the preceding periods are not shown in this figure. The annual equivalent cost is computed as

$AE(12\%) = (P - F)(A/P, 12\%, 6) + F \quad i + A$

$= (1,20,000 - 25,000)(0.2432) + 25,000 \quad 0.12 + 25,000$

$= Rs.51,104$ **(6M)**

6

Consider a new machine that would cost Rs.20,000 have operating cost of rupees zero during the first year and if increases by Rs.1000 every year thereafter, Find the economics service life of this new machine.

Given: First cost = Rs.20,000

OperatingcostisRs.0duringthefirstyearanditincreasesbyRs.1000everyyearthereafter. (13M)

BTL2

Answer : Page 4.1-Dr.S.Senthil

To find: Economic service life

Year of service(N)	Operating cost at end of year	Cumulative operating cost	Average operating cost	Average first cost	Average total cost
		€B	C/A	20,000/A	D+E
A	B (Rs.)	C (Rs.)	D (Rs.)	E (Rs.)	F (Rs.)
1	0	0	0	20,000	20,000
2	1,000	1,000	500	10,000	10,500
3	2,000	3,000	1,000	6,666.67	7,666.67
4	3,000	6,000	1,500	5,000	6,500
5	4,000	10,000	2,000	4,000	6,000
6	5,000	15,000	2,500	3,333.33	5857.14

Result: The above table shows that the average total cost decreases till the end of year 6 and then it increases. Therefore, the economic service life of this new machine is six years, ie., the optimal replacement period issixyears**.** **(13M)**

PART *C

1

Determination of group replacement cost. (13M) BTL2

Answer : Page 4.1 -Dr.S.Senthil

Determination of group replacement cost

Cost of transistor when replaced simultaneously = Rs. 3

Cost of transistor when replaced individually = Rs. 9

The costs of group replacement policy for several replacement periods are summarized in Table.

Table Calculations of Cost for Preventive Maintenance

End of week A	*Costofreplacing 100transistors atatime* B(Rs.)	*Cost ofreplacingtransistors individuallyduringgiven replacement period* C(Rs.)	*Total cost* (B+C) D(Rs.)	*Average cost/week* (D/A) E(Rs.)
1	300	7 9=63	363	363.00
2	300	(7 + 12) 9=171	471	235.50
3	300	(7 + 12 + 14) 9=297	597	199.00
4	300	(7 + 12 + 14 + 21) 9=486	786	196.50*
5	300	(7 + 12 + 14 + 21 + 27) 9=729	1,029	205.80
6	300	(7 + 12 + 14 + 21 + 27 + 30) 9=999	1,299	216.50
7	300	(7 + 12 + 14 + 21 + 27 + 30 + 25) 9 =1,224	1,524	217.71

*Indicates the minimum average cost/week.

From Table it is clear that the average cost/week is minimum for the fourth week. Hence, the group replacement period is fourweeks.

Individual replacement cost/week = Rs. 207 Minimum group replacement cost/week = Rs.196.50

Since the minimum group replacement cost/week is less than the individual replacement cost/week, the group replacement policy is the best, and hence all the transistors should be replaced once in four weeks and the transistors which fail during this four- week period are to be replacedindividually.

(13M)

2

Two years ago, a machine was purchased at a cost of Rs. 2,00,000 to be useful for eight years. Its salvage value at the end of its life is Rs. 25,000. The annual maintenance cost is Rs.25,000.

The market value of the present machine is Rs. 1,20,000. Now,anew machine to cater to the need of the present machine is available at Rs. 1,50,000 to be useful for six years. Its annual maintenance cost is Rs. 14,000. The salvage value of the new machine is Rs.20,000.

Using an interest rate of 12%, find whether it is worth replacing the present machine with the new machine.(15M) BTL4

Answer : Page 4.55-Dr.S.Senthil

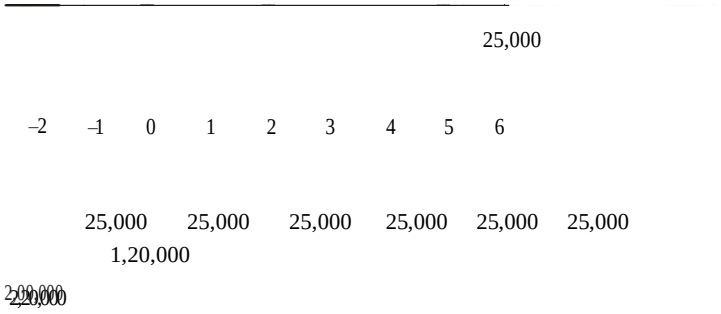
Present machine

Purchase price = Rs. 2,00,000

Present value (*P*) = Rs. 1,20,000

Salvage value (F) = Rs. 25,000
Annual maintenance cost (A) = Rs. 25,000
Remaining life = 6 years
Interest rate = 12%

The cash flow diagram of the present machine is illustrated in Fig.



(10M)

annual maintenance cost for the preceding periods are not shown in this figure. The annual equivalent cost is computed as

$AE(12\%) = (P - F)(A/P, 12\%, 6)+F \quad i +A$

$= (1,20,000 - 25,000)(0.2432)+25,000 \quad 0.12 +25,000$
$=$Rs.51,104 **(5M)**

3

A multinational company in India purchased a machine whose production capacity is 200 units/hour before two years. The current market value of the machine is Rs.30,000.Due to rapid increase in market demand, the company is in a position to increase its production volume. The company can cope with the situation either by augmenting an additional machinewiththeproductioncapacityof50units/hourorreplacingtheexistingmachinewith a new imported machine with the production capacity of 250 units/hour. The details of these machines are given in the following table.

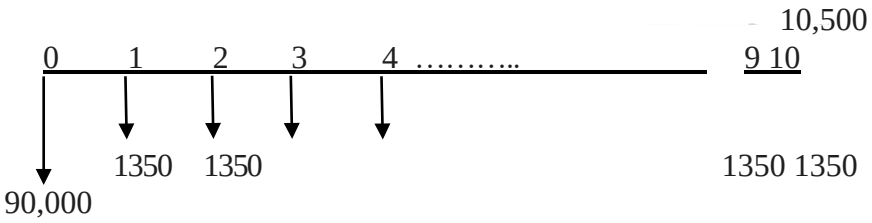
	Old machine 200 units/hour	New machine 50 units/hour	New machine 250units/hour
Purchase(P)	**50,000**	**8,000**	**90,000**
Life(N)	**12 yrs**	**10 yrs**	**10 yrs**
Salvage value(F) at the end of machine life(Rs.)	**3600**	**800**	**10,500**
Annual operating and maintenance cost(Rs.)	**4500**	**900**	**1350**

Findthebestalternativeassumingtherateofinterestis20%. **(13M)**BTL2

Answer : Page 4.14 -Dr.S.Senthil

Calculations of annual equivalent cost of new imported machine (250 units/unit)

Given: Purchase cost(P) = Rs.90,000
Life(N) = 10years
Salvage vaule(F) = Rs.10,500
Annual O & M cost(A) = Rs.1350
Interest rate(i) = 20%
To find: Annual equivalent cost
The cash flow diagram of this new imported machine is illustrated in figure



Cash flow diagram **(10M)**

The formula to obtain annual equivalent cost is
AE(20%) = (P-F)(A/P, 20%,10)+F*I+A
=(90,000-10,500)(0.2385)+10,500*0.20+1350
= RS. 22,410.75 **(5M)**

Subject code:MG6863 **Year/Semester :IV/08**
Subject: ENGINEERINGECONOMICS **Subject Handler:Mrs.I.SHARON MARISHKA**

	UNITV DEPRECIATION 9
	Depreciation- Introduction, Straight line method of depreciation, declining balance method of depreciation-Sum of the years digits method of depreciation, sinking fund method of depreciation/ Annuity method of depreciation, service output method of depreciation-Evaluation of public alternatives- introduction, Examples, Inflation adjusted decisions – procedure to adjust inflation, Examples on comparison of alternatives and determination of economic life of asset.
	PART - A
Q.No.	**Questions**
1.	**Define the term Depreciation.** BTL1 Depreciation is the process of allocating the acquisition cost of the tangible assets less salvage value, if any, in a systematic and a rational manner over the estimated life of the asset.
2.	**Mention the various methods used in depreciation calculation.** BTL1 The various methods used in depreciation calculations are: • Straight line method • Declining balance method • Sum of the years digits method • Sinking fund of annuity method • Service output method.
3.	**What are the causes of depreciation?** BTL1 The causes of depreciation are: • Wear and tear • Depletion • Obsolescence • Lapse of time.
4.	**Write five reasons for providing depreciation.** BTL1 The reasons for providing depreciations are: • To know the correct profits • To show correct financial position • To make provision for replacement of assets • To compute tax liability • To decide for how much to buy or sell the assets in the second-hand market.
5	**How to compute the sum of the digits of the years, if an asset has a life of six years?** BTL3

	Sum of the years = 1+2+3+4+5+6 = 21 n $21 = \frac{(n+1)}{2}$ $\frac{6\ (6+1)}{2} =$ $= 42/2 = 21$
6	**What is evaluation of public alternatives?** BTL1 Evaluation of public alternative is nothing but the selecting of best alternative from the available alternatives.
7	**What is the main objective of evaluation of public alternatives?** BTL1 To provide goods and services to the public at the minimum cost is the main objective of evaluation of public alternatives. In this situation, public alternative evaluation must consider a point that whether the benefits of the public activity are at least equal to its costs of consumption during the job.
8	**What is Book value?** BTL1 The value at which an asset is carried on a balance sheet is called book value. In other words the cost of an asset minus accumulated depreciation is known as book value.
9	**Define the term Benefit cost ratio.** BTL1 The ratio between the equivalent benefit and equivalent costs is called the benefit cost ratio.
10	**Define the term inflation.** BTL1 Inflation may be defined as a sustained rise in the general price level. It is an economic condition where there is a rise in prices resulting in the fall in the purchasing power of money.
11	**What are the types of inflation?** BTL1 The types of inflation are: • Creeping inflation • Moderate inflation • Galloping inflation • Hyperinflation.
12	**What is service output method of depreciation?** BTL1 Service output method of depreciation is a type of computing depreciation based on service rendered by an asset.
13	**What is sinking fund?** BTL1 A depreciation fund, equal to be actual loss in the value of the asset, is estimated for each year. This amount is invested outside the business in a separate account called sinking fund investment account at a certain rate and the interest will be earned on the fund. Therefore the sinking fund will rise year after year.
14	**What is amortization?** BTL1 Amortization is a routine decrease in value of an intangible asset, or the process of paying off a debt over time through regular payments. Amortization refers to the expensing of intangible capital assets (intellectual property: patents, trademarks, copyrights, etc.) to show their decrease in value because of use or passage of time.
15	**What is functional depreciation? (13M)** BTL1 Functional depreciation occurs because of changes in the organisation or in technology that

	decrease or eliminate the need for an asset. Examples of functional depreciation include obsolescence attributable to advances in technology, a declining need for the services performed by an asset, or the inability to meet increased quantity and/or quality demands.
	PART * B
1	**Define depression and list its types. (13M)** BTL2 **Answer : Page 5.3 - Dr.S. Senthil** Any equipment which is purchased today will not work for ever. This may be due to wear and tear of the equipment of technology. Hence, it is to be replaced at the proper time for continuance of any business. The replacement of the equipment at the end of its life involves money. This must be internally generated from the earnings of the equipment. The recovery of money from the earnings of an equipment for its replacement purpose is called depreciation fund since we make an assumption that the value of the equipment decreases with the passage of time. Thus the word –depreciation means decrease in value of any physical asset with the passage of time**.** **(6M)** **Methods of Depreciation** There are several methods of accounting depreciation fund. These are as follows: 1. Straight line method of depreciation 2. Declining balance method of depreciation 3. Sum of the years—digits method of depreciation 4. Sinking-fund method of depreciation **5.** Service output method of depreciation **(7M)**
2	**A company has purchased an equipment whose first cost is Rs. 1,00,000 with an estimated life of eight years. The estimated salvage value of the equipment at the end of its lifetime is Rs. 20,000. Determine the depreciation charge and book value at the end of various years using the straight line method of depreciation. (13M)** BTL2 **Answer : Page 5.4-Dr.S.Senthil** P = Rs. 1,00,000 F = Rs. 20,000 n = 8 years $D_t = (P – F)/n$ = (1,00,000 – 20,000)/8 = Rs. 10,000 In this method of depreciation, the value of D_t is the same for all the years. The calculations pertaining to B_t for different values of t are summarized in Table .

Endof year	Depreciation (D_t)	Bookvalue ($B_t = B_{t-1} – D_t$)
0		1,00,000
1	10,000	90,000

	2	10,000	80,000
	3	10,000	70,000
	4	10,000	60,000
	5	10,000	50,000
	6	10,000	40,000
	7	10,000	30,000
	8	10,000	20,000

If we are interested in computing Dt and Bt for a specific period the formulae can be used. In this approach, itshouldbenotedthatthe depreciation isthe samefor all theperiods**.** **(6M)**

Consider Example and compute the depreciation and the book value for period 5.

P = Rs. 1,00,000

F = Rs. 20,000

n = 8 years

$D_5 = (P - F)/n$

= (1,00,000 – 20,000)/8

= Rs. 10,000 (This is independent of the time period.)

$B_t = P - t \quad (P - F)/n$

$B_5 =$ 1,00,000–5 (1,00,000 –20,000)/8

=Rs.50,000 **(7M)**

3

Consider Example 1 and demonstrate the calculations of the declining balance method of depreciation by assuming 0.2 for *K*. (13M) BTL2

Answer : Page 5.5 - Dr.S.Senthil Declining Balance Method of Depreciation

P = Rs. 1,00,000

F = Rs. 20,000

n = 8 years

K = 0.2

The calculations pertaining to D_t and B_t for different values of t are summarized in Table 9.2 using the following formulae:

$$D_t = K \quad B_{t-}$$

$$_1B_t = B_{t-1} - D_t$$

$D_t$and $B_t$according to Declining Balance Method of Depreciation

Endofyear (n)	*Depreciation* (D_t)	*Bookvalue* (B_t)
0		1,00,000.00
1	20,000.00	80,000.00
2	16,000.00	64,000.00
3	12,800.00	51,200.00
4	10,240.00	40,960.00
5	8,192.00	32,768.00
6	6,553.60	26,214.40
7	5,242.88	20,971.52
8	4,194.30	16,777.22

If we are interested in computing D_t and B_t for a specific period t, the respective formulae can be used. **(7M)**

Consider Example 1 and calculate the depreciation and the book value for period 5 using the declining balance method of depreciation by assuming 0.2 for *K*. (13M) BTL2

Answer: Page -Dr.S.Senthil

P = Rs. 1,00,000

F = Rs. 20,000

n = 8 years

K = 0.2

$D_t = K(1-K)^{t-1} \quad P$

$D_5 = 0.2(1-0.2)^4 \quad 1,00,000$

= Rs. 8,192

$B_t = (1-K)^t \quad P$

$B_5 = (1-0.2)^5 \quad 1,00,000$

=Rs.32,768 **(6M)**

4

Sinking Fund Method of Depreciation

Consider Example 1 and give the calculations regarding the sinking fund method of depreciation with an interest rate of 12%, compounded annually.(13M) BTL2

Answer : Page 5.18 - Dr.S.Senthil

P = Rs.1,00,000

F = Rs.20,000

n = 8 years

i = 12%

A = (P–F) [A/F, 12%, 8]

= (1,00,000– 20,000) 0.0813

= Rs. 6,504

In this method of depreciation, a fixed amount of Rs.6,504 will be depreciated at the end of every year from the earning of the asset.

The depreciated amount will earn interest for the remaining period of life of the asset at an interest rate of 12%, compounded annually.

For example, the calculations of net depreciation for some periods are as follows:

	Depreciation at the end of year 1 (D1) = Rs. 6,504. Depreciation at the end of year 2 (D2) = 6,504+ 6,504 0.12 =Rs.7,284.48 **(7M)** Depreciation at the end of the year 3 (D_3) = 6,504 + (6,504+7,284.48) .12 = Rs. 8,158.62 Depreciation at the end of year 4 (D_4) = 6,504 + (6,504 + 7,284.48+8,158.62) 0.12 = Rs. 9,137.65 These calculations along with book values are summarized in Table . **(6M)**
5	**Service Output Method of Depreciation** **The first coat of a road laying machine is Rs. 80,00,000. Its salvage value after five years is Rs.50,000. The length of road that can be laid by the machine during its lifetime is 75,000 km. In its third year of operation, the length of road laid is 2,000 km. Find the depreciation of the equipment for that year. 13M)**BTL2 **Answer : Page 5.20 - Dr.S.Senthil** P = Rs. 80,00,000 F = Rs.50,000 X = 75,000km x = 2,000 km Depreciation for x units of service in a period $= \frac{P-F}{X}x$ **(7M)**

	Depreciation for year 3 = $\frac{(80{,}00{,}000 - 50{,}000)}{75{,}000}$ =Rs.2,12,000 **(6M)**
	PART *C
1	**Single-Payment Compound Amount** A person deposits a sum of Rs. 20,000 at the interest rate of18% compounded annually for 10 years. Find the maturity value after 10 years. **(15M)** BTL2 **Answer: Page -Dr.S.Senthil** P = Rs. 20,000 i = 18% compounded annually n = 10 years $F = P(1 + i)^n = P(F/P, i, n)$ = 20,000 (F/P, 18%, 10) =20,000 5.234 = Rs.1,04,680 The maturity value of Rs.20,000 invested now at 18% compounded yearly is equal to Rs. 1,04,680 after10years. **(7M)** **Single-Payment Present Worth Amount** A person wishes to have a future sum of Rs. 1,00,000 for his son‘s education after 10 years from now. What is the single-payment that he should deposit now so that he gets the desired amount after 10 years? The bank gives 15% interest rate compounded annually. F = Rs. 1,00,000 i = 15%, compounded annually n = 10 years $P = F/(1 + i)^n = F(P/F, i, n)$ = 1,00,000 (P/F, 15%, 10) =1,00,000 0.2472 = Rs. 24,720 The person has to invest Rs. 24,720 now so that he will get a sum of Rs. 1,00,000 after 10 years at 15% interest rate compounded annually. **(8M)**
2	**Equal-Payment Series Sinking Fund** A company must replace a present facility after 15 years at an outlay of Rs. 5,00,000. It plans to deposit an equal amount at the end of every year for the next 15 years at an interest rate of 18% compounded annually. Find the equivalent amount that must be deposited at the end of every year for the next 15 years. **(13M)**BTL2 **Answer : Page 5.19 - Dr.S.Senthil** F = Rs. 5,00,000 n = 15 years i = 18% A = ? The corresponding cash flow diagram is shown in Fig.

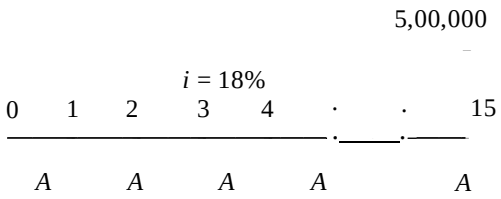


Fig. Cash flow diagram of equal-payment series sinking fund.

$$A = F\frac{i}{(1+i)^n - 1} = F(A/F,\ i,\ n)$$

$$= 5,00,000(A/F,\ 18\%,\ 15)$$
$$= 5,00,000 \quad 0.0164$$
$$= \text{Rs. } 8,200$$

The annual equal amount which must be deposited for 15 years is Rs. 8,200.

(15M)

3

Equal-Payment Series Present Worth Amount

A company wants to set up a reserve which will help the company to have an annual equivalent amount of Rs. 10,00,000 for the next 20 years towards its employee's welfare measures. The reserve is assumed to grow at the rate of 15% annually. Find the single- payment that must be made now as the reserve amount. **(15M)** BTL2

Answer : Page 5.19 - Dr.S.Senthil

A = Rs. 10,00,000
i = 15%
n = 20 years
P = ?
The corresponding cash flow diagram is illustrated in Fig.

= Rs. 8,200

	A bank gives a loan to a company to purchase an equipment worth Rs.10,00,000 at an interest rate of 18% compounded annually. This amount should be repaid in 15 yearly equal installments. Find the installment amount that the company must pay to the bank. . (15M)BTL2 **Answer : Page 5.7 -Dr.S.Senthil** *P* = Rs. 10,00,000 *i* = 18% *n* = 15 years *A* = ? The corresponding cash flow diagram is shown in Fig. **(15M)**

IE6605 PRODUCTION PLANNINGANDCONTROL L T PC

3 0 0 3

OBJECTIVES:

- To understand the various components and functions of production planning and control such
  as work study, product planning, process planning, production scheduling, Inventory Control.
- To know the recent trends like manufacturing requirement Planning (MRP II) and Enterprise
  Resource Planning (ERP).

UNITI INTRODUCTION 9

Objectives and benefits of planning and control-Functions of production control-Types of production job- batch and continuous-Product development and design-Marketing aspect - Functional aspects- Operational aspect-Durability and dependability aspect aesthetic aspect. Profit consideration- Standardization, Simplification & specialization- Break even analysis- Economics of a new design.

UNIT IIWORKSTUDY 9

Method study, basic procedure-Selection-Recording of process - Critical analysis, Development - Implementation - Micro motion and memo motion study – work measurement - Techniques of work measurement - Time study - Production study - Work sampling - Synthesis from standard data - Predetermined motion time standards.

UNIT III PRODUCT PLANNING ANDPROCESS PLANNING 9

Product planning-Extending the original product information-Value analysis-Problems in lack of product planning-Process planning and routing-Pre requisite information needed for process planning- Steps in process planning-Quantity determination in batch production-Machine capacity, balancing- Analysis of process capabilities in a multi product system.

UNIT IVPRODUCTION SCHEDULING 9

Production Control Systems-Loading and scheduling-Master Scheduling-Scheduling rules-Gantt charts-Perpetual loading-Basic scheduling problems - Line of balance – Flow production scheduling-Batch production scheduling-Product sequencing – Production Control systems-Periodic batch control-Material requirement planning kanban – Dispatching-Progress reporting and expediting-Manufacturing lead time-Techniques for aligning completion times and due dates.

UNIT V INVENTORY CONTROL AND RECENT TRENDSIN PPC 9

Inventory control-Purpose of holding stock-Effect of demand on inventories-Ordering procedures. Two bin system -Ordering cycle system-Determination of Economic order quantity and economic lot size- ABC analysis-Recorder procedure-Introduction to computer integrated production planning systems elements of JUST IN TIME SYSTEMS-Fundamentals of MRP II and ERP.

TOTAL: 45 PERIODS

OUTCOMES:

Upon completion of this course, the students can able to prepare production planning and control activities such as work study, product planning, production scheduling, Inventory Control.

They can plan manufacturing requirements manufacturing requirement Planning (MRP II) and Enterprise Resource Planning (ERP).

TEXT BOOK:

1. Martand Telsang, "Industrial Engineering and Production Management", First edition,S.

Chand and Company,2000.

2. James.B.Dilworth," Operations management – Design, Planning and Control for manufacturing

and services" Mcgraw Hill International edition 1992.

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1. Samson Eilon, "Elements of Production Planning and Control", Universal BookCorpn.1984

2. Elwood S.Buffa, and Rakesh K.Sarin, "Modern Production / Operations Management", 8thEdition, John Wiley and Sons,2000.

3. Kanishka Bedi, " Production and Operations management", 2nd Edition, Oxford university press,2007.

4. Melynk, Denzler, " Operations management – A value driven approach" Irwin Mcgrawhill.

5. Norman Gaither, G. Frazier, "Operations Management", 9th edition, Thomson learning IE, 2007

6. Jain. K.C & L.N. Aggarwal, "Production Planning Control and Industrial Management", Khanna Publishers,1990.

7. Chary. S.N. "Theory and Problems in Production & Operations Management", Tata McGraw Hill, 1995.

8. Upendra Kachru, "Production and Operations Management – Text and cases", 1st Edition, Excel books2007

UNIT I – INTRODUCTION	
Objectives and benefits of planning and control-Functions of production control-Types of production job- batch and continuous-Product development and design-Marketing aspect - Functional aspects- Operational aspect- Durability and dependability aspect aesthetic aspect. Profit consideration- Standardization, Simplification & specialization- Break even analysis-Economics of a new design.	
PART * A	
Q.No.	**Questions**
1.	**Define production planning and control. (Nov. 2011)** (BTL1) PPC may be defined as the direction and coordination of the organizations materials and physical facilities towards the attainment of pre-specified goals in the most efficient way.
2	**What are the Phases of PPC?** (BTL2) PPC involves three phases 1. Pre-planning phase, 2. Planning phase, 3. Control phase
3	**List the various functions/activities of PPC? (Nov. 2011, May 2015)** (BTL2) 1. Materials planning 2. Facility planning 3. Methods planning 4. Estimating 5. Process planning(routing) 6. Scheduling and loading 7. Dispatching 8. Expediting (or follow up) 9. Inspection and testing 10. Evaluation
4	**Differentiate between routing and scheduling.** (BTL4) Routing provides the best and the most economical production sequence, whereas scheduling prepares a logical time- table showing the starting and finishing time of each production work in accordance with some predetermined program. In simple words routing considers the 'where' aspects and scheduling 'when' aspects.
5	**What is Production system? (April 2011)** (BTL2) A production system is the frame work within which the conversion of inputs into output occurs. At the one end of the production system are the inputs and at the other end outputs.
6	**How can you classify the production system?** (BTL4) 1. Job shop production 2. Batch production 3. Mass production 4. Process or continuous production.
7	**What do you mean by batch production?** (BTL1) In batch production, the products are made in small batches and in large variety. Each batch contains identical items but every batch is different from others.
8	**Differentiate between intermittent and continuous production systems.** (BTL4) The job shop production and batch production are also known as intermittent production systems.

	The mass production and process production are termed as continuous production system.
9	**What types of plant layouts are suitable for job shop, batch and continuous production?** (BTL2) 1. Job shop production – Process of functional layout 2. Batch production - Cellular layout 3. Continuous production – Line or product layout
10	**What is the objective of product analysis?** (BTL1) The main objective of product analysis is to obtain qualitative as well as quantitative evaluation of the influencing factors which determine primarily the success of a manufactured product.
11	**Distinguish the terms durability and dependability.** (BTL4) Durability refers to the length of the active life or endurance of the product under given working conditions. Dependability refers to the reliability with which the product serves its intended function.
12	**What do you mean by design manufacture and design for assembly?** (BTL2) Design for manufacture (DFM) means the design for ease of manufacture of the components of a product. Design for assembly (DFA) means the design of the product for ease of assembly.
13	**What do you understand by product standardization?** (BTL1) Standardization means setting up standards or measuring sticks by which extent, quality, quantity, value, performance, or service may be gauged or determined
14	**What are the 3S's with respect to product development techniques?** (BTL1) 1. Standardization 2. Simplification 3. Specialization
15	**What do you mean by specialization?** (BTL2) Specialization is the process whereby particular firms concentrate on the manufacture of a limited number of products or types of products
16	**What are the advantages of specialization?** (BTL2) 1. Better utilization of equipment 2. Higher productivity 3. Greater efficiency 4. Better quality 5. Reduced production cost & hence lower unit price, and 6. Use of standardized methods.
17	**What do you understand by break-even analysis? (April 2014, May 2015)** (BTL2) Break-even analysis, also known as cost-volume-profit analysis, is the study of inter-relationships among a firm's sales, costs and operating profit at various levels of output. The break-even point is the point at which revenue is exactly equal to costs. At this point, no profitismadeandnolossesareincurred.Thebreak-evenpointcanbeexpressedintermsofunit sales or dollar sales.
18	**Contrast product simplification with product diversification.** (BTL4) Product simplification is the process of reducing the variety of products manufactured i.e., variety reduction. Product diversification is completely opposite to simplification. Product diversification involves adding new products or lines products to achieve a balanced product range.
19	**List the Objectives of Planning and Control (May 2015)** (BTL2) Production planning is an activity that is performed before the actual production process takes place. It involves determining the schedule of production, sequence of operations, economic

	batch quantities, and also the dispatching priorities for sequencing of jobs. Production control is mainly involved in implementing production schedules and is the corollary to short-term production planning or scheduling.
20	**What is meant by production control?** (BTL1) Production control through control mechanism, tries to take corrective action to match the plant actual production .Thus production control reviews the progress of the work and takes corrective steps in order to ensure that programmed production takes place.
	PART * B
1	**Explain the objectives and benefits of planning and control (13M)(Dec2014)** (BTL1) **Answer: Page 1.4-1.6 -Dr.V.Jayakumar** Objectives of Planning and control 1. Predetermine from sales forecasts and engineering information 2. Preparation for manufacturing 3. implement the production plans 4. coordinate and monitor 5.provideresources 6. low cost of productions (6M) Benefits of Planning and control 1. control of planning 2. control of materials 3. control of tooling 4. control of manufacturing capacity 5. control of activities 6. control of quantity 7. control of material handling 8. control of due dates 9.control of information 10. control of quality (7M)
2	**Discuss the functions of production planning and control (13M) (April 2008, May 2015,April 2017)**(BTL2) **Answer: Page 1.9-1.14 -Dr.V.Jayakumar** 1. material planning 2.methods planning 3. machines and equipments 4. process planning 5. estimating 6. scheduling and loading 7.dispatching 8. expediting 9. inspection and testing 10. evaluation (13M)
3	**Discuss the various aspects of Product Design and Development in detail. (13M) (May 2015, Dec 2014, April 16,2017)** (BTL2) **Answer: Page 1.22-1.23-Dr.V.Jayakumar** Product design deals with form and function

	Product design includes whole development of product through preliminary to actual manufacturing begins.
4	**Describe Standardization, Simplification and Specialization. (13M) (April 2008)**(BLT4) **Answer: Page 1.35-1.43 -Dr.V.Jayakumar** The concepts of simplification, standardization and specialization (known as three S's) are closely interrelated and lead to interchangeability. These concepts can be effectively used in industry to minimize unnecessary activity, reduce inventory costs, simplify controls and improve product quality. All these factors lead to higher efficiency in production. Standardization is the process of implementing and developing technical standards based on the consensus of different parties that include firms, users, interest groups, standards organizations. (3M) Benefits and limitation (2M) Simplification is the process of reducing the variety of products manufactured. Simplification is concerned with the reduction of product range, assemblies, parts, materials and design. (2M) benefits and limitation (2M) Specialization is concentration of effort in a particular area or occupation. It is the natural outcome of simplification and standardization. For example: Electricians, doctors, and lawyers specialize in their chosen fields. In product specialization, a firm may produce and market only one or a limited range of similar products. (2M) Benefits and limitation (2M)
5	**Write a note on Economics of new design. (13M) (Dec 2014), May 2015)**(BTL3) **Answer: Page 1.60-1.62 -Dr.V.Jayakumar** In order to survive in the competitive atmosphere of industrial world, a new product (or) modification of existing product is essential. During the launch of a new model (or) design, a careful analysis of the economics of the proposed project has to be done. (4M) The reason for introducing a new model to the market is 1. To increase the profit of the company. 2. To avoid decrease in sales of an existing product. (4M) φ =Profit + Fixed cost/Quantity sold (1M) Before Investment $P_1 = \varphi_1 N_1 - F$ (2M) Before Investment $P_2 = \varphi_2 N_2 - F - I$ (2M)
6	**Explain Types of production systems. (13M) (April 2014, Dec 2014,April 2017)**(BTL3) **Answer: Page 1.16-1.19 -Dr.V.Jayakumar** **Types of Production System** According to the volume of production (quantity) and product standardization, the production systems are classified as 1. Job shop production 2. Batch production 3. Continuous production 4. Mass production (1M) Job Shop Production In Job shop production system, products are manufactured to meet the requirements of a specific order.

	Examples: Space vehicles, aircraft, machine tools, special purpose machines etc. (3M) Batch Production In batch production system, the products are made in small batches and in large variety. Each batch contains identical items but every batch is different from the others. Examples: Batch production plant includes machine shops, foundries, plastic moulding units, press shops, chemical and pharmaceutical units. (3M) Continuous Production Production facilities for continuous production are arranged as per a predetermined sequence of production operations from the first operation to the finished product. Examples: conveyers, transfer devices etc. (3M) Mass Production Mass production refers to the process of creating large number of similar products efficiently. Examples: Automobile assembly line is a typical example of mass production. (3M)
7	**Describe the Factors influencing product design (13M)** (BLT6) **Answer: Page 1.22-1.23 -Dr.V.Jayakumar** (13M)
8	**What is Break Even analysis? Explain it.(13M) (BLT3)** **Answer: Page 1.46-1.51 -Dr.V.Jayakumar** The Break Even Analysis is used to analyses the relationship between AQ cost, volume and profit. It is also called as CVP (Cost, Volume, and Profit) analysis. Break even analysis is used to find the level at which the total cost and total revenue becomes equal. It is foolishness on the part of management to run a business without break even analysis (3M)

(6M)

Break Even Point (BEP)

'BEP' is the production/sales level at which the total revenue equals total expenses. It is the point at which a product, project or a business becomes commercially viable. Operating beyond the BEP results in profits and operating below the BEP results in losses. Also BEP is a measure of how long it takes to recover ones investments. Many companies prefer a BEP of 18 months or less. (2M)

Gross profit, $Z = PQ - (QV + F)$

$QBEP = F/(P-V)$ (2M)

PART * C

1 **The fixed costs for the year 2000-01 are Rs 6,00,000 variable costs per unit is Rs 40. Each unit sells at Rs 160. Determine (i) break even point (a) in terms of physical units and (b) in terms of rupees (ii) if a sales of a volume of 5500 units has been expected then what will the profit or loss earned? (iii) if a profit target of Rs 1,20,000 has been budgeted, compute the number of units to be sold. (iv) if the company sells 6500 units, calculate the margins of safety and profit. (15M)** (BTL5)

Answer: Page 1.46-1.51 -Dr.V.Jayakumar

(10M)

(5M)

2 **Madison industries has the following data on table on costs at two volumes of production for the product that sells for Rs. 50 (a) construct a two volume break even chart. (b) computethevariablescost,thecontributionandtheBEP.(c)usingthecontributionfrom (b) estimate the profit at a volume of 8800 units.**

	Labour	Material	Overhead	Other FC	Total
6000 unit volume	**Rs 60,000**	**Rs 36,000**	**Rs 54,000**	**Rs 80,000**	**Rs 2,30,000**
1000 unit volume	**Rs 1,00,000**	**Rs 60,000**	**Rs 60,000**	**Rs 80,000**	**Rs 3,00,000**

(15M) (BTL5)

Answer: Page 1.46-1.51 -Dr.V.Jayakumar

(5M)

(5M)

(5M)

3	**The annual fixed cost of a product are known to be Rs. 3 lacs and the annual net profit Rs 60,000, the average monthly sale being 1000 units. A new design is contemplated, involving an expenditure for preparation amounting to Rs 1,20,000 to be returned in two years, it is expected that with new production methods the P/V ratio may be increased by 5 percent.**

What should the annual sales figure for the new design be (i) so that same net profit will be realized; (ii) so that addition to this profit a yield of 10 per cent on the capital invested will be obtained? (15M) (BTL5)

Answer: Page 1.61-1.63 -Dr.V.Jayakumar

(5M)

(5M)

(5M)

UNIT II - WORK STUDY

Method study, basic procedure-Selection-Recording of process - Critical analysis, Development - Implementation - Micro motion and memo motion study – work measurement - Techniques of work measurement - Time study - Production study - Work sampling - Synthesis from standard data - Predetermined motion time standards.

PART * A

Q.No.	Questions
1.	**Define work study.** (BTL1) Work study is a generic term for those techniques, particularly method study and work measurement, which are used in the examination of human work in all its contexts and which leads systematically to the investigation of all factors which after the efficiency and economy of the situation being reviewed, in order to effect improvement.
2	**List the objective of work study.** (BTL2) 1. To find the most economical way of doing the work 2. To simplify and standardize the methods, materials, tools and equipment. 3. To determine the time required by a qualified worker to perform the work at a normal pace. 4. To plan the training program for the workers for the new methods.
3	**Define method study. (Nov. 2011, Dec 2014, May 2015)** (BTL1) Method study is the systematic recording and critical examination of existing and proposed ways of doing work, as a means of developing and applying easier and more effective methods and reducing costs.
4	**List the objectives of method study. (Dec. 2013)** (BTL2) 1. To improve the processes and procedures. 2. To improve the design of plant and equipment 3. To improve the plant layout. 4. To improve the use of men, materials and machines. 5. To achieve efficient material handling. 6. To improve the flow of production and processes.
5	**Differentiate between operation and inspection.** (BTL4) An operation always takes the material, component or service a stage further towards completion. An inspection does not take the material any nearer to become a completed product. It merely verifies that an operation has been carried out correctly as to quality and / or quantity.
6	**Differentiate between 'Permanent storage' and 'Delay'.** (BTL4) The difference is that a requisition, chit, or other form of formal authorization is generally required to get an article out of permanent storage but not out of temporary storage.
7	**What is a process chart? Mention its types** (BTL3) A process chart is a graphical representation of the sequence of events and related information that occur in the work method or procedures. There various types of process charts are Outline process chart, Flow process chart, Two- handed process chart
8	**Differentiate between outline process chart and flow process chart.** (BTL4) An outline process chart is a process chart given an overall picture by recording in sequences only

	the main operations and inspections. A flow process chart is a graphical representation of all operations, transportations, inspections, delays and storages occurring during a process or procedure.
9	**Distinguish between flow diagram and string diagram.** (BTL4) The sting diagram must be drawn correctly to scale. The flow diagram can be drawn approximately to scale. The flow diagram would look cumbersome when there are too many to and fro movement between points but, such movements will not affect the string diagram.
10	**Define time study. (Nov. 2011, Dec 2014)** (BTL2) Time study is defined as a work measurement technique for recording the times and rates of working for the elements of a specified conditions and for analyzing the data so as to obtain the time necessary for carrying out the job at a defined level of performance.
11	**Why the job is divided into elements?** (BTL6) 1) To ensure that productive work is separated from un productive activity. 2) To ensure better and accurate performance rating. 3) To identify and distinguish different types of elements. 4) To facilitate checking of method.
12	**What is meant by performance rating?** (BTL3) Performance rating is the process of adjusting the actual pace of working of an operator by comparing it with the mental picture of pace of an operator working at normal speed.
13	**List the various allowances to be considered while calculating the standard time of job.** (BTL2) i) Relaxation allowances ii) Contingency allowances iii) Process allowances iv) Interference allowances v) Special allowances
14	**Define the terms basic time and standard time.** (BTL2) Basic time may be defined as the time for carrying out an element of work standard rating. Standard time is the time allowed to an operator to carry out the specified task under specified conditions and defined level of performances.
15	**What is meant by work sampling?** (BTL3) Work sampling is defined as a method of finding the percentage occurrence of a certain activity by statistical sampling and random observations.
16	**What do you mean by synthetic data?** (BTL3) Synthetic data is the data derived from the analysis of the accumulated work measurement data in the form of tables and formulas where the data is arranged in a form suitable for building up the standard times and similarly machine processing times by synthesis.
17	**What is PMTS?** (BTL2) PMTS stands for Predetermined Motion Time System. A predetermined motion time system consists of a set of time data which has been developed from many observations of a worker's performance.
18	**Mention the tools used in time study. (May 2015)** (BTL3) Stop watch Study, Work Sampling etc.
19	**What are the advantages of SIMO chart? (April 2011)** (BTL3) Simultaneous motion Cycle Chart – (i) The principles behind the multiple activity chart and the two handed process chart are combined in SIMO chart, (ii) It is drawn on a time based scale, due to that which allows the job designer to see the relative time taken by each part of the job.

20	**List the steps involved in Time study. (April 2014)** (BTL2) SELECT(Job to be timed) OBTAIN & RECORD(Details regarding method, operator, job & working condition) DEFINE(the elements, break the job into element convenient for timing) MEASURE (time duration for each element and assets the rating EXTEND(Observed time into normal time[basic time]) DETERMINE(Relaxation and Personal Allowances) COMPUTE(Standard time for the operation for defined job or operation)
	PART * B
1	**Describe about Method study and its procedure in detail. (13M) (Dec 2014, May 2015) (April 2017)**(BTL3) **Answer: Page 2.15-2.17 -Dr.V.Jayakumar** Method study is the process of subjecting work to systematic, critical scrutiny to make it more effective and/or more efficient. It is one of the keys to achieving productivity improvement. (3M) Process charts (1M) 1. outline process charts (3M) 2. flow process charts (3M) 3. two handed process charts (3M)
2	**Describe about Micro motion and Memo motion study. (13M) (April 2008) (May 2015) (April 2017)** (BTL3) **Answer: Page 2.37-2.41 -Dr.V.Jayakumar** Micro motion is the technique in time and motion study of making a pictorial elapsed-time study of the elements or subdivisions of an operation by means of a high-speed motion-picture camera and a specialized timing device (3M) Purpose of micro motion study Advantage of micro motion study (2M) Disadvantage of micro motion study (2M) Memo motion or spaced-shot photography is a tool of time and motion study that analyzes long operations by using a camera. (3M) Purpose of micro motion study Advantage of micro motion study (2M) Disadvantage of micro motion study (1M)
3	**Write a note about Work measurement techniques. (13M) (April 2008), Dec 2014, May 2015) (April 2017)** (BTL2) **Answer: Page 2.42-2.43 -Dr.V.Jayakumar** Work measurement is the application of techniques to establish the time for an average worker to carry out a specified manufacturing task at a defined level of performance. (2M) Techniques Time study (3M) Predetermined motion time systems (3M) Synthesis from elemental data (3M) Work sampling (3M)
4	**Describe about Time study and production study. (13M) (April 2017)**(BLT3)

	Answer: Page 2.44-2.47 -Dr.V.Jayakumar Time study Time study is a direct and continuous observation of a task, using a timekeeping device (e.g., decimal minute stopwatch, computer-assisted electronic stopwatch, and videotape camera)to record the time taken to accomplish a task (4M) • there are repetitive work cycles of short to long duration, • wide variety of dissimilar work is performed, or • process control elements constitute a part of the cycle. (3M) Production study a continuous study of relatively lengthy duration often made with the object of checking an existing or proposed standard time or its constituents parts, or obtaining information concerning the rate of output. (3M) • Obtaining a detailed account of a representative period; • Validation of issued standard and allowed times; • Checking of contingencies for adequate coverage; • Assessing the amount of waiting time and other ineffective time; (3M)
5	**Discuss about Predetermined Motion Time System (PMTS). (13M) (April 2008)** (BTL3) **Answer: Page 2.64-2.66 -Dr.V.Jayakumar** A predetermined motion time system (PMTS) is frequently used to perform Labor Minute Costing in order to set piece-rates, wage-rates and/or incentives in labor (labour) oriented industries by quantifying the amount of time required to perform specific tasks under defined conditions. Today the PMTS is mainly used in work measurement for shorter cycles in labour oriented industries such as apparel and footwear. This topic comes under wider industrial and production engineering. (3M) Predetermined Motion Time Standard and Predetermined Time standards (PTS), Pre-determined Time Systems are other terms that describe same concept by different authors. Main outcome of PMTS application is quantifying labor inputs in terms of SMV (Standard Minute Value) or SAM (Stranded Allocated Minute). (2M) Types (2M) 1. methods of time study (MTA) (2M) 2. work force system (WFS) (2M) 3. method time measurements (MTM) (2M)
6	**Explain the steps involved in work study. (13M) (April 2014)**(BTL3) **Answer: Page 2.5-2.6 -Dr.V.Jayakumar** • SELECT the job or process to be suited. (2M) • RECORD from direct observation everything that happens in order to obtain data for analysis. (2M) • EXAMINE the recorded facts critically and challenge everything that is done, considering in turn the purpose of activity, the place where it is Performed, the sequence in which the elements are performed, the person who is doing it, the means by which it is done. (2M) • DEVELOP the most economic methods, taking into account all the circumstances. • MEASURE the amount of work involved in the method used and calculate a "standard

	time" for doing it. (2M) • DEFINE the new method and there lated time (2M) • INSTALL the new method and time as agreed standard practices. (2M) • MAINTAIN the new standard practice by proper control procedures. (1M)
7	**Discuss the steps in work sampling study. (13M) (April 2014) (April 2017) (**BTL6) **Answer: Page 2.59-2.62 -Dr.V.Jayakumar** Work sampling is the statistical technique for determining the proportion of time spent by workers in various defined categories of activity (e.g. setting up a machine, assembling two parts, idle…etc.) (3M) It is as important as all other statistical techniques because it permits quick analysis, recognition, and enhancement of job responsibilities, tasks, performance competencies, and organizational work flows. Other names used for it are 'activity sampling', 'occurrence sampling', and 'ratio delay study. (3M) • Define the manufacturing tasks for which the standard time is to be determined. • Define the task elements. These are the defined broken-down steps of the task that will be observed during the study. Since a worker is going to be observed, additional categories will likely be included as well, such as "idle", "waiting for work", and "absent". • Design the study. This includes designing the forms that will be used to record the observations, determining how many observations will be required, deciding on the number of days or shifts to be included in the study, scheduling the observations, and finally determining the number of observers needed. • Identify the observers who will do the sampling. • Start the study. All those who are affected by the study should be informed about it. • Make random visits to the plant and collect the observations. • After completing the study, analyze and present the results. This is done by preparing a report that summarizes and analyzes all data and making recommendations when required. (7M)
	PART * C
1	**An industrial job involves six elements with the following observed times and performance ratings.** **Element — Observedtime(min) — Performance rating (%)** **1 — 0.32 — 85** **2 — 0.11 — 95** **3 — 0.62 — 90** **4 — 0.14 — 100** **5 — 0.22 — 95** **6 — 0.10 — 80** **Calculate : (i) normal time for each elements, and (ii) standard time per piece. Assume rest and personal allowance as 9 % and contingency allowance as 2% of the basic time.** **(15M) (April 2016) (**BTL5) **Answer: Page 2.57 -Dr.V.Jayakumar**

(5M)

(5M)

(5M)

2 **The elemental times (in minutes) for 4 cycles of an operation using a stop watch are presented below:**

Element	Cycle times in minutes			
	1	2	3	4
1	2.6	2.4	2.7	2.6
2	1.3	1.5	1.4	1.5
3	0.52	0.49	0.51	0.51
4	3.4	3.2	3.3	3.4
5	1.2	1.2	1.2	1.1

Calculate the standard time for operation if: (i) Elements 1 and 3 are machine elements (ii) for the elements the operator is rated at 90 % (iii) the total allowance are 14% of the normal time.

(15M) (BTL5) **Answer: Page 2.58 -Dr.V.Jayakumar**

(10M)

	Normal time for the cycle = 8.415 min Total allowance = $\frac{14}{100} \times 8.415 = 1.178$ min $\therefore$ Standard time = 8.415 + 1.178 = **9.593 min Ans.**	(5M)
3	**A time study was conducted on a job consisting of four elements. Stop watch reading in hundredth of a minute are given below using a cumulative time method along the rating factors. (15M) (**BTL5) **Answer: Page 2.59 -Dr.V.Jayakumar**	(10M) (5M)

UNIT III - PRODUCT PLANNING AND PROCESS PLANNING

Product planning-Extending the original product information-Value analysis-Problems in lack of product planning-Process planning and routing-Pre requisite information needed for process planning-Steps in process planning-Quantity determination in batch production-Machine capacity, balancing-Analysis of process capabilities in a multi product system.

PART * A

Q.No.	Questions
1.	**What is product planning?** (BTL2) i) The evaluation of the range, mix, specification and pricing of existing and new products in relation to present and future market requirements and competition. ii) Planning of product range, mix, specification and pricing to satisfy company object iii) Specifying the research, design and development support required.
2	**What is the purpose of feasibility study in relation to product planning?** (BTL2) The purpose of feasibility study is to extend the market analysis with the intent of arriving at a preferred system configuration that the firm is willing to offer the product or product-mix in response to an identified need.
3	**List the information that can be obtained from the system operation concept.** (BTL3) i) Identification of prime mission of the system ii) Definition of operating characteristics of the system iii) Anticipated usage of the system and its elements iv).Identification of effectiveness factors
4	**List the information that can be obtained from the system maintenance concept.** (BTL2) i) Identification of level of maintenance support. ii) Definition of repair policies iii) Definition of effectiveness measures iv). Establishment of supportability requirements in system/ equipment design v) Establishment of requirements of logistics support
5	**List the activities of advanced product planning.** (BTL2) i) Product selection and justification ii) Products specifications and plans iii) Product acquisition plan iv) Product evaluation plan
6	**What is value analysis? (April 2011, May 2015)** (BTL2) Value analysis is a disciplined approach that ensure the necessary functions at minimum cost without comprising on quality, reliability, performance and appearance.
7	**What is value? List its types.** (BTL2) Value, in general, taking the 'use value' as an objective, is the ratio between the function and the cost. Value=Types of economic value: 1. Use value, 2. Esteem value, 3. Cost value, 4.Exchange value.
8	**How can you increase the value of a product?** (BTL3) The value of a product can be increased: i) By reducing the costs ii) By improving function iii) By increasing function by increasing the costs disproportionately low

9	**Differentiate between primary and secondary functions with respect to value analysis.** (BTL4) Primary functions are the basic functions which the product is specially designed to perform. Secondary functions are those which if deleted would not prevent the devices from performing its primary functions
10	**Distinguished between value analysis an value engineering (April 2014).** (BTL4) Value analysis is the application of a set of techniques to an existing product with a view to improve its value. Thus value analysis is a remedial process. Value engineering is the application of exactly same set of techniques to a new product at the design stage itself. Therefore value engineering is a preventive process.
11	**Mention any four uses of value analysis.** (BTL2) i) It reduces the cost of product and determines the appropriate cost for the liable performance of the product. ii) It helps employees to understand their jobs in a better fashion iii) It creates new ideas and concepts for R&D department iv) It creates cost consciousness among the employees in the firm
12	**List any four reasons for product's unnecessary costs.** (BTL3) i) Failure to utilize specialized knowledge ii) Poor design of the component iii) Lack of ideas and relevant information iv) Unavoidable delivery constraints
13	**When do you apply value analysis?** (BTL3) Value analysis can be applied in case of the following indications. i) When the firm is unable to meet delivery schedules ii) Due to change in technology iii) When the cost of manufacturing is high iv) When rate of profit has a falling trend
14	**List the various phases of value analysis** (BTL2) i) Orientation phase ii) Information phase iii) Functional analysis iv) Creative phase v) Evaluation phase
15	**What is meant by process planning?** (BTL2) Process planning can be defined as "an act of preparing a detailed processing documentation for the manufacture of a piece part or assembly".
16	**What are the considerations in selection of an equipment or process? (April 2014)** (BTL2) Consideration in selection of an equipment or process -Economic considerations, production rate and unit cost of production, Durability and dependability, lower process rejection, minimum setups and put away times, longer productive life of machine or equipment and functional versatility.
17	**What are the factors affecting process planning?** (BTL3) i) Volume of production ii) The skill and expertise of manpower iii) Delivery dates for parts or products iv). Materials specifications v) Accuracy requirements of parts or products.
18	**What is meant by machine balancing?** (BTL2) Machine balancing refers to the procedure of adjusting the times at work centers to conform as much as possible to the required cycle time.

19	**List the commonly used methods to reduce the cycle time to a minimum.** (BTL2) (i) Reduce/eliminate idle time in the bottleneck activity (ii) Reduce the independent activity time (iii) Reduce the concurrent activity time.
20	**State the major objective of assembly line balancing. (Nov. 2011)** (BTL1) It is to subdivide the network into several sub networks (stations) without violating the precedence relationships and allocating operations to each station without exceeding the cycle time. i.e the sum of the times of operations allocated to each station should not exceed the cycle time.
	PART * B
1	**Discuss about Product planning. (13M) (April 2008, May 2015) (April 2017)** (BTL5) **Answer: Page 3.1-3.3 -Dr.V.Jayakumar** Product Planning is the ongoing process of identifying and articulating market requirements that define a product's feature set. Product planning serves as the basis for decisions about price, distribution and promotion. Product planning is the process of creating a product idea and following through on it until the product is introduced to the market. (4M) a small company must have an exit strategy for its product in case the product does not sell. Product planning entails managing the product throughout its life using various marketing strategies, including product extensions or improvements, increased distribution, price changes andpromotions. (3M) Advantages (3M) Disadvantages (3M)
2	**Explain the steps in Value Analysis / Engineerig**. **(13M) (Dec 2014, April 2014, April 2008)** (BTL5) **Answer: Page 3.9-3.18 -Dr.V.Jayakumar** Value analysis is an approach to improving the value of a product or process by understanding its constituent components and their associated costs. It then seeks to find improvements to the components by either reducing their cost or increasing the value of the functions. (3M) Steps 1. Information 2. Function Analysis 3. Creative 4. Evaluation 5. Development 6. Presentation (6M) Advantages (2M) Disadvantages (2M)
3	**Discuss in detail about Process planning and Routing. (13M) (April 2017)**(BTL5) **Answer: Page 3.19-3.20 -Dr.V.Jayakumar** process planning for manufacturing and the realisation of a product according to a product specification. The product specification (it may also be referred to as Product Design Specification) is a document describing the product; it's features, design, tolerances and what kind of specific behaviour certain components should have etc. Basically it should describe the product in great detail. This document is usually the final thing when having designed the product and perhaps also produced a prototype of some kind. (3M) Advantages (2M)

	Disadvantages (2M) Routing is the process of selecting a path for traffic in a network, or between or across multiple networks. Broadly, routing is performed in many types of networks, including circuit-switched networks, such as the public switched telephone network (PSTN), and computer networks, such as the Internet. (2M) Advantages (2M) Disadvantages (2M)
4	**What are the Steps in process planning? Explain in detail (13M) (April 2008, May 2015) April 2017)** (BTL5) **Answer: Page 3.30-3.32 -Dr.V.Jayakumar** The planning process is the steps a company takes to develop budgets to guide its future activities. The documents developed may include (3M) • Strategic plans (long-range, high-level company goals) • Tactical plans (shorter-term, specific plans to work toward goals in the strategic plan) • Operating plans (detailed plans for a specific department to implement) • Project plans (plans to implement projects such as launching new products or building a new plant) (6M) • Advantages (2M) • Disadvantages (2M)
5	**Describe in detail about Quantity determination in batch production problems (13M) (Dec 2014) (April 2017)**(BTL5) **Answer: Page 3.33-3.34 -Dr.V.Jayakumar** The economic production quantity model (also known as the EPQ model) determines the quantity a company or retailer should order to minimize the total inventory costs by balancing the inventory holding cost and average fixed ordering cost. (3M) The difference between these two methods is that the EPQ model assumes the company will produce its own quantity or the parts are going to be shipped to the company while they are being produced, therefore the orders are available or received in an incremental manner while the products are being produced. While the EOQ model assumes the order quantity arrives complete and immediately after ordering, meaning that the parts are produced by another company and are ready to be shipped when the order is placed. (3M) "Economic manufacturing quantity" model (EMQ) is used for "economic production quantity" model (EPQ). Similar to the EOQ model, EPQ is a single product lot scheduling method. A multiproduct extension to these models is called product cycling problem. (3M) Assumptions 1. Demand for items from inventory is continuous and at a constantrate 2. Production runs to replenish inventory are made at regular intervals 3. During a production run, the production of items is continuous and at a constantrate 4. Production set-up/ordering cost is fixed (independent of quantity produced) 5. The lead time is fixed 6. The purchase price of the item is constant, i.e. no discount is available 7. The replenishment is made incrementally. (4M)
6	**What is Machine capacity, balancing? (13M) (Dec 2014)** (BTL5) **Answer: Page 3.46&3.53 -Dr.V.Jayakumar**

	Machine Capacity is the process of determining the production capacity needed by an organization to meet changing demands for its products. In the context of capacity planning, design capacity is the maximum amount of work that an organization is capable of completing in a given period. Effective capacity is the maximum amount of work that an organization is capable of completing in a given period due to constraints such as quality problems, delays, material handling, etc. (2M) The phrase is also used in business computing and information technology as a synonym for capacity management. IT capacity planning involves estimating the storage, computer hardware, software and connection infrastructure resources required over some future period of time. A common concern of enterprises is whether the required resources are in place to handle an increase in users or number of interactions. (1M) Advantages (2M) Disadvantages (2M) Machine Balancing is a measuring tool used for balancing rotating machine parts such as rotors for electric motors, fans, turbines, disc brakes, disc drives, propellers and pumps. The machine usually consists of two rigid pedestals, with suspension and bearings on top supporting a mounting platform. The unit under test is bolted to the platform and is rotated either with a belt-, air-, or end-drive. As the part is rotated, the vibration in the suspension is detected with sensors and that information is used to determine the amount of unbalance in the part. Along with phase information, the machine can determine how much and where to add or remove weights to balance the part. (2M) Advantages (2M) Disadvantages (2M)
	PART * C
1	**Machine components supplied to assembly shop are produced in a plant at the rate of 125 piece/day. A cost analysis showed that the constant production costs per piece, including labour, material, and overhead, amount to Rs.210 per piece per day, and storage costs are Rs 0.025 per piece per day. If the preparation and machine setup costs for a production run amount to Rs.2000 and the assembly bay is usage 50 piece per day. Find the minimum- cost batch size and the length of the production run. Also estimate the production cost per production run. Assume interest changes are 15 percent and 300 working days in year.** **(15 M)** (BTL5)**Answer: Page 3.44 -Dr.V.Jayakumar** (10M)

We know that the minimum-cost batch size,

$$Q_m = \sqrt{\frac{2\,d\,S}{I\,(1+\gamma)+2\,B}}$$

$$= \sqrt{\frac{2 \times 50 \times 2000}{0.105\,(1+0.4)+2 \times 0.025}}$$

$$= 1007.58 \text{ units} \approx \mathbf{1008 \text{ units}} \quad \textbf{Ans.}$$

(5M)

2 **A product has to undergo 10 stages in the production sequence. Table shows the preparation time out machine time for those 10 stages.**

Operation	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Preparation time (min)	**0.2**	**0.4**	**0.2**	**0.1**	**0.1**	**0.20**	**0.2**	**0.2**	**0.2**	**0.6**
Machine time (min)	**0.8**	**9.6**	**0.4**	**0.9**	**1.3**	**4.6**	**2.2**	**2.6**	**2.4**	**3.0**

(i) determine the total operation time, cycle time, the output of the line and the efficiency of the actual given production sequence. (ii) it is required that the cycle time to be reduced to 5 min. Explain how it can be accomplished. (iii) Also determine the output and efficiency of the

(i) To find total operation time, cycle time, cycle output and efficiency of the current production line:

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The total operation time can be calculated as shown in table below:

Operation	Preparation time (t_1) min	Machine time (t_2) min	Total operation time, ($t = t_1 + t_2$) min
1	0.2	0.8	1.0
2	0.4	9.6	10.0
3	0.2	0.4	0.6
4	0.1	0.9	1.0
5	0.1	1.3	1.4
6	0.2	4.6	4.8
7	0.2	2.2	2.4

(5M)

	(10M)
3	**A product is sold at a rate of 400 pieces a day and is manufactured at a rate of 2000 pieces a day. The setup costs of the machines are Rs.5000 and the storage costs are found to be Rs.0.015 per unit per day. Labour charges are Rs.120,materialsRs.80,and overheads Rs.160 per piece. If the interest charges are 13% percent, find the minimum-cost batch size and the costs of the production run. Assume 300 working days in a year. (15M)** (BTL5) **Answer: Page 3.56&3.59-Dr.V.Jayakumar**

(iii) To find output and efficiency of the new line:

Total operation time of the new line = 30.2 min

Cycle time of the new line, T = 5 min

$\therefore$ Output of the new line, $Q_{th} = \frac{60}{T} = \frac{60}{5}$

= **12 units per hour Ans.** (10M)

$$\text{Efficiency} = \frac{\text{Total operation time}}{\text{No. of machines} \times \text{Cycle time}} \times 100$$

$$= \frac{30.2}{11 \times 5} \times 100 = \textbf{54.9\% Ans.}$$ (5M)

UNIT IV – PRODUCTION SCHEDULING

Production Control Systems-Loading and scheduling-Master Scheduling-Scheduling rules-Gantt charts-Perpetual loading-Basic scheduling problems - Line of balance – Flow production scheduling- Batch production scheduling-Product sequencing – Production Control systems-Periodic batch control- Material requirement planning kanban – Dispatching-Progress reporting and expediting-Manufacturing lead time-Techniques for aligning completion times and due dates.

PART * A

Q.No.	Questions
1.	**What do you mean by loading?** (BTL2) Loading may be defined as the assignment of work to a facility without specifying when the work is done and in what sequence.
2	**What is scheduling? What are its objectives?** (BTL3) Scheduling refers to the setting of operation start dates so that jobs will be completely by their due date. The objectives of production scheduling are: i) To meet due date ii) To minimize lead time iii) To minimize setup time or cost iv) To minimize work-in process inventory v) To maximize machine or labor utilization
3	**What is master scheduling?** (BTL2) The master schedule, also known as master production schedule (MPS), formalize the production plan and translates it into specific end-item requirements over a short to immediate planning horizon.
4	**What is MPS?** (BTL3) The master schedule, also known as master production schedule (MPS), formalize the production plan and translates it into specific end-item requirements over a short to immediate planning horizon.
5	**What are Gantt charts? (May 2015)** (BTL3) Gantt charts are usual aids used to depict the sequencing, load on facilities, or progress associated with work effort over a well-defined time period.
6	**What is priority sequencing?** (BTL2) Priority sequencing is a systematic procedure for assigning priorities to waiting jobs thereby determining the sequence in which the jobs will be performed.
7	**What are the dispatching rules?** (BTL2) Dispatching rules, also known as priority rules or sequencing rules or scheduling rules, are the rules used in obtaining a job sequence.
8	**What is meant by product sequencing?** (BTL2) Priority sequencing is a systematic procedure for assigning priorities to waiting jobs thereby determining the sequence in which the jobs will be performed.
9	**What is meant by EBQ scheduling?** (BTL2) EBQ scheduling is nothing is nothing but the economic batch quantity scheduling that can be performed by using aggregate run-out method.
10	**What do you mean by line-of-balance? What are its uses?** (BTL3) Line-of-balance is a charting technique that uses lead times and assembling sequencing to compare planned component completion with actual component completions.

11	**List the various charts that are used in line-of-balance analysis.** (BTL2) 1. Operation programme chart/ or assembly chart, 2. Objective chart 3. Progress chart 4. Line of balance chart
12	**What is the use of objective chart?** (BTL2) The objective chart shows the contrast between expected completion schedules of production and the actual performance.
13	**When do you use progress chart?** (BTL2) The progress chart is a bar type chart which shows the actual number of items produced at each operation stage against the quantities that should have been produced as indicated by line of balance.
14	**What is MRP?** (BTL3) Materials requirements planning (MRP) is a computational technique that converts the master schedule for final products into a detailed schedule for the raw materials and parts used in the final products.
15	**List the various inputs required for MRP (April 2011)** (BTL3) 1. Master production schedule 2. Bill of materials file 3. Inventory record file
16	**What is MPS?** (BTL2) Master Production Schedule (MPS) is a detailed plan that shows how many end items will be available for sale or distribution during specific periods.
17	**List some commonly used forms in dispatching.** (BTL2) 1. Material requisitions 2. Job cards/ Tickets 3. Labour cards/Tickets 4. Move cards/Tickets 5. Inspection cards/Tickets 6. Tool and gauge tickets
18	**What is meant by Gantt Chart and how it is constructed? (April 2014)** (BTL3) Gantt chart is a principal tool used for both loading and scheduling. It consists of a simple rectangular grid, divided by series of parallel horizontal and vertical lines. Vertical lines divide the chart into units of time. The scale units can be year months weeks or days or hours according tothedutyforwhichchartisrequired.Thehorizontallinesdividethechartintosections,which can be used to represent either work status tasks or work centers.
19	**List the various recording methods for the progressing purpose.** (BTL2) 1. Gantt charts 2. Visual charts 3. Cumulative and weekly charts
20	**What do you mean by expediting?** (BTL3) Expediting, also known as follow-up or progressing, is a control function that keeps track of the 'progresses of work in accordance with planned schedule.
	PART * B
1	**Briefly explain the various techniques used for loading and scheduling (13M) (Dec 2010, May 2015)**(BTL3) **Answer: Page 4.2&4.4 - Dr.V.Jayakumar** various techniques used for loading 1. Master scheduling (Master production scheduling) (3M) 2. Gannt chart (3M) 3. Perpatual scheduling (3M) various techniques used for scheduling 1. Economic Batch Quantity(EBQ) (3M) 2. Batch scheduling (1M)
2	**Explain different techniques employed for aligning completion times and due dates) (13M) (Dec. 2010, Dec 2014, May 2015** (BTL3)**Answer: Page 4.34-4.36 -Dr.V.Jayakumar**

	A production line is said to be in balance when every worker's task takes the same amount of time. Line balancing is a manufacturing-engineering function in which whole collection of production-line tasks are divided into equal portions. Well-balanced lines avoid labour idealness and improve productivity. (3M) Stage 1 : Draw the cumulative completion schedule Stage 2 : Draw a vertical line AB for cumulative completion schedule Stage 3 : Draw the line of balance schedule Stage 4 : Find out how many have been completed Stage 5 : Draw line of balance (5M) Techniques employed for aligning completion times and due dates i) Define task ii) Identify precedence requirements. iii) Calculate minimum number of workstations required to produce desired output. iv) Apply heuristics to assign task to each station. v) Evaluate effectiveness and efficiency. vi) Seek further improvement. (5M)
3	**Explain the significance of scheduling. What are the types of scheduling? (13M) (Dec. 2011)** (BTL6) **Answer: Page 4.5-4.6 -Dr.V.Jayakumar** Scheduling is the process of arranging, controlling and optimizing work and workloads in a production process or manufacturing process. Scheduling is used to allocate plant and machinery resources, plan human resources, plan production processes and purchase materials. (3M) various types of scheduling 1. Master scheduling (Master production scheduling) (2M) 2. Gannt chart (2M) 3. Perpatual scheduling (2M) 4. Economic Batch Quantity(EBQ) (2M) 5. Batch scheduling (2M)
4	**Explain the following (i) GANTT Chart construction (ii) MRP (13M) (Dec. 2011, Dec2014)** (BLT6) **Answer: Page 4.9&4.41 -Dr.V.Jayakumar** A Gantt chart is a type of bar chart that illustrates a project schedule, named after its inventor, In a progress Gantt chart, tasks are shaded in proportion to the degree of their completion: a task that is 60% complete would be 60% shaded, starting from the left. A vertical line is drawn at the time index when the progress Gantt chart is created, and this line can then be compared with shaded tasks. If everything is on schedule, all task portions left of the line will be shaded, and all task portions right of the line will not be shaded. This provides a visual representation of how the project and its tasks are ahead or behind schedule. (6M) Material requirements planning (MRP) is a production planning, scheduling, and inventory control system used to manage manufacturing processes. Most MRP systems are software-based, but it is possible to conduct MRP by hand as well. An MRP system is intended to simultaneously meet three objectives: (2M) • Ensure materials are available for production and products are available for delivery to customers. • Maintain the lowest possible material and product levels in store • Plan manufacturing activities, delivery schedules and purchasing activities. (5M)
5	**Explain the Period Batch Control, Flow Production Scheduling (13M) (Dec 2014, May 2015)** (BTL5)**Answer: Page 4.14-4.16-Dr.V.Jayakumar** Period Batch Control

	Period Batch Control (PBC) system, a production planning system that has strongly been advocated for application within cellular manufacturing. It is said to be a simple and effective instrument in obtaining the benefits of group technology. Period Batch Control is a cyclical planning system that co-ordinates the various stages of transformation that are required in order to fulfill the demand of the customers. Effective coordination of the supply chain should make it possible to avoid or reduce decoupling stocks or other types of inefficiencies between successive transformation processes. (3M) 1 Single cycle ordering refers to the frequency of releasing work orders: each part has the same ordering frequency as its parent product 2 Single phase refers to the release moment of work orders: work orders are released to the production system at the same moment (defined as the start of a period) 3 Single offset time refers to the lead time of work orders (per stage): all work orders have identical lead times. (4M) Flow Production Scheduling is the process of arranging, controlling and optimizing work and workloads in a production process or manufacturing process. Scheduling is used to allocate plant and machinery resources, plan human resources, plan production processes and purchase materials. (3M) It is an important tool for manufacturing and engineering, where it can have a major impact on the productivity of a process. In manufacturing, the purpose of scheduling is to minimize the production time and costs, by telling a production facility when to make, with which staff, and on which equipment. Production scheduling aims to maximize the efficiency of the operation and reduce costs. (3M)
6	**What do you mean by Production control system, loading and scheduling: Describe them? (13M) (**BTL5) **Answer: Page 4.1-4.4 -Dr.V.Jayakumar** Production control system Since medium-sized suppliers are becoming increasingly involved in their customers' product development, the subject of Product Lifecycle Management (PLM) is gaining importance. The development and production of complex products at different sites with a large number of people involved requires significant coordination and collaboration. A central database, as provided by abas ERP, ensures that your team has access to the latest CAD data, drawings and specifications at all times. You can trace the version history seamlessly over many years to check what was developed or changed and when. No confusion or redundancy of effort here. With abas ERP Production Planning & Control, your production processes become much more coordinated, collaborative, and streamlined, enabling you to increase value creation throughout production. (3M) various techniques used for loading 1. Master scheduling (Master production scheduling) (2M) 2. Gannt chart (2M) 3. Perpatual scheduling (2M) various techniques used for scheduling 1. Economic Batch Quantity(EBQ) (2M) 2. Batch scheduling (2M)
	PART * C
1	**Processing time of five jobs on two machines are given below. Using Johnson's rule,**

schedule these jobs. Also find the minimum total flow time.

Time required for job (hours)					
	A	**B**	**C**	**D**	**E**
Machine M1	**5**	**4**	**8**	**7**	**6**
Machine M 2	**3**	**9**	**2**	**4**	**10**

(15M) (BTL5) **Answer: Page 5.22 – 5.23 -Dr.V.Jayakumar**

(10M)

(5M)

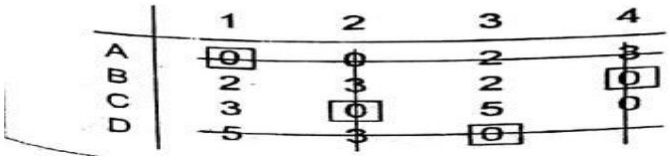
2

A scheduler has four jobs that can be done on any of four machines with respective times (minutes) as shown in the table below. Determine the allocation of jobs to machines that will result in minimum time.

Job	**Machines**			
	1	**2**	**3**	**4**
A	**5**	**6**	**8**	**7**
B	**10**	**12**	**11**	**7**
C	**10**	**8**	**13**	**6**
D	**8**	**7**	**4**	**3**

(15M) (BTL5)**Answer: Page 5.27 – 5.28 Dr.V.Jayakumar**

Step 3. Cover all zeros



(10M)

(5M)

3

The table below gives the data on current inventory, production lot sizes, standards hours per unit and the forecast of demand for all items required for a product. Determine the sequence of production (i.e., production schedule) using the aggregate run-out (AROT) method. The available production capacity is 320 hours. Also analyse the effect of capacity on the schedule.

Item	Standard hours Perunit	Lot Size	Forecast Demand/week	Current Inventory	Machine hours per order
A	0.20	200	70	200	40
B	0.40	300	100	240	120
C	0.30	200	80	260	60
D	0.40	400	120	160	160
					380

(15M) (BTL5)**Answer: Page 4.1-4.4 -Dr.V.Jayakumar**

(10M)

Table: Schedule requirements

Item	Standard hours per unit	Forecast demand per week	AROT	Gross inventory	Current inventory	Net requirements
A	0.20	70	4.746	4.746 × 70 = 332	200	332 – 200 = 132
B	0.40	100	4.746	4.746 × 100 = 474	240	474 – 240 = 234
C	0.30	80	4.746	4.746 × 80 = 380	260	380 – 260 = 120
D	0.40	120	4.746	4.746 × 120 = 570	160	570 – 160 = 410

(5M)

UNIT V – INVENTORY CONTROL AND RECENT TRENDS IN PPC	
Inventory control-Purpose of holding stock-Effect of demand on inventories-Ordering procedures. Two bin system -Ordering cycle system-Determination of Economic order quantity and economic lot size- ABC analysis-Recorder procedure-Introduction to computer integrated production planning systems elements of JUST IN TIME SYSTEMS-Fundamentals of MRP II and ERP.	
PART * A	
Q.No.	**Questions**
1.	**Define term inventory and inventory control.** (BTL2) An inventory is a stock of an item or idle resource held for future use. Inventory control may be defined as the Scientific method of determining what to order , when to order and how much to order and how much to stock so that the costs associated with buying and storing are optimal without interrupting production and sales.
2	**Mention at least four reasons for keeping an inventory.** (BTL3) 1. To maintain independence of operations. 2. To meet variation in product demand. 3. To allow flexibility in production scheduling. 4. To provide a safeguard for variation in raw material delivery time.
3	**What are inventory costs?** (BTL2) The major costs associated with procuring and holding inventories are: 1. Ordering costs, 2. Carrying (or holding) costs, 3. Shortage (or stock out) costs 4. Purchase costs.
4	**Define the following terms: (a) Lead time (b) Re-order point**(BTL1) (a) Lead time: The time gap between placing of an order and its actual arrival in the inventory is known as a lead time. (b) Re-order point: The level of inventory at which an order is placed is known as Re-order point or re-orders level
5	**Define the terms buffer stock, and re-order quantity.** (BTL1) Safety or buffer stock: This represents the minimum stock which must be maintained at all times. If stock is less than the buffer stock, then the work will stop due to shortage of materials. Re-order quantity: The quantity of items to be ordered at re-orders level is known as re-order quantity.
6	**What is EOQ?** (BTL2) The technique of economic ordering quantity (EOQ) strikes a balance between the ordering cost and the carrying cost. EOQ is the size of order which minimizes the total cost of carrying inventory and ordering.
7	**What do you understand by fixed-time period model?** (BTL2) The fixed time period models are also referred to us the periodic system, periodic review system, fixed order interval system and P model. In a fixed time period system, periodic review of inventories is made and order is invariably placed in that period.
8	**What do you mean by kanban production control system? Brief about Kanban (May 2015)** (BTL1) Kanban means sign or instruction card in Japanese. A kanban is a card that is attached to a

	storage and transport container. It identifies the part number and container capacity, along with other information.
9	**What is JIT? List its Benefits (April 2011)** (BTL3) Reduction in inventories Improved quality Reduced space requirements Shorter lead times Lower production costs Increased productivity Increased machine utilization Greater flexibility
10	**What are the objectives of JIT? (April 2011)** (BTL3) 1. Zero defects 2. Zero setup time 3. Zero inventories 4. Zero handling 5. Zero breakdowns 6. Zero lead time and 7. Lot size of one.
11	**List the seven wastes that becomes the target of elimination in a JIT process.** (BTL2) 1. Waste of overproduction 2. Waste of waiting 3. Waste of transportation 4. Waste of processing itself 5. Waste of stocks 6. Waste of motion 7. Waste of making defective products
12	**Differentiate between Pull system and Push system** (BTL4) A kanban system, is a Pull system, in which the Kanban is used to Pull parts to the next production state when they are needed i.e., in Pull system product is made to order. A MRP system is a Push system in which a detail production scheduled for each part is used to Push the parts to the next production stage when scheduled i.e., in a Push system the product is made to stock.
13	**What is MRP II? (May 2015)** (BTL2) MRP II is defined as a computer base system for planning scheduling and controlling the materials, resources and supporting activities needed to meet the Master Production Schedule. In fact MRP II consist of virtually functions in a PPC system plus additional business functions that are related to production.
14	**What are the functions of MRP II?** (BTL2) 1. Management planning: Business strategy aggregate production planning, maser production scheduling, rough cut capacity planning and Budget planning. 2. Customer services: Sales forecasting, order entry, sales analysis and finished goods inventory 3. Operations planning: Purchase order and work order release 4. Operations execution: Purchasing, product scheduling and control, work in-process, inventory control shop floor control and labour hour tracking 5. Financial function: Cost accounts receivable, accounts payable, general ledger and payroll.
15	**Define the terms inventory and inventory control?** (BTL2) An inventory is a stock of an item or idle resource held for future use. Inventory control may be defined as the scientific method of determining what to order, when to order and how much to order and how much to stock so that costs associated with buying and storing are optimal without interrupting production and sales.

16	**Differentiate between anticipation and fluctuation inventories.** (BTL4) Anticipation inventories: these are stocks maintained to meet the anticipated i.e., expected demand. Fluctuation inventories: these are safety stocks maintained to meet the unexpected demand and thereby to avoid the risk of losing sales.
17	**What is two bin system? List its advantages (April 2011)(May 2015)** (BTL3) A two-bin system is a type of fixed-order system in which inventory is carried in two bins. A replenishment quantity is ordered when the first bin is empty. During the replenishment lead time, material is used from the second bin. A two-bin system is mostly used in assembly environments. The advantage of a two-bin system is a minimal chance of a stock-out and the ease to handle. Inventory control method (used usually for small or low value items) in which when the first bin is used up, an order is made out for replenishment. The second bin contains enough quantity of the item to last until the ordered quantity arrives.
18	**State the elements of JIT? (April 2014, May 2015)** (BTL2) Basic elements of JIT - Flexible resources - Cellular layouts -Pull production system - Kanban production control - Small-lot production - Quick setups - Uniform production levels - Quality at the source - Total productive maintenance - Supplier networks
19	**What is EOQ?**(BTL1) The technique of economic ordering quantity (EOQ) strikes a balance between the ordering cost and the carrying cost. EOQ is that size of order which minimizes the total costs of carrying inventory and ordering.
20	**Mention any four ERP packages that are widely used in India.** (BTL1) 1. SAP 2. JD Edwards 3. Manufacturing / Pro 4. BPCS 5. Marshal 6. Oracle Financials
	PART * B
1	**What are the Effects of demand on inventories? (May 2015) (13M)** (BTL6) **Answer: Page 5.2 -Dr.V.Jayakumar** Working capital (2M) More storage space (2M) High taxes (2M) Greater handling cost (2M) high cost of recording (2M) deterioration of quality (2M) chances of pilferage. (1M)
2	**Describe about the Fundamentals of MRP-II. (Nov. 2010) (13M)** (BTL3) **Answer: Page 5.45-5.46 -Dr.V.Jayakumar** Management planning (3M) Customer services (3M) operation planning (3M) operation execution (2M) financial functions (2M)
3	**Write a note on ERP. (13M) (Nov. 2010, May 2015)** (BLT3) **Answer: Page 5.48-5.51 - Dr.V.Jayakumar** Enterprise resource planning (ERP) is business process management software that allows an organization to use a system of integrated applications to manage the business and automate many back office functions related to technology, services and human resources. (3M) ERP software typically integrates all facets of an operation — including product planning, development, manufacturing, sales and marketing — in a single database, application and user

	interface. (3M) organizations implement ERP for the following reasons: To replace out-of-date ERP software (49%) To replace homegrown systems(16%) To replace accounting software(15%) To replace other non-ERP systems / had no system (20%) (4M) modules to manage back-office activities and tasks including the following: Distribution process management Supply chain management Services knowledge base Configure prices Improve accuracy of financial data Facilitate better project planning Automate the employee life-cycle Standardize critical business procedures Reduce redundant tasks Assess business needs Accounting and financial applications Lower purchasing costs Manage human resources and payroll (3M)
4	**Explain briefly the procedure for ABC analysis and list its merits and demerits. (13M) (April/May 2017) (April 2014)** (BTL2) **Answer: Page 5.26-5.29 -Dr.V.Jayakumar** ABC Analysis is a comprehensive way of segmenting your customers or products to make sure that you get the most out of your time and your resources when you're servicing them by breaking the items down into three easily distinguishable categories. (4M) (4M) ABC analysis is a method of analysis that divides the subject up into three categories: A, B andC. Category A Category B Category C (5M)
5	**Describe the elements of JIT System? (13M) (Dec 2014, May 2015, April 2016)** (BTL3) **Answer: Page 5.39-5.42 -Dr.V.Jayakumar** Continuous improvement. (2M) Eliminating waste. (2M) Good housekeeping (2M) workplace cleanliness and organisation. (2M)

	Set-up timer education increases flexibility and allows smaller batches. Leveled /mixed production To smooth the flow of products through the factory.	(2M) (1M) (1M) (1M)
6	**Discuss in detail about MRP-II. (April 2016) (13M)** (BTL3) **Answer: Page 4.34-4.36 - Dr.V.Jayakumar**	(13M)
	PART * C	
1	**The annual demand for an item is 3200 units. The unit cost is Rs.6 and inventory carrying charges are estimated as 25% per annum. If the cost of one procurement is Rs.150, determine:** **(i) Economic order quantity,** **(ii) Number of orders per year,** **(iii) Time between two consecutive orders, and** **(iv) Optimal cost.** **(15M)** (BTL5) **Answer: Page 5.13 - 5.14 -Dr.V.Jayakumar**	

		(10M) (5M)
2	**Monthly consumption of an item is 500 units. The price per units Rs.25. Inventory carrying cost is 16 per cent and ordering cost is Rs.50 per order. Lead time of 1 months stock. For a ROL i.e, Q-system, determine:** **(i) Re-Order quantity,** **(ii) Minimum level,** **(iii) Re-order level,** **(iv) Maximum level, and** **(v) Average inventory** **(15M)** (BTL5) **Answer: Page 5.16 - 5.17 -Dr.V.Jayakumar**	(5M) (10M)
3	**Perform ABC analysis on the following sample of items in an inventory.**	

Item	Annual consumption (units)	Price/unit (in Rupees)
A	**5950**	**5**
B	**21250**	**4**
C	**1000**	**8.75**
D	**2087**	**5**
E	**27600**	**2.50**
F	**28000**	**0.50**
G	**36000**	**0.25**
H	**911**	**4.10**
I	**300**	**2.90**
J	**29450**	**0.30**
K	**11500**	**8.15**
L	**3934**	**5**

(15M) (BTL5) **Answer: Page 5.29 - 5.30 -Dr.V.Jayakumar**

(10M)

(5M)

ME6016 ADVANCEDICENGINES L T P C
3 0 0 3

OBJECTIVES:

- To understand the underlying principles of operation of different IC Engines andcomponents.
- To provide knowledge on pollutant formation, control, alternate fueletc.

UNITI SPARKIGNITIONENGINES 9

Mixture requirements – Fuel injection systems – Mono-point, Multipoint & Direct injection - Stages of combustion – Normal and Abnormal combustion – Knock - Factors affecting knock – Combustion chambers.

UNITII COMPRESSIONIGNITIONENGINES 9

Diesel Fuel Injection Systems - Stages of combustion – Knocking – Factors affecting knock – Direct and Indirect injection systems – Combustion chambers – Fuel Spray behaviour – Spray structure and spray penetration – Air motion - Introduction to Turbocharging.

UNITIII POLLUTANT FORMATIONANDCONTROL 9

Pollutant – Sources – Formation of Carbon Monoxide, Unburnt hydrocarbon, Oxides of Nitrogen, Smoke and Particulate matter – Methods of controlling Emissions – Catalytic converters, Selective Catalytic Reduction and Particulate Traps – Methods of measurement – Emission norms and Driving cycles.

UNITIV ALTERNATIVEFUELS 9

Alcohol, Hydrogen, Compressed Natural Gas, Liquefied Petroleum Gas and Bio Diesel - Properties, Suitability, Merits and Demerits - Engine Modifications.

UNITV RECENTTRENDS 9

Air assisted Combustion, Homogeneous charge compression ignition engines – Variable Geometry turbochargers – Common Rail Direct Injection Systems - Hybrid Electric Vehicles – NOx Adsorbers - Onboard Diagnostics.

TOTAL : 45 PERIODS

OUTCOME:

• Upon completion of this course, the students can able to compare the operations of different IC Engineand components and can evaluate the pollutant formation, control, alternatefuel

TEXT BOOKS:

- Ramalingam. K.K., "Internal Combustion Engine Fundamentals", Scitech Publications,2002.
- Ganesan, "Internal Combustion Engines", II Edition, TMH,2002.

REFERENCES:

- Mathur. R.B. and R.P. Sharma, "Internal Combustion Engines"., Dhanpat Rai & Sons2007.
- Duffy Smith, "Auto Fuel Systems", The Good Heart Willcox Company, Inc.,1987.
- Eric Chowenitz, "Automobile Electronics", SAE Publications,1995

Subject Code :ME6016 **Year/Semester : IV/08**
Subject Name : Advanced IC Engines Subject Handler: Dr.B.RAJESHKUMAR & Mr.J.RAVIKUMAR

UNITI SPARK IGNITIONENGINES	
Mixture requirements – Fuel injection systems – Mono-point, Multipoint & Direct injection - Stages of combustion – Normal and Abnormal combustion – Knock - Factors affecting knock – Combustion chambers.	
PART * A	
Q.No.	**Questions**
1.	**Mention the different jets used in a carburetor. (May/June 2012)** BTL3 Main jet, Pilot jet and slow jet.
2	**List down the air fuel ratio requirements of a S.I engine. (May/June 2012)**BTL1 Chemically correct mixture, rich mixture and lean mixture.
3	**Sketch T-Head type combustion chamber used in S.I. engines. (May/June 2013)** BTL1 Diagram of T type combustion chamber.
4	**What is heterogeneous air-fuel mixture? In which engine is it used. (May/June 2013)** BTL1 In a heterogeneous gas mixture, the rate of combustion is determined by the velocity of mutual diffusion of fuel vapours in to the air, and the rate of chemical reaction is of minor importance. Heterogeneous air-fuel mixture is used in CI engines.
5	**List the various factors that influences the flame speed in SI engine combustion. (Nov/Dec 2013)** BTL **1** Turbulence, air fuel ratio, temperature and a pressure, compression ratio, engine speed, size and output.
6	**Why do we require rich mixture during idling? (Nov/Dec 2013)** BTL4 In order to minimize the effect of dilution of fresh charge by the mixing with exhaust gas.
7	**What are the factors that influence the flame speed? (April/May 2014)** BTL3 Turbulence, air fuel ratio, temperature and a pressure, compression ratio, engine speed, size and output.
8	**What are different air-fuel mixtures on which an engine can be operated?** (**April/May 2014)** BTL3

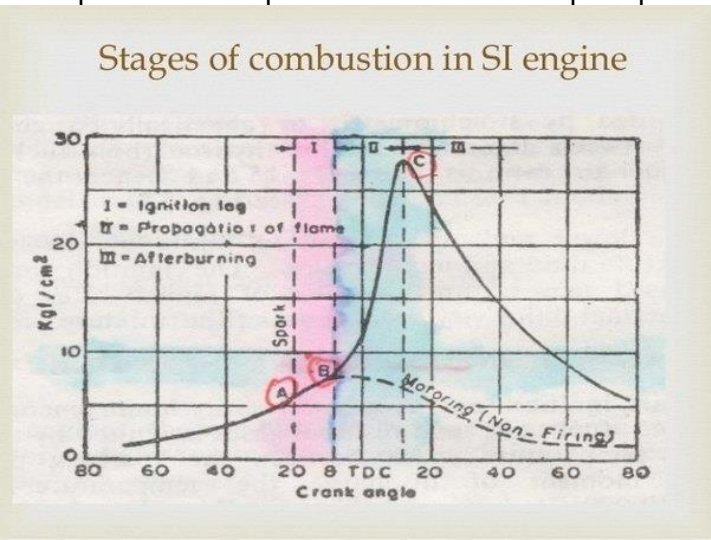
	Air fuel ratio for Idling, starting, medium load, maximum load, maximum power range and acceleration.
9	**What is the principle of a carburetor? How are jet and venturi sizes decided? (April/May 2015)** BTL2 The process of formation of a combustible fuel -air mixture by mixing the proper amount of fuel with air before admission to engine cylinder is called carburetion and the device which does this job is called carburetor.
10	**Why a SI engine requires a rich mixture during idling and at full load? (April/May 2015)** BTL5 DuringIdlingthepressureneartheintakemanifoldisconsiderablybelowatm.Pr.Duetorestriction of the air flow. The engine requires rich mixture, this is due to the existing pressure conditions between the combustion chamber and the intake manifold which causes exhaust gas dilution of the fresh charge.
11	**State any four important types (shapes) of combustion chambers common in SI engines. (Nov/Dec 2015)** BTL1 T-head combustion chamber,L-head or side valve combustion chamber, F-Head or Ricardo turbulent head side valve, Overhead valve or I-head combustion chamber.
12	**List the different Air-Fuel ratios required for different operating conditions of a gasoline engines. (Nov/Dec 2015)** BTL2 Idling- rich mixture , Crushing or normal power range-17:1 , Power range-rich mixture (14:1)
13	**List the different types of combustion chambers found in spark ignition engine. (April 2016)** BTL **3** T-head combustion chamber,L-head or side valve combustion chamber,F-Head or Ricardo turbulent head side valve, Overhead valve or I-head combustion chamber
14	**What are the various factors affecting knock in spark ignition engine? (April 2016)** BTL1 (i) Temperature factor (ii) Density factor (iii) Time factor (iv) Composition In temperature factor (a) Compression ratio (b) Supercharging (iii) Raising the inlet temperature (iv) Increasing the load (v) Raising the coolant temperature.
15	**Define normal combustion.** BTL1 In normal combustion, the flame initiated by the spark travels across the combustion chamber in a fairly uniform manner.
16	**Define abnormal combustion and its consequences.** BTL4 Under certain operating conditions the combustion deviates from its normal Course leading to loss of performance and possible damage to the engine are termed as abnormal combustion (or) knocking

	combustion.Consequences are(1).Loss of power(2).Recurring pre-ignition(3).Mechanical damage to the engine.
17	**Explain the type of vibration produced when auto ignition occurs.** BTL4 Two different vibrations are produced. 13.In one case, a large amount of mixture may auto ignite giving use to a very rapid increase in pressure throughout the chamber and there will be a direct blow on free vibration of the engine parts 14.In another case, larger pressure differences may exit in the combustion chamber and the resulting gas vibration can force the walls of the chamber to vibrate at the same frequency as the gas.
18	**What is the method to detect the phenomenon of knocking?** BTL1 The scientific method to detect the phenomenon of knocking is to use a pressure transfer this transducer is connected, usually to a cathode ray oscilloscope. Thus Pressure-time traces can be obtained from the pressure transducer.
19	**Define performance number.** BTL1 Performance number is defined as the ratio of Knock limited Indicated mean effective pressure with the sample fuel to knock limited Indicated mean effective pressure with ISO-OCTANE .when the inlet pressure is kept constant.
20	**List the parameters in time factors that reduce the knocking.** BTL3 Parameters are turbulence, engine speed, flame travel distance, combustion chamber shape and location of spark plug.
21	**What are the factors to be considered to obtain high thermal efficiency?** BTL4 1. A high volumetric efficiency. 2. Anti-knock characteristic must be improved. 3. Compact combustion chamber reduces heat loss during combustion increases the thermal efficiency.
	Part B
1	**Explain the stages of combustion in S.I engine with a pressure crank angle diagram. (13M)** **(April/May 2017), (Nov/Dec 2016)**BTL5 **Answer: Page 2.11- Dr.S.Senthil**

The first stage, normally called as preparation phase or ignition lag. Every chemical reactions including combustion have some delay period (that includes physical and chemical delays). In this period the charge is basically preparing for combustion. Time of this period is depends upon the temperature, pressure, composition IN the cylinder. 1st stage is marked as the region on indicator diagramfromsparkingpointtopointwhenpressure-crankangle diagramdisconnectsfrommotoring curve. (3M)

At 2nd stage, flame propagates throughout the cylinder with constant velocity and a quick rise in pressure is observed. Flame velocity is dependent on composition inside the cylinder. This period is marked as the region from the point when pressure-crank angle diagram disconnects from motoring curve to the peak pressure point. (3M)

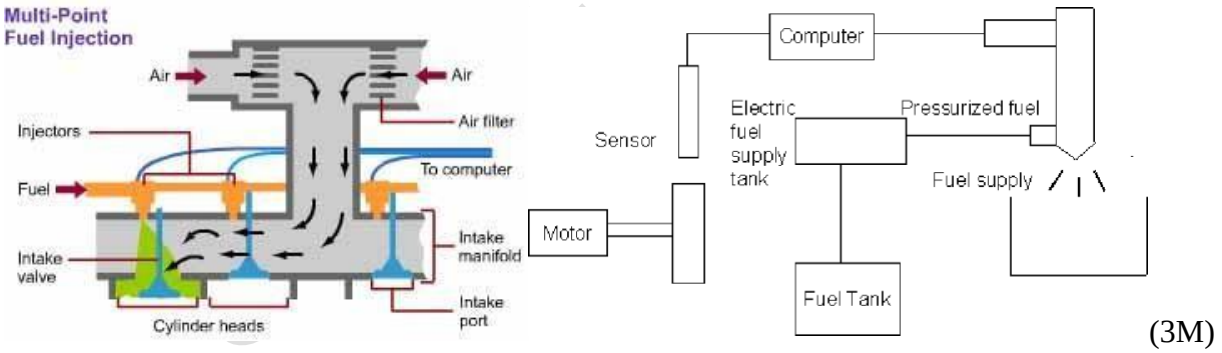
At 3rd stage the flame speed reduced. Piston already starts to move away from TDC, so no further rise in pressure. This period is marked as the peak pressure point to BDC. (3M)



(4M)

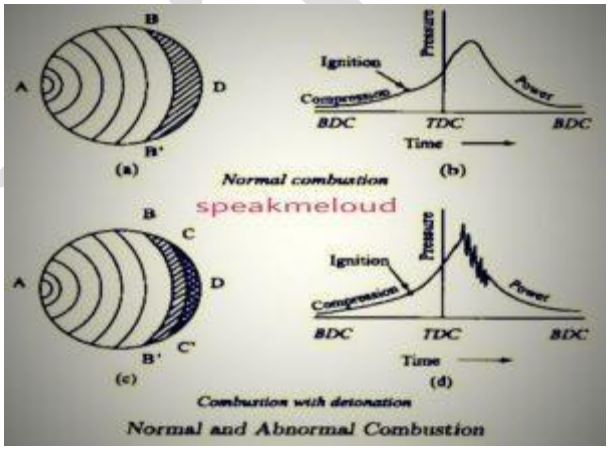
2 **Explaintheworkingofmultipointandgasolinedirectinjectionsystemsusedin S.Ienginewith block diagram. (13M) (April/May 2017)**BTL5

Answer: Page 2.53 & 6.32- Dr.S.Senthil



(3M)

Multi point injection systems **Gasoline direct injection systems**

	Multi point fuel injection system injects fuel into the intake ports just upstream of each cylinder's intake valve, rather than at the central point within the intake manifold. Multi point fuel injection systems are of three types, first is BATCHED in which fuel is injected to the cylinders in groups, without precisely bringing together to any particular cylinder's intake stroke, the second one is simultaneous in which fuel is injected at the same time to all the cylinders and the third one is sequential in which injection is timed to coincide with each cylinder's intake stroke. (5M) **Gasoline direct injection (GDI)** (also known as petrol direct injection, direct petrol injection, spark-ignited direct injection (SIDI) and fuel-stratified injection (FSI)), is a form of fuel injection employed in modern two-stroke and four-stroke gasoline engines. The gasoline is highly pressurized, and injected via a common rail fuel line directly into the combustion chamber of each cylinder, as opposed to conventional multipoint fuel injection that injects fuel into the intake tract or cylinder port. Directly injecting fuel into the combustion chamber requires high-pressure injection, whereas low pressure is used injecting into the intake tract or cylinder port. (5M)
3	**Explain in detail how the fuel jet size and venturi size of the carburetor are decided for an automotive engine. (8 M) (Nov/Dec 2016)** BTL5 **Answer: Page SQ 25- Dr.S.Senthil** The size of a carburetor is commonly given in terms the diameter of the venturi tube in mm and the jet size is in hundred meter.Thecalibratedjethaveastampednumberwhichgivestheflow in ml/min under the head of 500 mm of pure benzol**.** (4M) Foraventuriof30to50mmsize(having a jet size which is one sixteenth of venturi size) the pressure difference(p_1-p_2)isabout50mmofHg.Thevelocityofthroatisabout90-100m/s and the coefficient of discharge for venturi C_{da} isusually0.85. (4M)
4	**Explain in detail about normal and abnormal combustion in S.I engines. (13M) (AU April/May 2016)** BTL5 **Answer: Page 2.24- Dr.S.Senthil**  (3M) Figure **normal and abnormal combustion in S.I engines** **Normal Combustion:** Under ideal conditions the common internal combustion engine burns the fuel/air mixture in the cylinder in an orderly and controlled fashion. The combustion is started by the

spark plug some 10 to 40 crankshaft degrees prior to top dead center (TDC), depending on many factors including engine speed and load.Thisignitionadvanceallowstimeforthecombustionprocess to develop peak pressure at the ideal time for maximum recovery of work from the expanding gases. . (5M)

Abnormal Combustion: When unburned fuel/air mixture beyond the boundary of the flame front is subjectedtoacombinationofheatandpressureforacertainduration(beyond the delay period of the fuel used), detonation may occur. Detonation is characterized by an almost instantaneous, explosive ignition of at least one pocket of fuel/air mixture outside of the flame front. A local shock wave is createdaroundeachpocketandthecylinderpressurewillrisesharply,and possibly beyond its design limits causing damage.

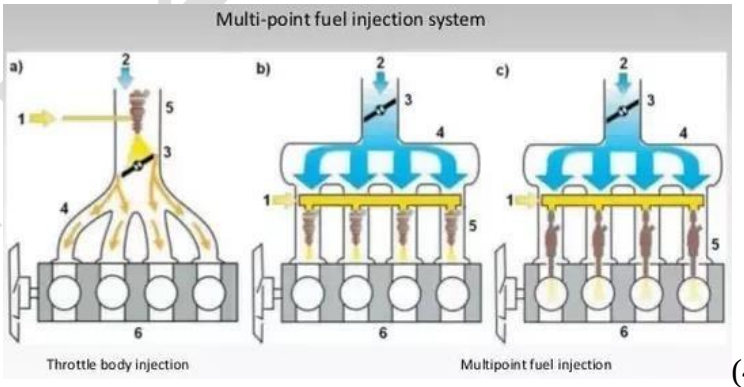
Ifdetonationisallowedtopersistunderextremeconditionsorovermanyenginecycles,engine parts can be damaged or destroyed. The simplest deleterious effects are typically particle wear caused by moderate knocking,whichmayfurtherensuethroughtheengine'soilsystemandcausewearonother parts before being trapped by the oil filter. (5M)

5

With a neat sketch in detail about different types of fuel injection system used in SI engines. (13M) (April/May 2016) BTL5

Answer: Page 2.49- Dr.S.Senthil

- **Single**-point or throttle **body injection**.
- Port or multipoint fuel injection.
- Sequential fuel injection.
- Direct injection. (2M)



(4M)

Figure. **fuel injection system**

Single point fuel injection are systems that have a single injector, or a group of injectors clustered together in one, usually centralized spot on the intake manifold. There are generally much fewer injectors than the rear cylinder so the engine,anditwasn'tuncommonforV-8enginestohavejust two fuel injectors. This style of fuel injection was more common as engine makers transitioned from the use of carburetors to fuel injection. In many instances early electronic fuel injection had the injector. (3M)

Multi-point, or multi-port is when there is a fuel injector for each cylinder and they are located as close as possible to the intake valve. These systems allow the engine management computer to hit a

	Desired air fuel ratio very accurately for each cylinder. I'dventure to say that all vehicles produced in advanced nations will be multi-point of some sort, that is if they aren't direct injected, but direct injectedsystemscanbeconsideredmulti-pointaswellsincethereisainjectorforeachcylindersina throttle body that bolted in place of a carburetor. (4M)
6	**5. Discuss the air fuel ratio requirements of a S.I engine.** **ExplainthestagesofcombustioninS.Ienginewithapressurecrankanglediagram.(5+8M) (April/May 2015)** BTL5 **Answer: Page 1.64 & 2.11- Dr.S.Senthil** • The best fuel economy is obtained with a 15:1 to 16:1 ratio, while maximum power output is achieved with a 12.5:1 to 13.5:1 ratio. A rich mixture in the order of 11:1 is required for idle heavy load, and high-speed conditions. A lean mixture is required for normal cruising and light load conditions. (3M) The approximate proportions of air to petrol (by weight) suitable for the different operating conditions are indicated below: Starting 9 : 1 , Idling 12 : 1 , Acceleration 12 : 1 , Economy 16 : 1 , Full power 12: 1 (2M) • Refer Question no. 1 (8M)
7	• **Explain the various factors that affect knock in a S.I engine.** • **Discuss the different types of combustion chambers employed in a S.I engine. (5+8 M) (April/May 2015)**BTL5 **Answer: Page 2.27 & 2.40- Dr.S.Senthil** • Temperature factor includes inlet temperature of the mixture and temperature of the combustion chamber walls. Pressure factor includes the final pressure of fresh charge that it can reach after completion of compression stroke. Density factor comprises mass of inducted charge and fuel-air ratio. (5M) • **There are two types of internal combustion chambers:** 1. Piston type internal combustion engines consist of a cylinder with a piston inside and are used in cars and boats. 2. Combustors are combustion chambers used in gas turbines and jet engines. (3M) Piston engines drive motorized vehicles such as cars and boats. They typically consist of a cylinder with a piston inside. The piston slides tightly within the cylinder driven by the force created by exploding combustion fuel. These engines have two types of combustion chambers. The combustion chamber may be located in the cylinder head, the cap at the end of the cylinder, or on top of the piston, called a 'heron head' combustion chamber. Combustion chambers in jet engines and gas turbines are called combustors and are configured differently than piston engines. In combustors, air is pulled in and compressed through the compressor. Some of this compressed air is channeled into the combustor to drive the combustion of fuel. (5M)

8	• **Briefly explain the stages of combustion in S.I engine with suitable flame propagation curve.** • **What is delay period and what are the factors that affect the delay period? (8+5 M) (April/May 2014)**BTL5 **Answer: Page 2.11 & 2.16- Dr.S.Senthil** □ Refer Questionno.1 (8M) □ The ignition delay in a diesel engine is defined as the time interval between the start of injection and the start of combustion. This delay period consists of (a) physical delay, wherein atomization, vaporization and mixing of air fuel occur and (b) of chemical delay attributed to pre-combustion reactions. (2M) Factors that influence ignition delay in *diesel engine* (Compression Ignition or 'CI' engine) are • Compression ratio • Inlet air temperature • Coolant temperature • Jacket water temperature • Fuel temperature • Intake pressure • Air-fuel ratio and • Engine size (3M)
9	**What is meant by abnormal combustion? Explain the phenomena of knock in S.I engines. (13M) (AU April/May 2014)** BTL5 **Answer: Page 2.25- Dr.S.Senthil** When unburned fuel/air mixture beyond the boundary of the flame front is subjected to a combination of heat and pressure or a certain duration (beyond the delay period of the fuel used),detonation may occur. Detonation is characterized by an almost instantaneous, explosive ignition of at least one pocket of fuel/air mixture outside of the flame front .A local shock wave is created around each pocket and the cylinder pressure will rise sharply, and possibly beyond its design limits causing damage. (8M) Knocking is the phenomena commonly occurring in a CI engine. You may know that in a CI engine the combustion occurs due to self-ignition of fuel at high temperature generated due to compression ofair.Duringthecompressionstroketheairiscompressedwhichgenerateshightemperatures.(5M)
10	**(i) Explain the stages of combustion in S.I engines elaborating the flame front propagation. (ii) Explain briefly the various factors that influence the flame speed in S.I engines. (8+5 M) (May/June 2013)** BTL5 **Answer: Page 2.18- Dr.S.Senthil** (i) Refer questionno.1 (8M)

(ii) The important factors

Molecular structure of fuel,Temperature of self ignition,effect of high temperature and pressure after compression, Temperature of combustion wall chamber, Rate of burning, Spark timing, Spark intensity and duration, Air-fuel ratio**.** (2M)

Temperature of self ignition
Generally, fuels with large self-ignition temperature are less detonating, even though there exists no strict relation between the self-ignition temperature and detonation. (1M)

Effect of high temperature and pressure after compression. The velocity of the flame decreases the tendency to detonate, though the pressure and temperature increase at the end of compression. In other words, increase in these two factors leads to decrease the delay period of the initial reactions there by increasing the tendency to detonate. This will also result in predomination and the tendency increases due to rise in both temperature and pressure. (1M)

Temperature of combustion wall chamber. Wall temperature gives a profound influence indicating theliabilityofanaircooledenginefordetonatingmorereadilythanwatercooledengineforthesame combustion chamber. The exhaust valves and effective cooling lead to reduce the detonation.

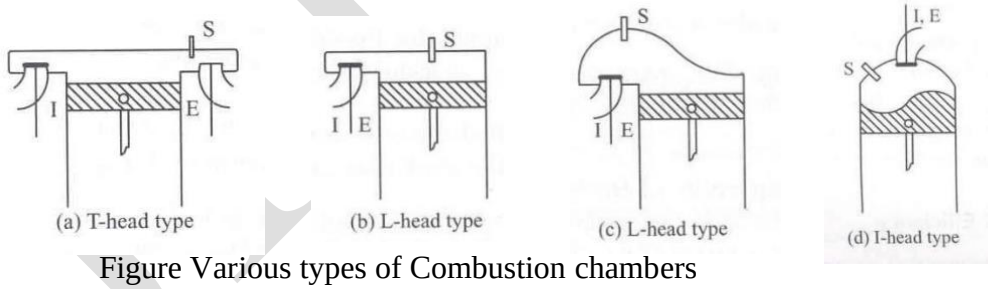
Rate of burning: The huge rate of burning will give less time for flow of heat to the wall of chamber and hence results in high temperature that normally increases the tendency to detonate. (1M)

11 **Describe the requirements of an S.I engine combustion chamber and explain the various types of combustion chambers. (13M) (May/June 2013)**BTL5

Answer: Page 2.37- Dr.S.Senthil

High power output, High thermal efficiency and low specific fuel, smooth engine operation. (4M)

Different type's combustion chambers have been developed over a period of time Some of them are shown in Fig. T-Head Type, L-Head Type, I-Head Type or Overhead Valve, F-Head Type. (5M)



(4M)

Figure Various types of Combustion chambers

The T-head combustion chambers were used in the early stage of engine development. Knocking tendency is high in this type of engines. This configuration provides two valves on either side of the cylinder.

Part *C

1 **A simple jet carburetor is required to supply 5.5 kg of air per minute and 0.6 kg of fuel per minute. The density of fuel is 750 kg/m3. The air is initially at 1 bar and 30C. Calculate the throat diameter of the choke for a flow velocity of 95 m/s. The velocity is taken as 0.78. If the**

	pressure drop across the fuel metering orifice is 0.76 of that at the choke. Calculate orifice diameter assuming C_{df}=0.62. (15 M) BTL5 **Answer: Page 1.52- Dr.S.Senthil 2018** Velocity at throat $V_2=\sqrt{2C_PT_1[1-(\frac{P_2}{P_1})^{\frac{\gamma-1}{\gamma}}]}$ ➔P_2=0.9176x10^{5}N/m^2 (3M) For adiabatic flow of air $v_2=v_1(\frac{P_1}{P_2})^{\frac{1}{\gamma}}$ =0.925m^3/kg (3M) Throat area, $A_2=\frac{m_a v_2}{v_2}$= ➔d =3.22cm (3M) Orifice diameter, from $\dot{m}_f = A_f C_{df}\sqrt{2\rho_f(P_1-P_2)}$ ➔A_f= 5.255$x10^{-6}m^2$ (3M) d_f =2.5867 mm (3M)
2	**The throat diameter of a carburetor is 80 mm and diameter is 6 mm. The Cda=0.85 and Cdf=0.7. The nozzle lip is 6 mm. The pressure difference causing the flow is 0.6 bar. Find (i) Air-fuelratiosuppliedbythecarburetorbyneglectingnozzlelip.(ii)Air-fuel ratio considering nozzle lip (iii) The minimum velocity of air required to start the fuel flow. Neglect air compressibility. Take $\rho_a = 1.2\ kg/m^3$ and $\rho_f = 750\ kg/m^3$. (15 M)**BTL5 **Answer: Page 1.60- Dr.S.Senthil** 5. When the nozzle lip is neglected Mass flow of air, $\dot{m}_a = C_{da}A_a\sqrt{2\rho_a(P_1-P_2)}$ Mass flow of fuel, $\dot{m}_f = C_{df}A_f\sqrt{2\rho_f(P_1-P_2)}$ Air-fuel ratio =$\frac{\dot{m}_a}{\dot{m}_f}$=8.635 (5M) 6. When the nozzle lip is taken for consideration $\dot{m}_f = C_{df}A_f\sqrt{2\rho_f(P_1-P_2-gh\rho_f)}$ Air-fuel ratio =$\frac{\dot{m}_a}{\dot{m}_f}$=8.645 (5M) 7. Minimum velocity of air $V_{min} = \sqrt{2gh\frac{\rho_f}{\rho_a}}$=8.58$m/s$ (5M)
3	**Air-fuel ratio of a mixture supplied to an engine by a carburetor is 13. The fuel consumption of the engine is 7.5 kg/hr. The diameter of the venturi is 20 mm. Find the diameter of fuel nozzle**

if the lip of the nozzle is 4 mm. Take the following data $\rho_f = 750\ ^{kg}$, $Cda = 0.8$, $Cdf = 0.7$ and atmospheric pressure =1.013 bar and temperature =27ºC. (15 M) BTL5

Answer: Page 1.62- Dr.S.Senthil

Density of air, $\rho_a = \frac{P1}{RT_1} = 1.1765^{kg}_{m3}$ (3M)

The air flow through the engine per second =0.0271kg/s (2M)

The mass flow of air, $\dot{m}_a = C_{da}A_a\sqrt{2\rho_a(P_1 - P_2)}$

$(P_1 - P_2)$=4935.17N/m2 (5M)

The fuel flow through the nozzle is $\dot{m}_f = C_{df}A_f\sqrt{2\rho_f(P_1 - P_2 - gh\rho_f)}$

$A_f = 1.097\ x\ 10^{-3}m^2$

d_f=1.1819 mm (5M)

Subject Code :ME6016 **Year/Semester : IV/ 08**

Subject Name : Advanced IC Engines Subject Handler : Dr.B.RAJESHKUMAR & Mr.J.RAVIKUMAR

UNITII COMPRESSION IGNITION ENGINES	
Diesel Fuel Injection Systems - Stages of combustion – Knocking – Factors affecting knock – Direct and Indirect injection systems – Combustion chambers – Fuel Spray behaviour – Spray structure and spray penetration – Air motion - Introduction to Turbocharging.	
PART * A	
Q.No.	**Questions**
1.	**List down the major constituents of natural gas and LPG. (May/June 2012)**BTL1 Natural gas is a mixture of components consisting mainly of methane (60-95%) with small amount of other hydrocarbons. LPG consists of mainly methane 90%, ethane 4%, propane 1.7% and other.
2	**Compare the octane number and the calorific value of alcohol with petrol. (May/June 2012)** BTL4 Octane number- 80 to 90 (Petrol) and 111 for ethanol, CV- 44100 kJ/kg for Petrol and 26880 kJ/kg for ethanol.
3	**Comment on the water tolerance of alcohol blends. (May/June 2013)** BTL3 **4.** Gasoline and water free alcohol are miscible in all proportions over a wide range of temperatures. **5.** However, even addition of small addition of water to this blended fuel causes separation of the alcohol and gasoline. iii) The difficulties due to water separation have commonly led to the use of either 20-25 % of blends of alcohol alone or 10-15% alcohol and Benzol to reduce preparation troubles.
4	**State the methods by which ethanol is produced. (May/June 2013)** BTL1 Manufacture from saccharine materials, Starchy materials, cellulose material and hydrocarbon gases.
5	**What are the advantages of hydrogen as a fuel? (Nov/Dec 2013)** BTL3 Its CV is about 19% higher in combustion energy density on a mass basis, Its wide flammability allows its utilization over extremely wide range of air fuel ratio without misfire, Its gaseous form eliminates the problem of atomization, vaporization, mixing and reconditioning leads to low emission, and H2 is easily ignites and has very high flame velocity.
6	**What are the commonly used alternative fuels? (Nov/Dec 2013)** BTL3 Alcohol can be used in CI engines. The techniques of using alcohol in CI engines are Alcohol diesel emulsions, dual fuel injection, Alcohol fumigation and surface ignition of alcohols.
7	**Can alcohol be used for CI engines? Explain. (April/May 2014)** BTL4

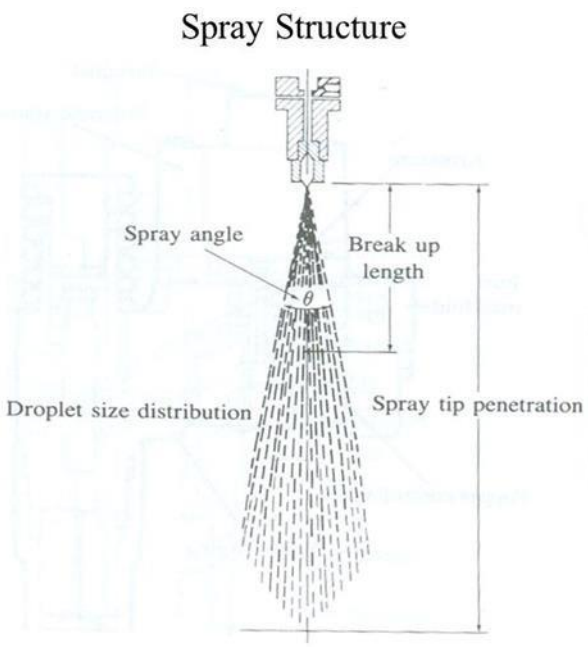
	Turbulence, air fuel ratio, temperature and a pressure, compression ratio, engine speed, size and output.
8	**Can one use solid fuels for IC engines? If so how. (April/May 2014)** BTL4 Yes, Solid fuels can be used for IC engines, a valve outlet for exhaust of combustion products, after combustion a fuel valve for retaining a quantity of solid fuel out of the cylinder and opening on pressure reduction in the cylinder by piston movement beyond top dead center to introduce the quantity of fuel into the cylinder.
9	**List down four properties that are important in the selection of a fuel for an engine. (April/May 2015)** BTL2 i)Air fuel ratio ii) Calorific value iii) latent heat of vaporization v) vapour pressure vi) Octane quality
10	**What are the problems of using methanol in an engine? (April/May 2015)** BTL2 i) low calorific value ii) produces more aldehydes iii) more corrosive iv) poor ignition characteristics v) danger of storage tank flammability -due to low vapour pressure.
11	**Indicate any two limitations of vegetable oil as a CI engine fuel. (Nov/Dec 2015)** BTL1 NOx emissions will form smoke and it does not suits all types of engines. In some engines the reduction in power occurred at 10%.
12	**State any two reasons for using ethyl alcohol as a SI engine fuel. (Nov/Dec 2015)** BTL1 Low lubricating qualities, much corrosive, increase the cetane number
13	**Which are the different types of onboard hydrogen storage methods that can be used? (April 2016)** BTL4 Hydrogen can be stored using six different methods and phenomena: (1) high-pressure gas cylinders (upto800bar),(2)liquid hydrogen in cryogenic tanks(at21K),(3) adsorbed hydrogen on materials with a large specific surface area (at T<100 K), (4) absorbed on interstitial sites in a host metal (at ambient pressure and temperature), (5) chemically bonded in covalent and ionic compounds (at ambient pressure), or (6) through oxidation of reactive metals, e.g. Li, Na, Mg, Al, Zn with water.
14	**W Alternative Fuel Types of alternative fuels available. (April 2016)** BTL2 Liquefied Petroleum Gas (LPG, commonly known as propane), Compressed Natural Gas (CNG), Liquefied Natural Gas (LNG), Methanol (M85), Ethanol (E85), Biodiesel (B20), Electricity, Hydrogen.
15	**What are the stages of combustion in C.I engine?** BTL1 The stages of combustion in C.I engine are four stages: Stage I: ignition delay period (preparatory phase), Stage 2: Period of rapid combustion. Stage 3: Period of controlled combustion. Stage 4: Period of after burning.
16	**What is ignition delay period?** BTL1

	The fuel does not ignite immediately upon injection into the combustion chamber. There is a definite period of inactivity between the time when the first droplet of fuel hits the hot air in the combustion chamber and the time it starts through the actual burning phase. This period is known as ignition delay period.
17	**What are two delays occur in ignition delay period?** BTL1 Thetwodelaysoccurinignitiondelayperiodarethephysicallydelayandchemicallydelay.Physical delay is the time between the beginning of injection and the attainment of chemical reaction conditions. Chemical delay is the reaction starts slowly and then accelerates until the inflammation or ignition takes place.
18	**Explain the effect of quality of fuel factor on the delay period?** BTL3 Self-ignitiontemperatureisthemostimportantpropertyofthefuelwhichaffectsthedelayperiod.A lower self-ignition temperature and fuel with higher cetane number give lower delay period and smooth engine operation. Other properties of the fuel which affects the delay period are latent heat, viscosity and surface tension.
19	**List the factors affecting the delay period?** BTL2 The factors affecting the delay period are: 1. Compression ratio. 2. Atomization of the fuel. 3. Quality of the fuel. 4. Intake temperature and pressure.
20	**What are the types of open combustion chamber?** BTL1 In open combustion chamber there are many designs some are a. Shallow depth chamber b. Hemispherical chamber c. Cylindrical chamber d. Toroidal chamber
21	**What are the advantages and disadvantages of open combustion chamber type?** BTL4 **Advantages:** 8. Minimum heat loss during compression because of lower surface area to volume ratio 9. No cold starting problems 10. Fine atomization because of multi hole nozzle **Disadvantages:** • High fuel injection pressure required and hence complex design of fuel injection pump • Necessity of accurate metering of fuel by the injection system, particularly for small engines.
22	**Why specific fuel consumption is high in indirect injection type combustion chamber?** BTL5 Specific fuel consumption is high because there is a loss of pressure due to air motion through the duct and heat loss due to large heat transfer area.
23	**Why there is a large pressure differences across the injector nozzle are required?** BTL5 The fuel is introduced in to the cylinder of a diesel engine through a nozzle with a large pressure differences across the nozzle jet will enter the chamber at high velocity to 1. Atomize in to small sized droplets to enables rapid evaporation and 2. Traverse the combustion chamber in the time available and fully utilize the air charge.
24	**Define rapid burning angle:** BTL1 The crank angle interval required to burn the bulk of the charge is defined as the interval between the end of the flame development stage and the end of the flame propagation process.

	Part B
1	**Give the detailed comparison of knock in C.I and factors affecting knock. (13 M) (April/May 2017)** BTL5 **Answer: Page 3.1- Dr.S.Senthil** **Knocking – Factors affecting knock** The diesel combustion process which includes ignition delay, premixed burning due to delay periodanddiffusionburningandinjectorneedleliftandpressurevariationwithrespecttocrankangle can be seen in fig. The premixed burning is responsible for diesel knock. The following are the factors which influence ignition delay and thereby contribute to knock: Higher inlet air pressure, air temperature and compression ratio reduce knock. Supercharging reduces knock. Increased humidity increases knock. Combustion chamber design and associated air motion influence heat losses from the compressed air. Tendency to knock will be lesser, with less heat losses. A combustion chamber with aminimumsurfacetovolumeratioandwithlesserintensityofairmotionisdesirable. **(6M)** Knocking tendency is lesser in engines where compressed air injects the fuel into the combustion space. In the case of mechanical injection of fuel, finer the atomization of fuel, lesser is the tendency to knock. A fuel with long pre flame reactions (i.e. self-ignition possible only at a higher temperature) will result in the injection of a considerable amount of fuel before the initial part ignites. This in turn results in a large amount or number of parts of the mixture to ignite at the same time and produce knock. Thus, a good CI engine fuel should have a short ignition delay and low self-ignition temperature, if knock is to be avoided. Ignitiondelayoffuelsisgenerallymeasuredintermsofcetanenumber.Fuels of higher cetane number have shorter ignition delay and thus will have a lesser tendency to knock. The ignition delay of CI engine fuels may be decreased by the addition of small amounts of certain compounds (called ignition accelerators or improves). These compounds are ethyl nitrate and amylthio nitrate. These compounds affect the combustion process by speeding the molecular interactions. **(7M)**
2	**Describe diesel fuel spray behavior and spray structure with neat sketch. (13 M) (April/May 2017)** BTL5 **Answer: Page 3.70, 3.67- Dr.S.Senthil** Fuel Spray behaviour • Spray formation is explained as Breakup Mechanism, described as: Stretching of fuel ligament into sheets or streams, Appearance of ripples and protuberances, Formation of small ligaments or holes in sheets, Collapse of ligaments or holes in sheets, Further breakup due to

vibration of droplets, Agglomeration or shedding from large drops, The flow parameters of a jet: Jet Reynolds number, Jet webe rnumber, Ohnesorge number. (5M)

Spray structure



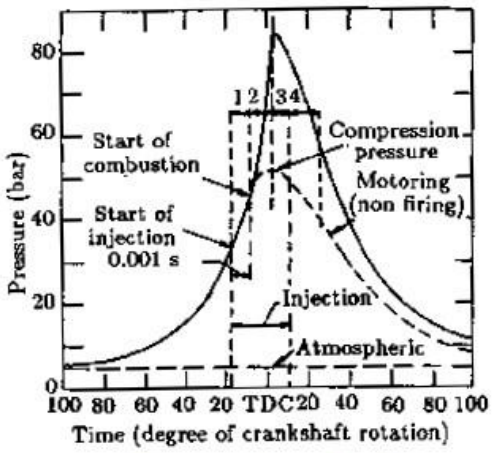
During spraying it is essential to maintain a constant top surface temperature and hence maintain steady-state conditions if a billet with consistent micro structure is to be produced. At the billet surface, during spraying an enthalpy balance must be maintained where the rate of enthalpy lost (H_{out})from the billet by conduction to the atomizing gas and through the substrate, convection and radiation must be balanced with the rate of enthalpy input (H_{in})from the droplets in the spray. There are a variety of factors that can be adjusted in order to maintain these conditions: spray height, atomizer gas pressure, melt flow rate, melt superheat and atomizer configuration, being those parameters most readily adjusted.

Figure-Spray structure (3M)

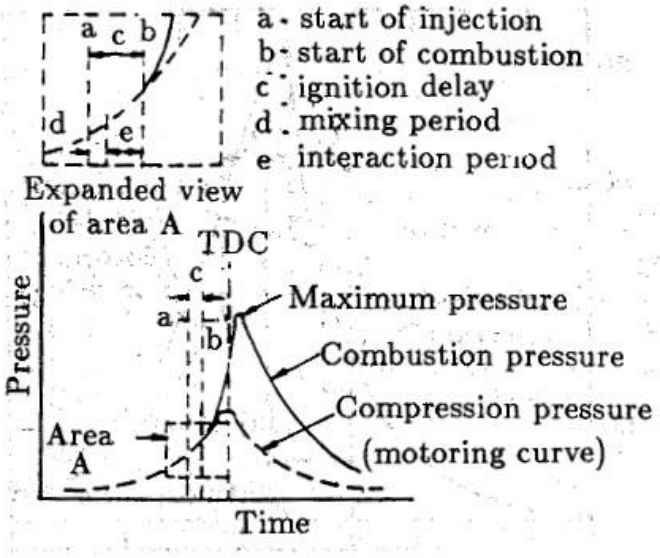
Typically equipment such as closed circuit cameras and optical pyrometry can be used to monitor billet size/position and top surface temperature. If H_{out} is much greater H_{in} then a steady temperature is maintained at the billet top surface. The top surface should be in a mushy condition in order to promote stickingofincomingdropletsandpartialre-meltingofsolidparticles.The necessary partial re-melting of solid droplets explains the absence of dendritic remnants from pre-solidified droplets in the final microstructure. If H in is insufficient to cause significant re-melting, a 'splat' micro structure of layered droplets will form, typical of thermal spray processes such as vacuum plasma spraying (VPS), arc spraying and high velocity oxy-fuel. Processing maps have been produced for plasma spraying and spray form in gushing a steady-state heat balance in terms of the inter layer time (time between deposition events) against average deposition rate per unit area. These maps show the boundaries between banded un-fused micro structure and an equated homogeneous structure. (5M)

3	**With the aid of a schematic diagram, explain the combustion process in a C.I engine. (13 M) (Nov/Dec 2016)** BTL5

Answer: Page 3.1- Dr.S.Senthil



Stages of combustion



Pressure Time diagram illustrating Ignition delay

(4M)

Delay period

In an actual engine, fuel injection beings at the point B during the compression stroke. The injected fuel does not ignite immediately. It takes some time to ignite. Ignition sets in at the point C. During the crank travel B to C pressure in the combustion chamber does not rise above the compression curve. The period corresponding to the crank angle B to C is called delay period or ignition delay (about 0.001 seconds).

Uncontrolled combustion takes place will depend upon the following:

- The quantity of fuel in the combustion chamber at the point C. This quantity depends upon the rate at which fuel is injected during delay period and the duration of ignition delay.
- The condition of fuel that has got accumulated in the combustion chamber at the point C.

The rate of combustion during the crank travel C to D and the resulting rate of pressure rise determine the quietness and smoothness of operation of the engine. (3M)

Controlled combustion

During controlled combustion, following thing happen. The flame spreads rapidly (but less than135m/min),as a turbulent , heterogeneous or diffusion flame with a gradually decreasing rate of energy release. Even in this stage, small auto ignition regions may be present. The diffusion flame is characterized by its high luminosity. Bright, white carbon flame with a peak temperature of 2500^{o} C is noticed. In this stage, radiation plays a significant part in engine heat transfer.

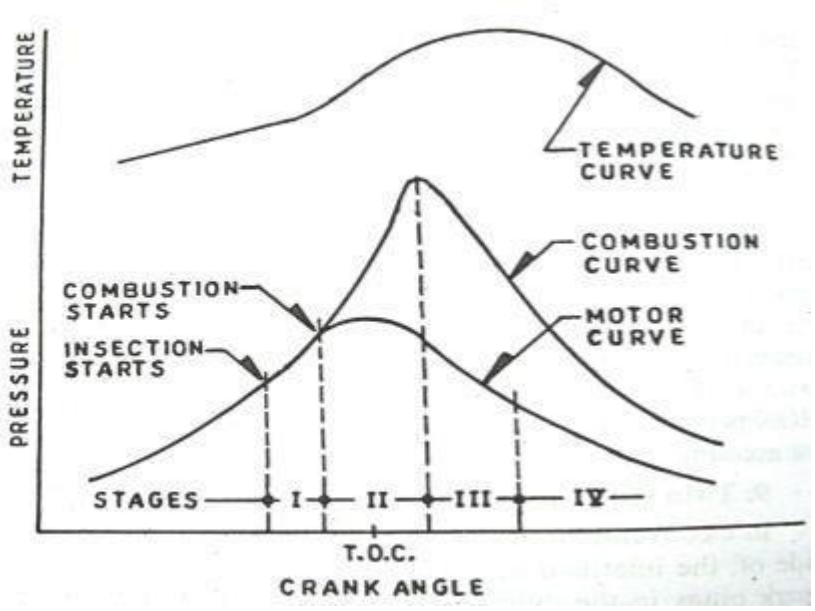
During the period D to E, combustion is gradual. Further by controlling the rate of fuel injection, complete control is possible over the rate of burning. Therefore, the rate of pressure rise is

	controllable. Hence, this stage of combustion is called Gradual combustion or Controlled combustion. (3M) **After burning** At the last stage, i.e. between E and F the fuel that is left in the combustion space when the fuel injection stops is burnt. This stage of combustion is called after burning (burning on the expansion stroke). In the indicator diagram after burning will not be visible. This is because the downward movement of the piston causes the pressure to drop inspired of the heat that is released by the burning of the last portion of the charge. Increasing excess air, or air motion will shorten after burning i.e. reduce the quantity of fuel that may undergo after burning). (3M)
4	**Explain the factors affecting the delay period in C.I engines and summarize them. (13 M) (Nov/Dec 2016)**BTL5 **Answer: Page 3.11- Dr.S.Senthil** Compression ratio , Engine speed, output, Injection timing, Quality of the fuel, Intake temperature, Intake pressure. • Compression ratio: With the increase in compression ratio reduces ignition lag, a higher pressure increases density resulting in closer contact of the molecules which reduce the time of action when fuel is injected. • Inlet air temperature: With the increase in inlet temperature increases the air temperature after compression and hence decreases the ignition delay. • Coolant temperature: Increase in engine speed increases cylinder air temperature and thus reduces ignition lag. The increase in engine speed increases turbulence and this reduces the ignition lag. • Jacket water temperature: With the increase in jacket water temperature also increases compressed air temperature and hence delay period is reduced. • Fuel temperature: Increase in fuel temperature would reduce both physical and chemical delay period. • Intake pressure (supercharging): Increase in intake pressure or supercharging reduces the auto-ignition temperature and hence reduces delay period. Since the compression pressure will increase with intake pressure, the peak pressure will be higher. Also, the power output will be more air and hence more fuel can be injected per stroke. • Air-fuel ratio (load): With the increase in air-fuel ratio (leaner mixture) the combustion temperatures are lowered and cylinder wall temperatures are reduced and hence the delay period increases, with an increase in load, the air-fuel ratio decreases, operating temperature increases and hence, delay period decreases. • Engine size: The engine size has little effect on the delay period in milliseconds. As large engines operate at low revolutions per minute (rpm) because of inertia stress limitations, the delay period in

terms of crank angle is smaller and hence less fuel enters the cylinder during the period. Thus combustion in large slow speed Compression Ignition engines is smooth. **(13M)**

5 **Discussindetailaboutthevariousstagesofcombustioninc.Iengines.(13M)(April/May2016)** BTL5

Answer: Page 3.6- Dr.S.Senthil



(2M)

Figure- Pressure-Crank angle diagram

- Ignition delay- During this stage there is a physical delay period which is the time from beginning of injection to the attainment of chemical reaction conditions. The fuel is atomized and mixed with air and its temperature is raised. This period is followed by a chemical delay period in which pre-flame reactions start and accelerate until local ignition takes place. (2M)

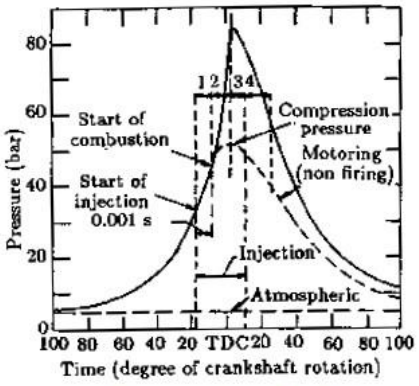
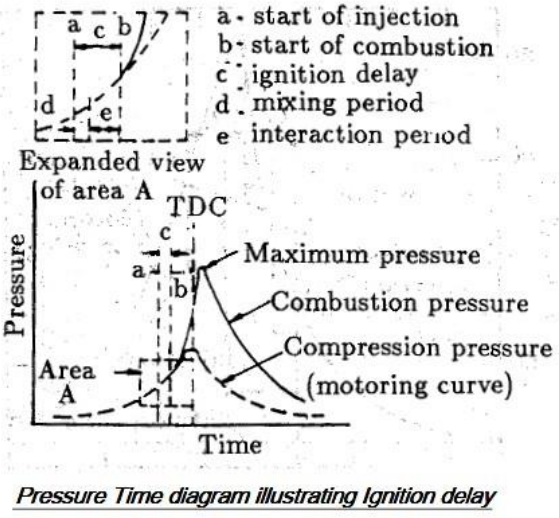
- Rapid or uncontrolled combustion-This is second stage in which pressure is rapid since during delay period the fuel droplets have time to spread themselves over a wide area and have fresh air around them. This phase extends from end of delay period to point of maximum pressure. (3M)

- Controlled combustion- The very high temperature and pressure at end of second stage cause the fuel droplets injected during last stage to burn instantly and any further pressure is can be controlled by purely mechanical means that is injection rate. This period ends at maximum cycle temperature. The heat evolved by end of this phase is70to80 percent of total heat of fuel supplied. (3M)

- After burning-This fourth stage may not be present in all cases but due to poor distribution of fuel particles combustion may continue in the expansion stroke. Its duration may be 70 to 80 degrees of crank travel from TDC. (3M)

6 **What are the various factors that influence spray penetration in C.I engines? Explain in detail. (13 M) (April/May 2016)** BTL5

Answer: Page 3.6- Dr.S.Senthil

	The graphs of the penetration of plume tips 1 and 6 are shown in Figure 6-4 to Figure 6-7 for gas pressures of 0.5 and 1.0 and injector bogy temperatures of 20, 90 and120°C. These graphs show the penetrations measured from the sprays produced by Ethanol and Butanol in comparison to those produced by the Standard Gasoline and the main high and low volatility components n-Pentane and iso-Octane. (6M) The overarching observation from the plume penetration graphs above is the striking similarity of penetration rate reaction to the conditions of Ethanol and Standard Gasoline and of Butanol and iso-Octane. This is especially evident from the graphs showing the spray plume penetrations at the elevated injector body temperature of 120,229°C which is also the condition where the most difference between high and low volatility fuels is observed. (7M)
7	**Using pressure-crank angle diagram explain the different stages of combustion observed a typical CI engine. Why is it undesirable to have the fourth phase of combustion (combustion during the late expansion stroke)? (13 M) (Nov/Dec 2015)** BTL5 **Answer: Page 3.55 Dr.S.Senthil**  ***Stages of combustion***  *Pressure Time diagram illustrating Ignition delay* (6M) **Afterburning** At the last stage, i.e. between E and F the fuel that is left in the combustion space when the fuel injection stops is burnt. This stage of combustion is called after burning (burning on the expansion stroke). In the indicator diagram after burning will not be visible. This is because the downward movement of the piston causes the pressure to drop inspired of the heat that is released by the burning of the last portion of the charge. Increasing excess air, or air motion will shorten after burning i.e. reduce the quantity of fuel that may undergo after burning). (7M)
8	**Discuss the characteristics of DI and IDI diesel engines. (13 M)** (**April/May 2015)** BTL5 **Answer: Page 3.70, 3.67- Dr.S.Senthil** **Direct injection systems**

Direct injection diesel engines inject fuel directly into the cylinder. Usually there is a combustion cup in the top of the piston where the fuel is sprayed. Many different methods of injection can be used. Electronic control of the fuel injection transformed the direct injection engine by allowing much greater control over the combustion. (3M)

Unit direct injection

Unit direct injection also injects fuel directly into the cylinder of the engine. In this system the injector and the pump are combined into one unit positioned over each cylinder controlled by the camshaft. Each cylinder has its own unit eliminating the high-pressure fuel lines, achieving a more consistent injection. This type of injection system,also developed by Bosch, is used byVolkswagen A Gincars (where it is called a *Pumpe-Düse-System*—literally *pump-nozzle system*) and by Mercedes-Benz ("PLD") and most major diesel engine manufacturers in large commercial engines (MANSE, CAT, Cummins, Detroit Diesel, Electro-Motive Diesel, Volvo). With recent advancements, the pump pressure has been raised to 2,400 bars (240 MPa; 35,000 psi), allowing injection parameters similar to common rail systems. (3M)

Common rail direct injection

"Common Rail "injection was first used in production by Atlas Imperial Diesel in the 1920s.The rail pressure was kept at a steady 2,000 - 4,000 psi. In the injectors a needle was mechanically lifted off of the seat to create the injection event.[79]Modern common rail systems use very high-pressures. In these systems an engine driven pump pressurizes fuel at up to 2,500 bar (250 MPa; 36,000 psi), in a "common rail". The common rail is a tube that supplies each computer-controlled injector containing a precision-machined nozzle and a plunger driven by a solenoid or piezoelectric actuator. (3M)

Indirect injection systems

An indirect Diesel injection system (IDI) engine delivers fuel into a small chamber called a swirl chamber, pre combustion chamber, pre chamber or ante-chamber, which is connected to the cylinder by a narrow air passage. Generally the goal of the pre camber is to create increased turbulence for better air / fuel mixing. This system also allows for a smoother, quieter running engine, and because fuel mixing is assisted by turbulence, injector pressures can be lower. Most IDI systems tend to use a single orifice injector. The pre-chamber has the disadvantage of lowering efficiency due to increased heat loss to the engine's cooling system, restricting the combustion burn, thus reducing the efficiency by 5–10%.. IDI engines are also more difficult to start and usually require the use of glow plugs.IDI engines may be cheaper to build but generally require a higher compression ratio than the DI counterpart. IDI also makes it easier to produce smooth, quieter running engines with a simple mechanical injection system since exact injection timing is not as critical. Most modern automotive engines are DI which have the benefits of greater efficiency, easier starting , however IDI engines can still be found in the many ATV and small Diesel applications. (4M)

9	**What are the Effects of turbo charging? (13 M)** BTL5 **Answer: Page 3.70, 3.67- Dr.S.Senthil** The following are the effects of supercharging engines. Some of the points refer to CI engines: Higher power output, Mass of charge inducted is greater, Better atomization of fuel, Better mixing of fuel and air, Combustion is more complete and smoother, Can use inferior (poor ignition quality) fuels, Scavenging of products is better, Improved torque over the whole speed range, Quicker acceleration (of vehicle) is possible, Reduction in diesel knock tendency and smoother operation, Increased detonation tendency in SI engines, Improved cold starting, Eliminates exhaust smoke, Lowers specific fuel consumption, in turbo charging, Increased mechanical efficiency, Extent of supercharging is limited by durability, reliability and fuel economy ,Increased thermal stresses, Increased turbulence may increase heat losses, Increased gas loading, Valve overlap period has to be increased to about 60 to 160 degrees of crank angle, Necessitates better cooling of pistons and valves. . **(13M)**

10	**Discuss the significance of air-motion in a CI engine. Also define and mention the significance of swirl, tumble and squish. (13 M)** BTL5 **Answer: Page 3.70, 3.67- Dr.S.Senthil** The air motion inside the cylinder greatly influences the performance of diesel engines. It is one of the major factors that controls the fuel-air mixing in diesel engines. Air-fuel mixing influences combustion, performance and emission level in the engine. The air motion inside the cylinder mainly depends on manifold design, inlet and exhaust valve profile and combustion chamber configuration. The initial in-cylinder intake flow pattern is setup by the intake process, and then it is modified during the compression process. The shape of the bowl in the piston and the intake system, control the turbulence level and air-fuel mixing of the DI diesel engine. The variation of shape of intake system, shape of piston cavity, etc. lead to a change in the flow field inside the engine. (3M) **EFFECTS OF AIR MOTION** The air motion inside the cylinder 1.Atomizes the injected fuel into droplets of different sizes. 2. Distributes the fuel droplets uniformly in the air charge. 3. Mixes injected fuel droplets with the air mass. 4. Assists combustion of fuel droplets. 5. Peels off the combustion products from the surface of the burning drops as they are being consumed. 6. Supplies fresh air to the interior portion of the fuel drops and thereby ensures complete combustion. 7. Reduces delay period. 8. Reduces after burning of the fuel. 9. Better utilization of air contained in the cylinder. Swirl is defined as the organized rotation of the charge about the cylinder axis. It is created by bringing the intake flow into the cylinder with an initial angular momentum. Swirl is generated during the intake process in DI diesel engines by the intake port and subsequently by combustion chamber geometry during the compression stroke. The swirl intensity increases the tangential component of the velocity of air inside the cylinder, which aids in the mixing of fuel and air, and significantly affects the combustion and emission characteristics of diesel engines. The squish motion of air is brought about by a recess in the piston crown. At the end of the compression stroke, the piston is brought to within a very small distance from the cylinder head. This fact causes a flow of air from the periphery of the cylinder to its center and into the recess in the piston crown. This radial inward movement of air is called squish by Ricardo. Turbulence contributes to the dispersion of fuel and the micro mixing of fuel and air respectively. As such, they greatly influence the diesel engine performance. The flow processes in the engine cylinder are turbulent. In turbulent flows, the rates of transfer and mixing are several times greater than the rates due to molecular diffusion. This turbulent diffusion results from the local fluctuations in the
	Flow field. It leads to increased rates of momentum and heat and mass transfer, and is essential to the satisfactory operation of Spark Ignition and Diesel engines. (10M)
	Part *C

1

Discuss about the functions, requirements and types combustion chambers used in CI engine with neat sketch. (15 M) (**April 2018)** BTL5

Answer: Page 3.70, 3.67- Dr.S.Senthil

The shape of the combustion chamber and the fluid dynamics inside the chamber are of great importance in diesel combustion. Diesel engines are divided into two basic categories according to their combustion chamber design.

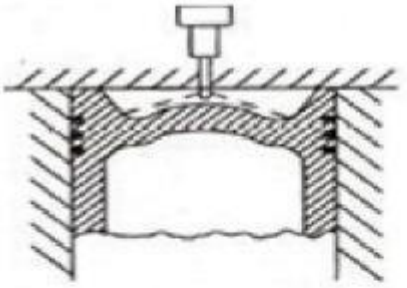
(2M)

Direct-Injection (DI) engines: This type of combustion chamber is also called an open combustion chamber. In this type, the entire volume of the combustion chamber is located in the main cylinder and the fuel is injected into this volume. (3M)

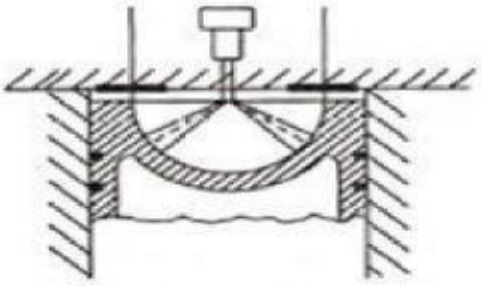
Indirect-Injection (IDI) engines: This type of combustion chambers, the combustion space is divided into two parts, one part in the main cylinder and the other part in the cylinder head. The fuel injection is effected usually into that part of the chamber located in the cylinder head. (3M)

These chambers are classified further into:

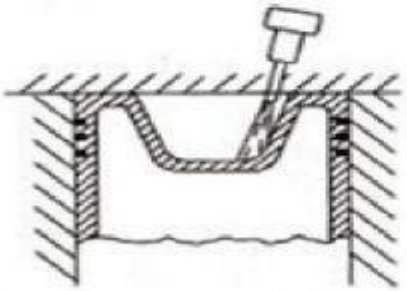
- Swirl chamber in which compression swirl is generated.
- Pre combustion chamber in which combustion swirl is induced.
- Air cell chamber in which both compression and combustion swirl are induced. (2M)



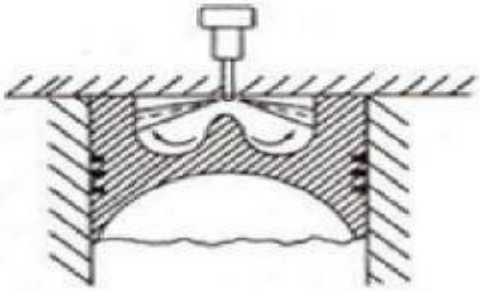
(a) Shallow depth chamber



(b) Hemispherical chamber



(c) Cylindrical chamber



(d) Toroidal chamber

(2M)

Shallow depth chamber

In the shallow depth chamber the depth of the cavity provided in the piston is quite small. This chamber is usually adopted for large engines running at low speeds. Since the cavity diameter is very large, the squish is negligible.

Hemispherical chamber

This chamber also gives small squish. However, the depth to diameter ratio can be varied to give any desired squish to give better performance.

Cylindrical chamber

This design was attempted in recent diesel engines. This is a modification of the cylindrical chamber intheformofatruncatedconewithabaseangleof30^o.The swirl was produced by masking the valve for nearly 180^o of circumference. Squish can also be varied by varying the depth.

Toroidal chamber

The idea behind this shape is to provide a powerful squish along with the air movement, similar to that of the familiarizing,within the toroidal chamber. Due to power fuls quish the mask needed on inlet valve is small and there is better utilization of oxygen. The cone angle of spray for this type of chamber is150^{o}to160^o. (3M)

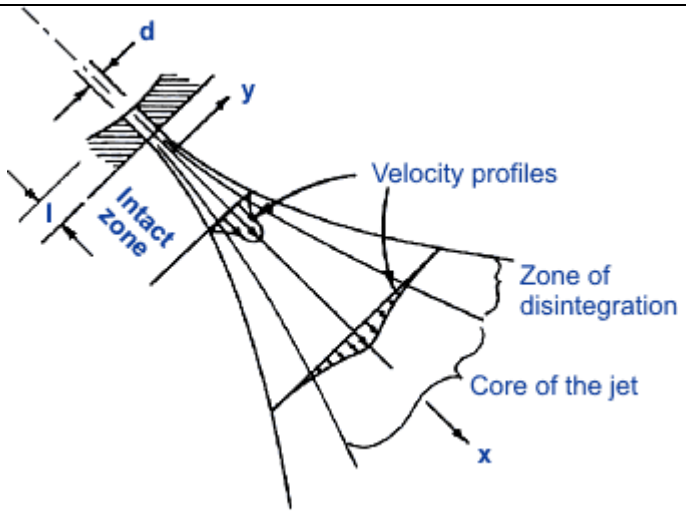
2

Explain the spray formation, spray behavior, spray structure and spray penetration in diesel engine. (15 M) BTL5

Answer: Page 3.67- Dr.S.Senthil 2018

Fuel Atomization

The first step in the mixture formation process in the conventional, mixing controlled diesel engine combustion is spray formation.Figure1showsasprayformedbyinjectingfuelfromasingleholein stagnantair.Up on leaving the nozzle hole,thejetbecomescompletelyturbulentaveryshortdistance from the point of discharge and mixes with the surrounding air. This entrained air is carried away by thejetandincreasesthemass-flowinthex-directionandcausesthejettospreadoutinthey-direction. Two factor slead to a decrease in the jet velocity: the conservation of momentum when air is entrained into the jet and frictional drag of the liquid droplets. Figure 1 gives the velocity distribution at two cross sections. The fuel velocity is highest at the centerline and decreases to zero at the interface between the zone of disintegration (or the conical envelope of the spray) and ambient air.(5M)



(3M)

Figure Schematic of a spray from a single hole nozzle

Primary Atomization. Near the inject or nozzle,the continuous liquid jet disintegrates into filaments and drops through interaction with the gas in the cylinder. This initial break-up of the continuous liquid jet is referred to as *primary atomization.*

Ingeneral,theatomizationofajetcanbedividedintodifferentregimesdependingonthejetvelocity:

7. *Rayleigh Regime.* In this low jet velocity regime, breakup is due to the unstable growth of surface waves caused by surface tension and results in drops larger than the jet diameter.

8. *First Wind Induced Breakup Regime.* In this medium jet velocity regime, forces due to the relative motion of the jet and the surrounding air augment the surface tension force, and lead to drop sizes of the order of the jet diameter.

9. *Second Wind-Induced Breakup Regime.* In this high jet velocity regime breakup is characterized by divergence of the jet spray after an intact or undisturbed length downstream of the nozzle.Theunstablegrowthofshort-wavelengthwavesinducedbytherelativemotion betweentheliquidandsurroundingairproducesdropletswhoseaveragesizeismuchlessthan the jet diameter.

10. *Atomization Regime.* At very high jet velocity, breakup of the outer surface of the jet occurs at, or before, the nozzle exit plane. The average droplet diameter is much smaller than the nozzle diameter. Aerodynamic interactions at the liquid/gas interface appear to be one major component of the atomization mechanism in this regime. (5M)

Initial break-up in diesel fuel jets generally occurs in the atomization regime. The dominant mechanisms driving this process are not entirely clear.Inter dependent phenomena such as turbulence and collapse of cavitating bubbles may initiate velocity fluctuations in the flow within the nozzle of the injector that destabilize the exiting liquid jet. The unsteadiness of the injection velocity and drop shedding also play an important role. (2M)

3	**Explain the principle of operation of turbocharger with a neat sketch. Indicate the objectives of turbocharging. (15 M)** BTL5

Answer: Page 3.43- Dr.S.Senthil 2018

Principle of operation: Have you ever watched cars buzzing past you with sooty fumes streaming from their tailpipe. It's obvious exhaust fumes cause air pollution, but it's much less apparent that they're wasting energy at the same time. The exhaust is a mixture of hot gases pumping out at speed and all the energy it contains—the heat and the motion (kinetic energy)—is disappearing uselessly into the atmosphere. Wouldn't it be neat if the engine could harness that waste power somehow to make the car go faster? That's exactly what a turbocharger does.

Car engines make power by burning fuel in sturdy metal cans called cylinders. Air enters each cylinder, mixes with fuel, and burns to make a small explosion that drives a piston out, turning the shaft sand gears that spin the car'swheels.When the piston pushes back in, it pumps the waste air and fuel mixture out of the cylinder as exhaust.The amount of power a car can produce is directly related to how fast it burns fuel. The more cylinders you have and the bigger they are, the more fuel the car can burn each second and (theoretically at least) the faster it can go. (5M)

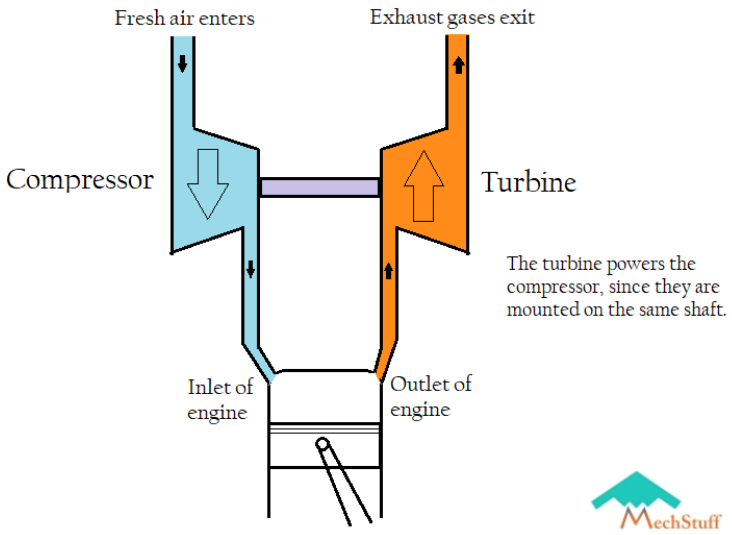


Figure- Principle of operation of turbocharger (5M)

Objectives of Turbocharger:(i)The objective of a turbo charger is to improve an engine's volumetric efficiency by increasing the intake density, (ii) The compressor draws in ambient air and compresses it before it enters into the intake manifold at increased pressure, that results in a greater mass of air entering the cylinders on each intake stroke, (iii) The power needed to spin the centrifugal compressor's is derived from the high pressure and temperature of the engine's exhaust gases, (iv) The turbine converts the engine exhaust's potential pressure energy and kinetic velocity energy into rotational power, which is in turn used to drive the compressor. (5M)

Subject Code :ME6016 **Year/Semester : IV/ 08**

Subject Name: Advanced IC Engines Subject Handler : Dr.B.RAJESHKUMAR & Mr.J.RAVIKUMAR

UNIT-III POLLUTANT FORMATIONANDCONTROL	
Pollutant – Sources – Formation of Carbon Monoxide, Unburnt hydrocarbon, Oxides of Nitrogen, Smoke and Particulate matter–Methods of controlling Emissions–Catalytic converters,Selective Catalytic Reduction and Particulate Traps – Methods of measurement – Emission norms and Driving cycles.	
PART * A	
Q.No.	**Questions**
1.	**What is the principle of Flame Ionization Detector? May/June 2012** BTL2 Applying a direct current voltage between two electrodes that face each other across the flame generates a minute ion current, proportional to the carbon number of the ionized hydrocarbon. The total hydrocarbon can be measured by passing this ion current through a high resistance to convert it to voltage.
2	**Indicate any four sources of unburnt hydrocarbon emissions. May/June 2012** BTL4 Incomplete combustion, Crevice volumes and flow in crevices, leakage past the exhaust valve, Deposits on walls, Valve overlap and oil in combustion chamber walls.
3	**State the significance of stoichiometric air-fuel mixture. May/June 2013** BTL1 Stoichiometric mixture is an ideal for complete and efficient combustion of all the fuel in the inlet charge, which can produce better fuel economy and higher efficiency.
4	**Why smoke is formed in a C.I engine? May/June 2013** BTL5 In CI engine irrespective of load at any speed always constant supply of air enters the cylinder but the quantity of fuel ranging from 18:1 at full load 80:1 at no load. Therefore considerable amount of smoke is emitted.
5	**Define conversion efficiency of a catalyst. Nov/Dec 2013** BTL2

	It is the ratio of the rate of mass removal in the catalyst of the particular constituent of interest to the mass flow rate of that constituent in the catalyst.
6	**What is greenhouse effect? Nov/Dec 2013** BTL2 The mechanisms that produces the difference between the actual surface temperature and the effective temperature of atmosphere caused by these greenhouse gasses is known as greenhouse effect.
7	**State the usage of Ringlemann chart. April/May 2014** BTL3 Ringlemann chart is used to measure the density of the apparent smoke.
8	**Give a brief account of other emissions from engines. April/May 2014** BTL4 Other emissions from engine are water vapour, CO2, NOx, UBHC, CO and aldehydes.
9	**What are emission norms? Give the major pollutants that are to be controlled. April/May 2015** BTL2 Emission norms are requirements that set specific limits to the amount of pollutants that can be released into the environment. HC, CO, CO2, NOx, Sox, soot and smoke.
10	**What is three way catalytic converter? Give the catalyst used in it. April/May 2015** BTL4 Generally, catalytic converters are called three way catalytic converters because they are used to reduce the concentration of CO,HC and NO in the exhaust.The catalyst are Palladium, platinum and rhodium. Palladium and platinum promote the oxidation of CO and HC. Rhodium promotes the reaction of NOx to form harmless N2 +O.
11	**Indicate any four locations within the SI engine cylinder where unburnt HC form. Nov/Dec 2015** BTL 5 Fuel tank, Engine cylinder, after combustion and incomplete combustion
12	**List the factors responsible for formation of NOx during combustion. Nov/Dec 2015** BTL5

	Valve overlap has significant effect on NO formation,Extended exhaust valve opening before bottom deadcenter.
13	**Briefly discuss about the working of three way catalytic convertor. AU April 2016** BTL2 Generally, Catalytic converters are called three-way converters because they are used to reduce the concentration of CO, HC and NO in the exhaust. The catalysts are palladium platinum and rhodium. Palladium and platinum promote the oxidation of CO and HC. Rhodium promotes of NOx to form harmless N2+O2
14	**What are the various pollutants present in combustion products? AU April 2016** BTL3 Unburned Hydrocarbons, Oxides of carbon, Oxides of Nitrogen, Oxides of Sulphur, Particulars, Soot and smoke.
15	**What are the causes for hydrocarbon emission from S.I engine ?** BTL2 The causes for hydro carbon emission from S.I engine are 1.Incomplete combustion.2.Crevice volume and flow in crevices.3.Leakage past the exhaust valve. 4. Valve overlap. 5. Deposits on walls. 6. Oil on combustion chamber walls.
16	**What are the reasons for incomplete combustion in SI engine?** BTL5 Incomplete combustion is due to **D)** Improper mixing due to incomplete mixing of the air and fuel. Some fuel particles do not find the oxygen to react with this cause the emissions. **E)**Flame quenching: As the flame goes very close to the walls it gets quenched at the walls leaving a small volume of unreacted air fuel mixture.
17	**What are the reasons for flame quenching?** BTL5 The reason for flame quenching is the expansion of gases. (i) As the piston moves down from TDC to BDC during power stroke, expansion of the gases lowers both pressure and temperature with in the cylinder. This makes combustion slow and finally quenches the flame and causes the emissions. (ii) High exhaust gas contamination causes poor combustion and which in turn causes quenching during expansion.

	(iii) As the flame goes very close to the walls it gets quenched at the walls leaving a small volume of unreacted air-fuel mixture.
18	**What is photochemical smog?** BTL2 NOx is the primary causes of photochemical smog, Smog is formed by the photochemical reaction of automobiles exhaust and atmospheric air in the presence of sunlight. NO2 + energy from sunlight NO + O +smog
19	**What are soot particles?** BTL2 Soot particles are clusters of solid carbon spheres. These spheres have diameter from 9nm to 90nm (1nm=10-9).Butmostofthemarewithintherangeof15–30nm.The spheres are solid carbon with HC and traces of other components absorbed on the surface. Single soot particles may contain up to 5000 carbon spheres.
20	**Which is the most effective after treatment for reducing engine emissions**? BTL4 The catalytic converter is the most effective after treatment for reducing engine emissions found on most automobiles. Co can be oxidized to CO2 and H2O in exhaust system and thermal converters if the temperature is held at 600- 700 C. If certain catalysts are present, the temperature needed to sustain these oxidation processes is reduced to 250 - 300 C, making for a much more attractive system.
21	**What is a catalyst? List the materials used as catalyst**. BTL4 A catalyst is a substance that accelerates chemical reaction by lowering the energy needed for it to proceed. The catalyst is not consumed in the reaction and so functions indefinitely unless degraded by heat age contaminants or other factors. The catalyst materials most commonly used are **a)** platinum **b)** palladium **c)** rhodium.
22	**List the invisible and visible emission.** BTL4 **Invisible emission:** Water vapour, carbon dioxide, oxides of nitrogen, unburnt hydrocarbons, carbon monoxide, aldehydes. **Visible emission:** Smoke, particulate.
23	**What are the methods of measuring the following emission?**BTL2 **a.** Oxides of nitrogen, **b.** Carbon monoxide **c.** Unburned hydrocarbons **a)** Oxides of nitrogen = CHEMILUMINESCENCE ANALYZER

	D) Carbon monoxide = NON DISPERSIVE INFRAREDANALYZER E) Unburned hydrocarbons = FLAME IONIZATION DETECTOR(FID)
	Part B
1	**(i) Discus the mechanism of formation of HC, CO and NO in SI engines. (ii) What is Indian driving cycle? What is the procedure adopted for it? Explain. (13 M)** (**AU April/May 2017), (AU Nov/Dec 2016)** BTL5 **Answer: Page 4.1, 4.34- Dr.S.Senthil** • Unburned Hydro Carbons(UBHC): ThemajorsourcesofUBHCinanautomobileare theengineexhaust, evaporative losses from fuel system, blow by loss and scavenging in case of 2-stroke petrol engines. Unburned or partially burned hydrocarbons in gaseous form combine with oxides of nitrogen in the presence of sunlight to form photo chemical smog. UBHC + NOx→ Photochemical smog The products of photochemical smog cause watering and burning of the eyes and affect the respiratory system, especially when the respiratory system is marginal for other reasons. Some of the high molecular weight aromatic hydrocarbons have been shown to be carcinogenic in animals. Some of the unburned hydrocarbons also serve as particulate matter in atmosphere. **(3M)** • **Carbonmonoxide:** Carbon monoxide is formed during combustion in engine only when there is insufficient supply of air. The main source is the engine exhaust. The toxicity of carbon monoxide is well known. The hemoglobin the human blood which carries oxygen to various parts of the body has great affinity towards carbon monoxide than for oxygen. When a human is exposed to an atmosphere containing carbon monoxide, the oxygen carrying capacity of the blood is reduced and results in the formation of carboxyhemoglobin. Due to this the human is subjected to various ill effects and ultimately leads to death.

Thetoxiceffectsofcarbonmonoxidearedependentbothontimeandconcentrationasshown in the diagram. **(3M)**

c. Oxides of Nitrogen (NOx):

Oxides of nitrogen (NO,NO_2,N_2O_2etc) are formed at higher combustion temperature present in engines and the engine exhaust is the major source.

Like carbon monoxide,oxidesofnitrogenalsotendtosettleonthehemoglobininblood.Their most undesirable effect is their tendency to join with moisture in the lungs to form dilute nitric acid. Because the amounts formed are minute and dilute, their effect is very small but over a long period of time cam be cumulatively undesirable, especially when the respiratory problems for other reasons are found.

Another effect is that, the oxides of nitrogen are also one of the essential component for the formation of photochemical smog. **(3M)**

Driving cycles

The driving cycle for both CVS-1 and CVS-3 cycles is identical. It involves various accelerations, decelerations and cruise modes of operation. The car is started after soaking for 12 hours in a 60-80 F ambient. A trace of the driving cycle is shown in figure. Miles per hour versus time in seconds are plotted on the scale.Topspeedis56.7mph.Shown for comparison is the FTP or California test cycle. For many advanced fast warm-up emission control systems, the end of thecold portionontheCVStestisthesecondidleat125seconds.Thisoccursat0.68miles. In the CVS tests, emissionsaremeasuredduringcrankingstart-upandfivesecondsafterignitionisturnedofffollowing the last deceleration. Consequently high emissions from excessive cranking are included. Details of operationformanualtransmissionvehiclesaswellasrestartproceduresandpermissibletesttolerance are included in the Federal Registers.

CVS-1 system:

The CVS-1 system, sometimes termed variable dilution sampling, is designed to measure the true mass of emissions. The system is shown in figure. A large positive displacement pump draws a constant volume flow of gas through the system.The exhaust of the vehicle is mixed with filtered room air and the mixture is then drawn through the pump. Sufficient air is used to dilute theexhaust

in order to avoid vapour condensation, which could dissolve some pollutants and reduce measured values. Excessive dilution on the other hand, results in very low concentration with attendant measurement problems. A pump with capacity of 30-350 cfm provides sufficient dilution for most vehicles.

Before the exhaust-air mixture enters the pump, its temperature is controlled to within +or – 10F by the heat exchanger. Thus constant density is maintained in the sampling system and pump.A fractionofthedilutedexhauststreamisdrawnoffbyapumpP2andejectedintoaninitiallyevacuated plastic bag.Preferably,thebagshouldbeopaqueandmanufacturedofTeflonorTeldar.Asinglebag is used for the entire test sample in the CVS-1system.

Because of high dilution, ambient traces of HC, CO or NOx can significantly increase concentrations in the sample bag. A charcoal filter is employed for leveling ambient HC measurement.Tocorrectforambientcontaminationabagofdilutionairistakensimultaneouslywith the filling of the exhaustbag.

HC, CO and NOx measurements are made on a wet basis using FID, NDIR and chemiluminescent detectors respectively. Instruments must be constructed to accurately measure the relatively low concentrations of diluted exhaust.

Bags should be analyzed as quickly as possible preferably within ten minutes after the test because reactions such as those between NO, NO2 and HC can occur within the bag quite quickly and change thetest results. **(2M)**

CVS-3 SYSTEM:

TheCVS-3systemisidenticaltotheCVS-1systemexceptthatthreeexhaustsamplebagsare used. The normal test is run from a cold start just like the CVS-1 test. After deceleration ends at 505 seconds, the diluted exhaust flow is switched from the transient bag to the stabilized bag and revolution counter number 1 is switched off and number 2 is activated. The transient bag is analyzed immediately. The rest of the test is completed in the normal fashion and the stabilized bag analyzed. However in the CVS-3 test ten minutes after the test ends the cycle is begun and again run until the endofdecelerationat505seconds.This second run is termed the hot start run. A fresh bag collects whatistermedthehottransientsample.Itisassumedthatthesecondhalfofthehotstartrunisthe

	same as the second half of the cold start run and is not repeated. In all, three exhaust sample bags are filled. An ambient air sample bag is also filled simultaneously. **Standards in India:** The Bureau of Indian Standards (BIS) is one of the pioneering organizations to initiate work on air pollution control in India. At present only the standards for the emission of carbon monoxide are being suggested by BIS given in IS: 9057-1986. These are based on the size of the vehicle and to be measured under idling conditions. The CO emission values are 5.5 percent for 2 or 3 wheeler vehicles with engine displacement of 75cc or less, 4.5 percent for higher sizes and 3.5 percent for four wheeled vehicles. **(2M)**
2	**Discuss the working of selective catalytic reduction (SCR) and particulate traps. (13 M) (AU April/May 2017)** BTL5 **Answer: Page 4.29, 4.31- Dr.S.Senthil** Selective Catalytic Reduction is a technology that injects urea – a liquid-reductant agent – through a catalyst into the exhaust stream of a diesel engine. The urea sets off a chemical reaction that converts nitrogen oxides into nitrogen and water, which is then expelled through the vehicle tailpipe. While urea is the primary operating fluid presently used in SCR systems, alternatives to the urea agent are currently being explored. One option involves the use of diesel fuel to transform NOx into harmless gases. SCR technology is one of the most cost-effective and fuel-efficient technologies available to help reduce emissions. SCR can reduce NOx emissions up to 90 percent while simultaneously reducingHCandCOemissionsby50-90percent, andPMemissionsby30-50percent.SCRsystems can also be combined with a diesel particulate filter to achieve even greater emission reductions for PM. SCR technology may play a key role in achieving emissions reductions that allow light-duty diesel vehicles to meet the new, lower EPA emissions regulations to be phased in through 2009 and potentially expand the diesel vehicle sales market to all 50states. SCR has been used to reduce stationary source emissions since the 1980s. In addition, more than100marinevesselsworldwidehavebeenequippedwithSCRtechnology,including cargo vessels,ferries and tugboats.WhileSCRhasbeeninstalledonbothhighwayandnon-roadenginesin

dieselretrofitdemonstrationprojectsthroughouttheU.S.,SCR systems have become the technology of choice for many of Europe's heavy-duty diesel truck and bus manufacturers where the urea agent is commonly known as Ad Blue. SCR technology may become more prevalent in the United States as both light- and heavy-duty engine manufacturers work to meet future emissions reduction standardsstartingin2009. In fact,severallightdutydieselmanufacturershavealreadyindicatedthat they are considering the use of SCR in future products. What are the technology challenges of using SCR? A major challenge of the SCR system is the replenishment of the urea solution.

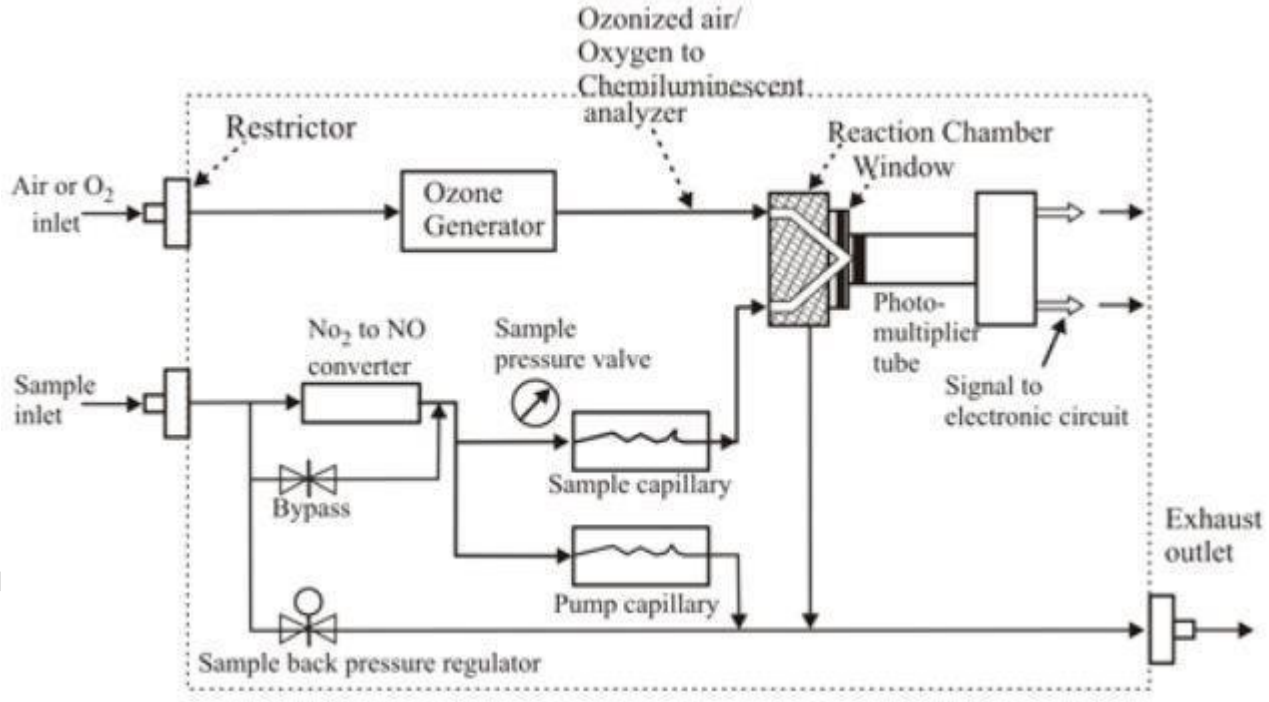
The urea solution is carried in an onboard tank which must be periodically replenished based on vehicle operation. For light-duty vehicles, urea refill intervals will occur around the time of a recommended oil change, while urea replenishment for heavy-duty vehicles will vary depending on the vehicle specifics and application requirements. While vehicles could continue to function normally even without the urea solution, the emissions system will not meet NOx reduction requirements. Manufacturers are currently working with the EPA to address these technology and emissions performance challenges. One concept is to establish a nationwide urea distribution infrastructure for consumers, while another option links the replenishment of urea with pre-existing scheduled maintenance intervals (i.e. oil changes). Other issues include the availability of space on vehicles to provide user-friendly access to the urea tank and other SCR components. In addition, properstorageofureaisrequiredtopreventtheliquidfromfreezingattemperaturesbelow12degrees Fahrenheit. **(8M)**

Particulate Traps

Diesel Particulate filters (DPF)or 'traps' do just that, they catch bits of soot in the exhaust. Aswithanyfiltertheyhavetobeemptiedregularlytomaintainperformance.Fora DPF this process is called 'regeneration' – the collected soot is burnt off at high temperature to leave only a tiny ash residue.

The exhaust emissions standards for new cars have effectively required fitment of a DPF in the exhaust of diesel cars since 2009 when the 'Euro 5' standard came into force. In fact, many cars registeredbefore2009willhavehadonefittedtooinanticipationofthechangeinstandards.

Standards aim to deliver an 80% reduction in diesel particulate(soot) emissions but the

	technologies not without problems – AA patrols are regularly called to cars with the particulatefilter warning light on indicating a partial block age of the filter. Even if your driving isn't mainly urban/stop-start, changes to driving style may be required to keep these systems working properly.. . **(5M)**
3	**What are the various types of instruments used for the measurements of emissions from IC engines? With a schematic diagram, describe in detail the chemiluminescence method of measuring oxides of nitrogen. (13 M) (AU Nov/Dec 2016)** BTL5 **Answer: Page 4.4, 4.5- Dr.S.Senthil** • **CO and CO2-NDIRAnalyzers** • **HC-Flame Ionization Detector(FID)** • **NOx-ChemiluminescenceAnalyzer(CLA)** **(3M)**  **Figure-** A schematic diagram of the chemiluminescence NOx analyzer **(4M)** When NO and ozone (O3) react a small fraction (about10%at26.7°C) of excited NO2*molecules is produced as per the following reactions: $NO+O_3 \leftrightarrow NO_2+O_2, NO2^* \rightarrow NO_2+h\gamma$

	As the excited molecules of NO2* decay to ground state, light in the wavelength region 0.6-3.0 μm is emitted. The quantity of excited NO2 produced is fixed at a given reaction temperature and the intensityoflightproducedduringdecayofexcitedNO2isproportionaltotheconcentrationofNOin the sample. The sample containing NO flows to a reactor where it reacts with ozone produced from oxygen in 'ozonator' .In the reactor NO is converted to NO2. AphotomultipliertubedetectsthelightemittedbytheexcitedNO2.The signal is then amplified and fed to recorder or indicating equipment. For the measurement of nitrogen oxides (NOx),NO2 in the sample is first converted to NO by heating in a NO2- to-NO converter prior to its introduction into the reactor. At 315^{o} C, about 90percent of NO2 is converted to NO2. The total concentration of NOx in the sample is thus, measured as NO. When the sample is introduced in the reactor bypassing the NO2- to- NO converter, concentration of NO alone is determined. The difference between the two measurements provides the concentration of NO2 in the sample. **(4M)** The response of the instrument is linear with NO concentration. The technique is very sensitive and can detect up to 10-3 ppm of NOx. The output signal is proportional to the product of sample flow rate and NO concentration. As the methodisflowsensitiveanaccurateflowcontrolisnecessary.The calibration and operation are done at the same flow rate and react or temperature. **(2M)**
4	**WriteshortnotesontheformationofparticulateandsmokeemissioninICengines.(13M)(AU April/May 2016)**BTL5 **Answer: Page 4.22, 4.15- Dr.S.Senthil** **Smoke** Themaincauseofsmokeformationisknowntobeinadequatemixingoffuelandair. Smoke is formed when the local temperature is high enough to decompose fuel in a region where there is insufficient oxygen to burn the carbon that is formed.The formation of over-rich fuel air mixtures either generally or in localized regions will result in smoke. Large amounts of carbons will be formed

	During the early stage of combustion.This carbon appears as smoke if there is insufficient air,if there is insufficient mixing or if local temperatures fall below the carbon reaction temperatures (approximately 1000C) before the mixing occurs. Acceptable performance of diesel engine is critically influenced by exhaust some emissions. Failureofenginetomeetsmokelegislationrequirementpreventssaleandparticularlyformilitaryuse, possible visibility by smoke is useful to enemy force. Diesel emissions gives information on effectiveness of combustion,general performance and condition of engine. **(7M)** **Particulate matter** Particulate matter comes from hydrocarbons, lead additives and Sulphur di oxide. If lead is used with the fuel to control combustional most 70% of the lead is air borne with the exhaust gasses. In that 30% of the particulates rapidly settle to the ground while remaining remains in the atmosphere. Lead is well known toxic compound. Particulates when inhaled or taken along with food leads to respiratory problems and other infections. Particulates when settle on the ground they spoil the nature of the object on which they are settling. Lead, a particulate is a slow poison and ultimately leads to death. **(6M)**
5	**Explain in detail about the different methods used for the measurement of exhaust emission in petrol engines. (13 M) (AU April/May 2016)** BTL5 **Answer: Page 4.18, 4.15- Dr.S.Senthil** **Methods of measurement** SO_2 concentration is measured by the ultraviolet fluorescence method, where the analyzed sample is exposed to UV-lamp irradiation with energetic excitation of SO_2 molecule. With the backward conversion of the molecule into the basic energetic level, energy as fluorescing radiation is released. This radiation is proportional to the sulfur dioxide concentration and is detected by a photo multiplier. NO_x concentration is measured by a chemiluminescence analyzer for the NO, NO_2 and NO_x concentration measurement. The principle of this method stands on the nitrogen molecule excitation by ozone. With the conversion of the molecule into the basic energetic level, liberation of radiation as chemiluminescence occurs. This radiation is detected by a photo multiplier.

	The analyzer design makes possible the acquirement of information on nitrogen monoxide (NO), nitrogen dioxide (NO_2) and nitrogen oxides (NO_x) concentrations. **(3M)** For PM_{10} concentration (suspended particulate matter fraction up to 10m particle size) measurement the radiometric method is used. It stands on beta-ray absorption in a sample captured on filtering material. The difference between the beta-ray absorption of the exposed and non-exposed filtering material, which is proportional to the mass of the captured suspended particle matter, gives the information on its concentration. **(4M)** The automated stations installed by the State Health Institute and some stations of the Public Health Service use for the suspended particulate matter continual monitoring the tapered element oscillating micro balance (TEOM). It measures the mass of the sample capture don are place able filter according to the oscillating tapered element frequency variation. The air sample passes through a filter where the dust particles are captured and runs through a hollow tapered element to a vacuum pump with an electronic flow control. CO concentration is measured by the method of IR-correlation absorption spectrometry. The radiation from an infra-red source passes through two parallel cells, one of which contains a non- absorbing background gas, the other contains the analyzed flowing sample of ambient air. **(3M)** The ozone concentration measurement is based on ultraviolet absorption photometry, resting upon absorption of radiation with the wavelength of 254nm by ozone in the analyzed sample. The radiation source is an UV-lamp and clean air(zero)and the sample itself are alternately measured in cells. The presented method with automatic pressure and temperature compensation meets the challenging requirements for O_3 measurement. During the year 1997 continual measurement of aromatic hydrocarbons (benzene, toluene and xy lenes) by BTX analyzers and gas chromatography method was introduced at two AMS (Libu, Most). It is a case of standard linkage to a sampling probe in a container. **(3M)**
6	**(i) Explain the mechanism of formation of CO, UBHC and NOx emissions. (ii) Why three way catalytic converters are employed in the modern-day S.I engine driven vehicles? Show the plot**

of pollutants versus air fuel ratio for all the major pollutants from S.I engines. (13 M) (AU April/May 2015) BTL5

Answer: Page 4.4, 4.9 & 4.28- Dr.S.Senthil

Formation of Carbon Monoxide

It is formed during combustion when there is insufficient oxygen to oxidize the fuel fully. Compression ignition engines have long been known to produce low levels of CO because of excess amount of air available for combustion. Theoretically its hold not emit any CO as it always operated with large amount of excess air. Nevertheless, CO is present in small quantities (0.1 to 0.75%) in the exhausts. This is possible because fuel injected in later part of the injection does not find enough oxygen due to local depletion in certain parts of the combustion chamber. **(3M)**

Formation of Unburnt hydrocarbon

The concentrations of hydrocarbons in diesel exhaust varies for a few parts per million to several thousand parts per millions depending on engine speed and load. Hydrocarbons in engine exhaust are composed of many individual hydrocarbons in the fuel supplied to the engine as well as number of hydrocarbon spartially unburnt produced during the combustion process. In addition, some unburnt hydrocarbons may be from lubricating oils. The tests on engine with single component fuels shows that these engines contained hydrocarbon so fhigher and lower molecular weights, than original fuel as well as molecules with different structures. Aromatic compounds have been observed in exhaust of engines operated on pureparaffin's. Polynuclear aromatics found in exhaust are products of this synthesis.

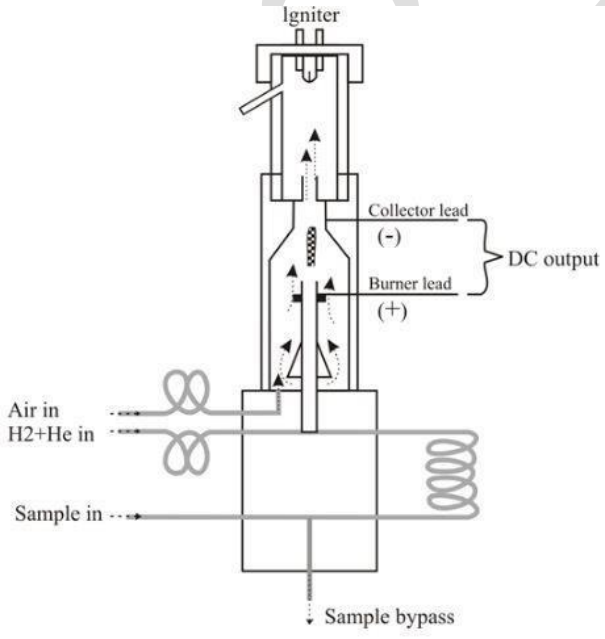
During the normal operation the relatively cold walls "quench" the fuel air mixture and inhibit combustionleavingathickskinofunburntairfuelmixtureovertheentireenvelopeofthecombustion chamber. The amount of unburnt fuel depends on the thickness of quench zone and the effective combustion chamber area. The thickness of quench zone depends on many variables as combustion temperature, pressure, mixture ratio, turbulence and residual gas dilution. Higher surface to volume ratio of combustion chamber leads to greater fraction of unburnt hydrocarbon from the quench zone.

	Partially oxidized hydrocarbons (aldehydes) have been associated with diesel exhaust. They produce objectionable odor and are high when engine idles and under cold starting indicating poor combustion. **(5M)** **Formation of Oxides of Nitrogen** Since nitrogen is a high temperature species its formation is influenced by combustion temperature and time available for combustion. Hence NO tends to increase with advanced injection timing. Also NO produced increase with fuel supply. Notable exception is pre-chamber. Indirect injection engines NO reaches maximum value at stoichiometric air fuel ratio, as lean and rich mixtures tend to reduce combustion temperatures. Increase in compression ratio leads to increase in combustion temperature and hence higher NO formation. Valve overlap has significant effect on NO formation. Higher valve overlap dilutes the incoming air more and more leading to increasing in fuel/air ratio. This in turn reduces combustion temperatures and hence lowers NO formation. Earlier inlet valve opening before TDC leads to increased dilution of incoming air and hence lower NO. Extended inlet valve opening up to 20 has no effect on NO formation as it does not vary manifold pressure. Extended exhaust valve opening before bottom dead center results in marginal increase in NO due to better scavenging, conversely later exhaust valve opening leads to delayed scavenging and higher dilution. Exhaust valve closing determine effect of scavenging and pronounced effect on dilution and hence Nitrogen formation. **(5M)**
7	**(i) With the help of a neat sketch describe the principle of operation of FID analyzer. (ii) Draw the Indian driving cycle and explain the various stages. (13 M) (AU April/May 2015)** BTL5 **Answer: Page 4.4, 4.9 & 4.28- Dr.S.Senthil** **Flame Ionization Detector (FID)** Pure hydrogen-air flames are practically ion-free but on introduction of even little amount of hydrocarbons the flame causes considerable ionization and becomes electrically conducting. The ionization current is proportional to the number of carbon atoms present in the hydrocarbon

molecules. Thus, FID is effectively a carbon atom counter e.g., one molecule of propane generates three times the response generated by one molecule of methane. The measurement of HC by FID is expressed as parts per million of methane i.e. as ppmC1 i.e., ppm of hydrocarbon containing equivalent of one carbon atom. The HC concentration is commonly written as ppm. HC concentration measured as ppm propane(C3) is tobemultipliedbyafactorof3toconvertittoppmC. All classes of hydrocarbons i.e., paraffin, olefins, aromatics, etc. show practically the same response to FID. Oxygenates, e.g. aldehydes and alcohols, however, have a somewhat lower response.

FID essentially consists of a hydrogen-air burner and an ion collector assembly as shown in Figure. Sample gas is introduced with hydrogen in the burner assembly and the mixture is burned in a diffusion flame. An electric potential is applied between the collect or plates that makes the ionization current to flow and generate signal proportional to HC concentration in the sample gas. This current is amplified, and the output signal is measured. **(8M)**

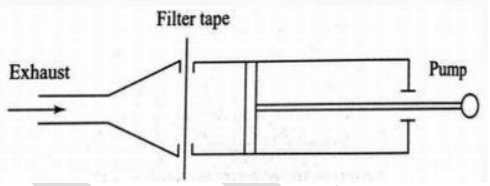
Figure - FID for HC measurement **(5M)**

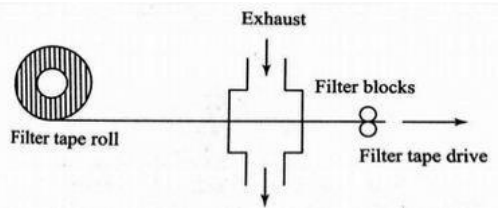


Part * C

1	**Briefly explain EURO and Bharath emission norms. (15 M)** -BTL5 **Answer: Refer class notes** **European emission standards:** European emission standards define the acceptable limits for exhaust emissions of new vehicles sold in the European Union and EEA member states. The emission standards are defined in a series of European Uni on directives staging the progressive introduction of increasingly stringent standards. Euro 6 emissions: The aim of **Euro 6** is to reduce levels of harmful car and van exhaust **emissions**, both in petrol and diesel cars. This includes nitrogen oxide (NOx), carbon monoxide (CO), hydrocarbons (THC and NMHC) and particulate matter (PM), which is basically soot from diesel cars. **(7M)** **Bharat stage emission standards (BSES) :** Bharat stage emission standards (BSES) are emission standards instituted by the Government of India to regulate the output of air pollutants from internal combustion engines and Spark-ignition engines equipment, including motor vehicles. The standards and the time line for implementation are set by the Central Pollution Control Board under the Ministry of Environment & Forests and climate change. The standards, based on European regulations were first introduced in 2000. Progressively stringent norms have been rolled out since then. All new vehicles manufactured after the implementation of the norms have to be compliant with the regulations. Since October2010, Bharat Stage (BS)III norms have been enforced across the country.In13majorcities,Bharat Stage IV emission norms have been in place since April 2010 and it has been enforced for entire country since April 2017. In 2016, the Indian government announced that the country would skip the BS-V norms altogether and adopt BS-VI norms by 2020. In its recent judgment, the Supreme Court has banned the sale and registration of

	Motor vehicles conforming to the emission standard Bharat Stage-IV in the entire country from April 1, 2020. **(8M)**
2	**Briefly explain greenhouse gasses and global warming potential. (15 M)** BTL5 **Answer: Refer class notes** **Greenhouse gasses:** Greenhouse gases are those that absorb and emit infrared radiation in the wave length range emitted by Earth. In order, the most abundant greenhouse gases in Earth's atmosphere are: Water vapor, Carbon dioxide, Methane, Nitrous oxide , Ozone , Chlorofluorocarbons, Hydrofluorocarbons , Atmospheric concentrations are determined by the balance between sources (emissions of the gas from human activities and natural systems) and sinks (the removal of the gas from the atmosphere by conversion to a different chemical compound or absorption by bodies of water). The proportion of an emission remaining in the atmosphere after a specified time is the "airborne fraction" (AF). The *annual airborne fraction* is the ratio of the atmospheric increase each year to that year's total emissions. As of 2006 the annual airborne fraction for CO_2 was about 0.45. The annual air borne fraction increased at a rate of 0.25±0.21%per year over the period1959–2006. **(8M)** **Global warming potential:** The global warming potential (GWP) depends on both the efficiency of themoleculeasagreenhousegasanditsatmosphericlifetime.GWP is measured relative to the same mass of CO_2 and evaluated for a specific timescale. Thus, if a gas has a high (positive) radiative forcing but also a short lifetime,it will have a large GWP on a 20-years small one ona100- year scale. Conversely, if a molecule has a longer atmospheric lifetime than CO_2 its GWP will increase when the timescale is considered. Carbon dioxide is defined to have a GWP of 1 over all time periods. Methane has an atmospheric life time of 12±3years. The 2007 IPCC report lists the GWP as 72 over a time scale of 20 years, 25 over 100 years and 7.6 over 500 years. A 2014 analysis, however, states that although methane's initial impact is about 100 times greater than that of CO_2, because of the Shorter atmospheric lifetime, after six or seven decades, the impact of the two gases is about equal,

	And from then on methane's relative role continues to decline. The decrease in GWP at longer times Is because methane is degraded to water and CO_2 through chemical reactions in the atmosphere. **(7M)**
3	**What is smoke and explain the principle used in the measurement of smoke? (15 M)** BTL5 **Answer: Page 4.18- Dr.S.Senthil 2018** Smoke is also a component of internal combustion engine exhaust gas, particularly diesel exhaust. Smoke is an aerosol (or mist) of solid particles and liquid droplets that are close to the ideal range of sizes for Mie scattering of visible light. This effect has been likened to three-dimensional textured privacy glass— a smoke cloud does not obstruct an image, but thoroughly scrambles it. **measurement of smoke:** **Smoke opacity:** Smoke opacity instruments measure optical properties of diesel smoke, providing an indirect way of measuring of diesel particulate emissions. There are two groups of instruments: capacity meters, which evaluate smoke in the exhaust gas, and smoke number meters, which optically evaluate soot collected on paper filters. Correlations have been developed to estimate PM mass emissions based on opacity measurement. Second generation opacity meters based on laser light scattering are much more sensitive and appear to hold promise for application to newer engines with much lower particulate emissions. **(7M)** **Spot filtering :**  A smoke strain obtained by filtering a given quantity of exhaust gas through a fixed filter paper is used for the measurement of smoke intensity. Figure-Spot filtering



Continuous type:

Measurement of smoke intensity is achieved by continuously passing exhaust gas through a moving strip of filter paper and collecting particles.

Figure-Continuous type **(8M)**

Subject Code :ME6016 **Year/Semester : IV/ 08**

Subject Name : Advanced IC Engines Subject Handler : Dr.B.RAJESHKUMAR & Mr.J.RAVIKUMAR

UNITIV ALTERNATIVE FUELS	
Alcohol, Hydrogen, Compressed Natural Gas, Liquefied Petroleum Gas and Bio Diesel - Properties, Suitability, Merits and Demerits - Engine Modifications.	
PART * A	
Q.No.	**Questions**
1.	**List down the major constituents of natural gas and LPG. (May/June 2012)** BTL3 Natural gas is a mixture of components consisting mainly of methane (60-95%) with small amount of other hydrocarbons. LPG consists of mainly methane 90%, ethane 4%, propane 1.7% and other.
2	**Compare the octane number and the calorific value of alcohol with petrol. (May/June 2012)** BTL4 Octane number- 80 to 90 (Petrol) and 111 for ethanol, CV- 44100 kJ/kg for Petrol and 26880 kJ/kg for ethanol.
3	**Comment on the water tolerance of alcohol blends. (May/June 2013)** BTL2 • Gasoline and water free alcohol are miscible in all proportions over a wide range of temperatures. • However, even addition of small addition of water to this blended fuel causes separation of the alcohol and gasoline. iii) The difficulties due to water separation have commonly led to the use of either 20-25 % of blends of alcohol alone or 10-15% alcohol and Benzol to reduce preparation troubles.
4	**State the methods by which ethanol is produced. (May/June 2013)** BTL2 Manufacture from saccharine materials, Starchy materials, cellulose material and hydrocarbon gases
5	**What are the advantages of hydrogen as a fuel? (Nov/Dec 2013)** BTL1 Its CV is about 19% higher in combustion energy density on a mass basis, Its wide flammability allows its utilization over extremely wide range of air fuel ratio without misfire, Its gaseous form eliminates the problem of atomization, vaporization, mixing and reconditioning leads to low emission, and H2 is easily ignites and has very high flame velocity.
6	**What are the commonly used alternative fuels? (Nov/Dec 2013)** BTL1 Alcohol, Bio-Diesel, Hydrogen, Bio-gas, LPG, CNG.
7	**Can alcohol be used for CI engines, Explain. (April/May 2014)** BTL3 Alcohol can be used in CI engines. The techniques of using alcohol in CI engines are Alcohol diesel emulsions, dual fuel injection, Alcohol fumigation and surface ignition of alcohols.

8	**Can one use solid fuels for IC engines, if so how? (April/May 2014)** BTL4 Yes, Solid fuels can be used for IC engines, a valve outlet for exhaust of combustion products, after combustion a fuel valve for retaining a quantity of solid fuel out of the cylinder and opening on pressure reduction in the cylinder by piston movement beyond top dead center to introduce the quantity of fuel into the cylinder.
9	**List down four properties that are important in the selection of a fuel for an engine. (April/May 2015)** BTL4 i)Air fuel ratio ii) Calorific value iii) latent heat of vaporization v) vapour pressure vi) Octane quality
10	**What are the problems of using methanol in an engine? (April/May 2015)** BTL2 i) low calorific value ii) produces more aldehydes iii) more corrosive iv) poor ignition characteristics v) danger of storage tank flammability -due to low vapour pressure..
11	**Write the advantage and disadvantage of alcohol as a fuel.** BTL4 The advantages of alcohols a fuel are: • it is a high-octane fuel with antiknock index number (octane number) of over100. • Alcohols have low Sulphur content in the fuel. • It produces fewer overall emissions when compared with gasoline Disadvantages: b Alcohols have poor ignition characteristics in general. c There is a possibility of vapor lock in fuel delivery system. d It has poor cold weather starting characteristics due to low vapor pressure and evaporation.
12	**What is the problem with gasoline-alcohol mixture as a fuel**? BTL4 Problems with gasoline-alcohol mixture as a fuel are the tendency for alcohol to combine with any water present. When this happens the alcohol separates to locally from the gasoline, resulting in a non-homogenous mixture. This causes the engine to run erratically due to the large air-fuel ratio difference between the two fuels.
13	**List the advantages of hydrogen as an IC engine.** BTL3 Advantages • Low emissions. • Fuel availability. • Fuel leakage to environment is not a pollutant • High energy continent per volume when stored as a liquid.
14	**List the disadvantages of using hydrogen as a fuel.** BTL3 Difficult to re fuel. Fuel cost would be high at present day's technology and availability. Poor engine volumetric efficiency. High NOx emission because of high flame.
15	**Write the methods for hydrogen can be used in SI engines.** BTL2 Hydrogen can be used in SI engines by three methods By manifold induction, By direct introduction of hydrogen into the cylinder.

	By supplementing gasoline.
16	**List the advantages and disadvantages of natural gas.** BTL3 Advantages: Octane number is around 120, which makes it a very good SI engines fuel. Low engine emissions Fuel is fairly abundant worldwide. Disadvantages: Low energy density resulting in low engine performance. Low engine volumetric efficiency because it is a gaseous fuel. Refueling is a slow process.
17	**Write the improvements required for the LPG vehicle in future.** BTL4 Effort must be made to have more LPG filling stations at convenient locations, so that LPG tank can be filled up easily. Safety devices are to be introduced to prevent accidents due to explosion of gas cylinders (or) Leakage in the gas pipes.
	Part B
1	**Compare the fuel properties of Diesel, petrol, Bio diesel and LPG. (13 M) (April/May 2017)** BTL5 **Answer: Page 5.23- Dr.S.Senthil** **https://afdc.energy.gov/fuels/fuel_comparison_chart.pdf** • **Property** **Diesel** **Petrol** **BioDiesel** **LPG No.** • MolecularWeight(gm/mole) 112 112 112 112 • ChemicalFormula mCnH2n mCnH2n mCnH2n mCnH2n 3 BoilingPoint(ºC) 40 to 170 40 to 170 40 to 170 40 to 170 4 Freezingpoint(ºC) -170.4 -170.4 -170.4 -170.4 5 Latentheat(kJ/kg) 400 400 400 400 6 Stoichiometric airfuelratio 14.6:1 14.6:1 14.6:1 14.6:1 7 Selfignition temperature(ºC) 300 to 450 300 to 450 300 to 450 300 to 450 • Octanenumbers 85 85 85 85 • Cetanenumber 15 15 15 15 10 Viscosity(Centipoise) 0.503 0.503 0.503 0.503 11 Lowercalorificvalue 44100 44100 44100 44100 (13M)
2	**(i) Discuss the methods of using alcohol as fuel in S.I and C.I engines. (ii) Explain the emission characteristics of using hydrogen in a C.I engine. (13 M) (April/May 2017)** BTL5 **Answer: Page 5.34- Dr.S.Senthil**

Comparison of performance characteristics: In analyzing the performance characteristics of the gasoline, we can take the brake thermal efficiency factor. (5M)

Comparison of emission characteristics:

Emission of CO: Emission of CO in the engine is reduced by increasing the speed of the engine.

Emission of NO: Emission of NO in the engine is significantly decreased by increasing the speed of the engine

Emission of HC: During combustion- incomplete combustion leads to the emission of HC

Comparison of combustion characteristics: Modifying the combustion chamber with good cooling mechanism will increase the efficiency. (8M)

3

Explain the fuel properties of alcohols, CNG, LPG and hydrogen. (13 M) (Nov/Dec 2016) (April/May 2014) BTL5

Answer: Page 5.19, 5.26 - Dr.S.Senthil

	Property	Alcohol	CNG	LPG	Hydrogen No.
•	MolecularWeight(gm/mole)	112	112	112	112
•	ChemicalFormula	mCnH2n	mCnH2n	mCnH2n	mCnH2n
3	BoilingPoint(ºC)	40 to 170	40 to 170	40 to 170	40 to170
4	Freezingpoint(ºC)	-170.4	-170.4	-170.4	-170.4
5	Latentheat(kJ/kg)	400	400	400	400
6	Stoichiometric airfuelratio	14.6:1	14.6:1	14.6:1	14.6:1
7	Selfignitiontemperature(ºC)	300 to 450	300 to 450	300 to 450	300 to 450
•	Octanenumbers	85	85	85	85
•	Cetanenumber	15	15	15	15
10	Viscosity(Centipoise)	0.503	0.503	0.503	0.503
11	Lowercalorificvalue	44100	44100	44100	44100

(13M)

4

Explain the performance, combustion and emission characteristics of CI engine using bio-diesel as a fuel. (13 M) (April/May 2016), (April/May 2014) BTL5

Answer: Page 5.23, 4.15- Dr.S.Senthil

Performance: It is found that its degradation rate is four times that of conventional diesel fuel. Brake specific fuel consumption of diesel and various blends of Jatropha and diesel oil at different loads. It is found that the specific fuel consumption for the blend B20 is close to diesel. However, if the concentration of jatropha oil in the blend is more than 30% the specific fuel consumption was found to be higher than diesel at all loads. This is because of the combined effects of lower heating value and the higher fuel flow rate due to high density of the blends. Higher proportions of jatropha oil in

	the blends increase the viscosity which in turn increased the specific fuel consumption due to poor atomization of the fuel. (5M) **Combustion: the smoke opacity of the exhaust gas increases with increase in load** for all the blends. It also shows that the smoke opacity increases with the concentration of jatropha oil in the blends. This is caused mainly due to the poor atomization and combustion because of the higher viscosity of the blends. The opacity for diesel showed a similar trend as that of the blends, however the values were comparatively lower at all loads. (4M) **Emission:** The HC emission decreased up to a load of 2.1kWand then increased slightly with further increase in load for diesel. The HC emission for the blends also followed a similar trend but comparatively the values were lower. The presence of oxygen in the jatropha oil aids combustion and hence the hydrocarbon emission reduced. However, at higher loads the effects of viscosity have increased these emission levels for the blends. (4M)
5	**(i) Discuss the salient properties of hydrogen as fuel. (ii) List down the advantages and disadvantages of using bio diesel in C.I engines. (6+7 M) (April/May 2015)** BTL5 **Answer: Page 5.27, 5.23 - Dr.S.Senthil** The Physical and Chemical Properties are the characteristics of a substance, like Hydrogen, which distinguishes it from any other substance. Most common substances, like Hydrogen, exist as States of Matter as solids, liquids, gases and plasma. Refer to the article on Hydrogen Element for additional information and facts about this substance. The Physical properties of Hydrogen are the characteristics that can be observed without *changing* the substance into another substance. Physical properties are usually those that can be observed using our senses such as color, luster, freezing point, boiling point, melting point, density, hardness and odor. (3M) Chemical Properties of Hydrogen are the characteristics that determine how it will *react* with other substances or *change* from one substance to another. The better we know the nature of the substance the better we are able to understand it. Chemical properties are only observable during a chemical reaction. Reactions to substances may be brought about by changes brought about by burning, rusting, heating, exploding, tarnishing etc. (3M) **Advantages of biodiesel fuel** • Biodiesel fuel is a renewable energy source unlike petroleum-based diesel. • An excessive production of soybeans in the world makes it an economic way to utilize this surplus for manufacturing the Bio-diesel fuel. • One of the main biodiesel fuel advantages is that it is less polluting than petroleum diesel. • The lack of sulfur in 100% biodiesel extends the life of catalytic converters. • Another of the advantages of biodiesel fuel is that it can also be blended with other energy resources and oil. • Biodiesel fuel can also be used in existing oil heating systems and diesel engines without making any alterations. • It can also be distributed through existing diesel fuel pumps, which is another biodiesel fuel advantage over other alternative fuels. • The lubricating property of the biodiesel may lengthen the lifetime of engines. (4M)

Disadvantages of biodiesel fuel

- At present, Biodiesel fuel is bout one and a half times more expensive than petroleum diesel fuel.
- It requires energy to produce biodiesel fuel from soy crops, plus there is the energy of sowing, fertilizing and harvesting.
- Another biodiesel fuel disadvantage is that it can harm rubber hoses in some engines.
- As Biodiesel cleans the dirt from the engine, this dirt can then get collected in the fuel filter, thus clogging it. So, filters have to be changed after the first several hours of bio-diesel use.
- Biodiesel fuel distribution infrastructure needs improvement, which is another of the bio-diesel fuel disadvantages. (3M)

6

- **What modifications are required in a C.I engine to use gaseous fuels? Explain. (ii) Explain the combustion and emission characteristics of using hydrogen in a C.I engine. (7+6M) (April/May 2015)**BTL5

Answer: Page 5.33, 5.28 & 5.34- Dr.S.Senthil

Fuel shut off valves are used to cut-off fuel supply. Functions of step motor and fuel shut off valves are controlled by ECU.

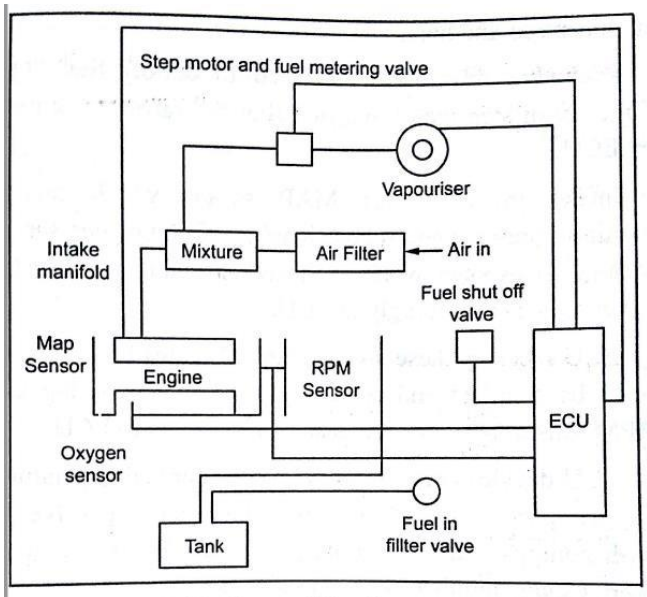


Fig. 5.19. Engine modification system for LPG

Figure (3M)

Intake manifold has MAP sensor which measures manifold pressure and sends signal to ECU.

ECU receives the signals and calculates how much fuel is to be supplied and sends signal to fuel metering valve.

RPM Sensor measures the speed and send signals to ECH.

ECU decides amount of fuel to be supplied depending on the engine speed and sends signals to fuel metering. (4M)

- Hydrogen generated from renewable sources is an eco-friendly fuel that can be used in automotive industry or for energy generation purposes. Hydrogen is a high-energy content gas and its carbonless chemical structure can provide significant benefits of high thermal efficiency and near zero or very low carbon emissions when combusted with other fuels.

(2M)

In this study, the implementation of hydrogen fuel was tested at low and medium operating loads in a heavy-duty hydrogen-diesel dual-fuel engine. The paper provides a detailed experimental analysis of the effects of hydrogen energy share ratio and various combustion strategies such as exhaust gas recirculation, diesel injection pressure and diesel injection patterns. (2M)

At low load conditions, engine operation with an H_2 energy share ratio of up to 98% was achieved without any engine operation implications. This condition provided a simultaneous reduction of carbon and NOx emission of over 90% while soot emissions were dropped by 85% compared to the

	conventional diesel-only operation. At medium load, the increased NOx emission due to the high energy content of hydrogen fuel was found to be the primary challenge. (2M)
	Part *C
1	**Briefly explain the modifications are required in a C.I engine to use bio-fuels. (15M) (April/May 2015)** BTL4 **Answer: Refer class notes** **Engine Modification**: The aim of this section of Biofuels for Transport is to discuss the engine modifications that may be required to run biofuels in conventional internal combustion engines. The fuels being looked at specifically are biodiesel, used in a compression ignition engine, and bio-ethanol, used in a spark ignition engine. (3M) ***Bioethanol Modification*** **Octane Number**: The octane number of a petrol fuel is defined as a measure of the resistance of the fuel to abnormal combustion known as "knocking". The higher the fuel octane number, then the less likely it becomes that the engine will be susceptible to "knock". The "knocking process" is caused by the incomplete combustion of the petrol fuel in the engine cylinder, which causes a sudden knock or blow to the piston, which over a period will seriously damage the vehicle engine. By adding an ethanol E10 blend to petrol, we can increase the octane number of the petrol fuel by two points. Therefore, bioethanol is termed as an "octane enhancer". (3M) **Air Fuel Mix**: The air/fuel mixing ratio that is required for 100% petrol fuels in order for complete combustion is about 14.6 air: 1 fuel. This means that 14.6 Kg of air is required for the complete combustion of 1 Kg of non-oxygenated petrol fuel. An ethanol E10 blend of fuel will normally have an oxygen content of about 3.5% oxygen. The oxygen that is present in the ethanol can affect the air to fuel ratio at which the engine is operating at. Therefore, it is usually necessary for certain car engines to have the air: fuel ratio reduced in order to take into account the oxygen content that is present in the ethanol blend. The air / fuel ratio for a VW Golf running on 22% ethanol is 12.7:1, which is slightly less than the 14.6:1 air / fuel ratio that is used for conventional fuels. This effect is also applicable to biodiesel as it is also an oxygenated fuel. (3M) The engine management systems that are fitted in most modern motor vehicles will electronically sense and change the air fuel mixing ratio in order to maintain the stoichiometric ratio when ethanol (oxygenated) fuels are added to the engine. For some vehicles, the maximum oxygen content that can be compensated for is 3.5% oxygen (E10 ethanol fuel blends). Older vehicles are usually not fitted with engine management systems, instead they operate with a normal fuel carburetor system. Thus, the carburetor air fuel mixture must be adjusted manually, in order to compensate for the increased oxygen content that is present in ethanol blended fuels. (3M) **Fuel Filters:** It may be necessary to change the vehicles fuel filter more often as ethanol blend scan loosen solid deposits that are present in vehicle fuel tanks and fuel lines.

	Cold Starting: Ethanol blends have a higher latent heat of evaporation than 100% petrol and thus ethanol blend shave a poorer cold start ability in Winter. Therefore some vehicles have a small petrol tank fitted containing 100% petrol for starting the vehicle in cold weather. **Engine Modifications for Ethanol blends of 14% to 24%**: The following engine modifications were carried out by car companies in Brazil, in the 1970's, when vehicles were operating on ethanol blends of between 14 and 24% ethanol: Changes to cylinder walls, cylinder heads, valves and valve seats, Changes to pistons, piston rings, intake manifolds and carburetors, Nickel plating of steel fuel lines and fuel tanks to prevent ethanol E20 corrosion, Higher fuel flowrate injectors to compensate for oxygenate qualities of ethanol. (3M)

Subject Code :ME6016 **Year/Semester : IV/ 08**

Subject Name : Advanced IC Engines Subject Handler : Dr.B.RAJESHKUMAR & Mr.J.RAVIKUMAR

UNITV RECENT TRENDS	
Air assisted Combustion, Homogeneous charge compression ignition engines – Variable Geometry turbochargers – Common Rail Direct Injection Systems - Hybrid Electric Vehicles – NOx Absorbers - Onboard Diagnostics.	
PART * A	
Q.No.	**Questions**
1.	**How the in-cylinder pressure is measured in an engine? (May/June 2012)** BTL3 High natural frequency pickups are used to measure the cylinder pressure. Piezoelectric pickups use quartz, which are stressed, when a pressure is applied, this cause two opposite sides of the crystal to get oppositely charged. The charge is proportional to the applied stress or pressure. The entire pressure measuring system must have a very high insulation resistance so that the charge does not leak and cause drifts.
2	**Mention the principle of a surface ignition engine. (May/June 2012)** BTL2 The surface ignition engine in which the super-heated fuel is ignited by being brought into contact with oxygen-rich fresh air rather than by a separate source of ignition, such as a spark plug.
3	**Mention the advantages of plasma ignition system. (May/June 2013)** BTL2 A high voltage ignition spark with a large ignition kernel temperature produces more power which is several times greater than conventional spark.
4	**What is the working principle of pre chamber stratified charge engine? (May/June 2013)** BTL4 In this rich mixture is formed near the spark plug by fuel supply from the injector and a carburetor supplies lean mixture to the main combustion chamber. ii) The auxiliary charge burn in pre-chamber and issues out, through its throat, into the main chamber and burns leaner mixture present there.
5	**What is the function of charge amplifier? (Nov/Dec 2013)** BTL2 A charge produced by the pressure sensor cannot be calibrated directly with the sensor. The charge amplifier simply converts to the voltage that can be measured by oscilloscope.
6	**Define charge stratification. (Nov/Dec 2013)** BTL1 Charge stratification means providing different fuel air mixture strengths at various places in the combustion chamber. A relatively rich mixture near the spark plug and a leaner mixture in the rest of the combustion chamber.
7	**What are the advantages of gasoline direct injection? (April/May 2014)** BTL2

	GDRI-Gasoline Direct Injection - GDRI is to have uniform distribution of fuel in a multi cylinder engine, to improve breathing capacity (i.e.,) volumetric efficiency and to reduce or eliminate detonation.
8	**Write a short note on pressure pickup used in engine measurement. (April/May 2014)** BTL2 Pressure pickup used in engine measurement, pickup for measuring the maximum pressure in the internal combustion engine cylinder comprises a spring-loaded reversing valve mounted in a housing and being in connect with the first seat made in the housing on the side of the compressed air supply passage.
9	**What do you understand by CDRI system? Give its salient features. (April/May 2015)** BTL2 GDRI-Gasoline Direct Injection - GDRI is to have uniform distribution of fuel in a multi cylinder engine, to improve breathing capacity (i.e.,) volumetric efficiency and to reduce or eliminate detonation.
10	**What is a multivalve engine? Indicate its advantages. (April/May 2015)** BTL3 A multi valve design typically has three, four or five valves per cylinder to achieve improved performance.
11	**List the components in the measuring chain for pressure measurement in engine research. (Nov/Dec 2015)** BTL4 Monitor max combustion pressure, IMEP measurement, Knock analysis, Cycle-to-cycle variation, Heat release analysis, Ignition timing (ignition delay)
12	**What is common rail direct injection diesel engine? (April 2016)** BTL2 Common-rail direct fuel injection is a direct fuel injection system for diesel engines. On diesel engines, it features a high-pressure fuel rail feeding solenoid valves, as opposed to a low-pressure fuel pump feeding unit injectors.
13	**What are the fuels used in HCCI engines?** BTL3 Diesel, gasoline, methanol, natural gas and hydrogen.
14	**List the disadvantages of homogeneous charge compression ignition engine?** BTL4 The major problem is controlling the ignition timing over a wide lead and speed. Power density is limited by combustion noise and high peak pressure.
15	**Explain the functions of the following components.** BTL4 • **Pumping element, (b) Metering element, (c) Timing control, (d) Ambient control.** **(a)Pumping element**- moves the fuel from the fuel tank to the injector. This include necessary piping, filter etc. • **Metering element**- measures and supplies the fuel at the rate demanded by load and speed conditions of the engine. • **Timing control**- fixes the start and stop of the fuel-air mixing process. • **Ambient control**-compensates for charges in temperature and pressure of either air or fuel that may affect the various elements of the system.

16	**Write notes on continuous injection system.** BTL3 Continuous injection system usually has a rotary pump. The pump maintains the fuel line gauge pressure of about **0.75 to 1.5 bar**. The system injects the fuel through a nozzle located in manifold immediately downstream of the throttle plate.
	Part B
1	**Explain the construction and working of common rail direct injection (CRDI) system with neat block diagram. (13 M) (April/May 2017)** BTL5 **Answer: Page 6.30- Dr.S.Senthil**

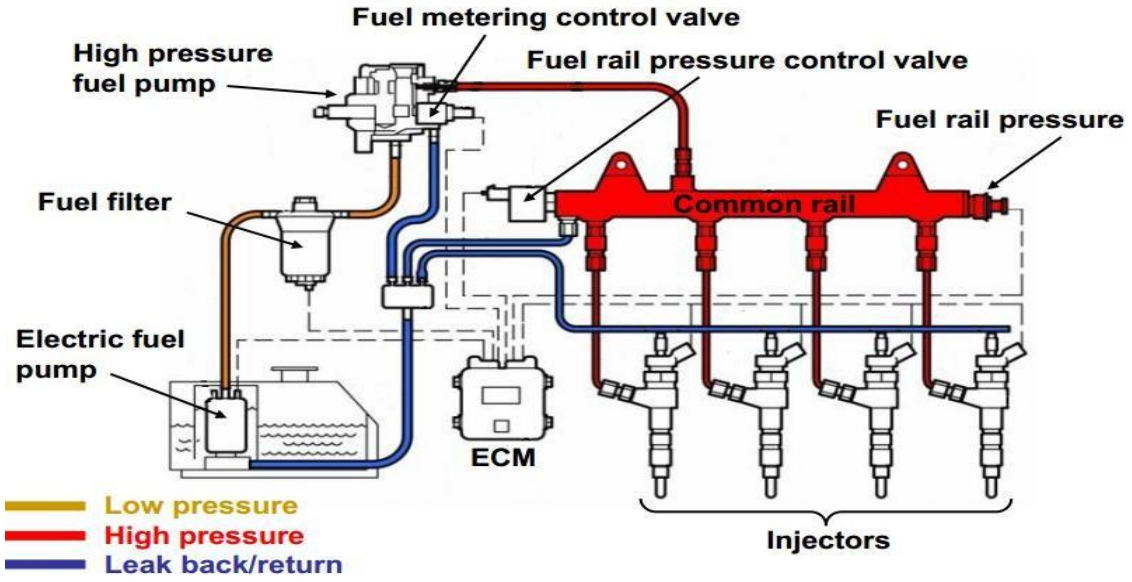


Figure- Common Rail Injection System **(5M)**

Common Rail Injection System has benefits of High Injection Pressure and finer atomizing of fuels and reduction in overall exhaust emissions.

Fuel Metering Control Valve:

It is located at the backside of high-pressure pump and controls the fuel intake volume to the pump. It receives battery voltage from engine Electronic Control module.

Fuel Intake Volume Regulation:

Only the required volume of fuel is supplied to the common rail from the high-pressure pump. Reduced fuel flow around the system result in lower fuel return flow temperature.

High Pressure Regulator Valve:

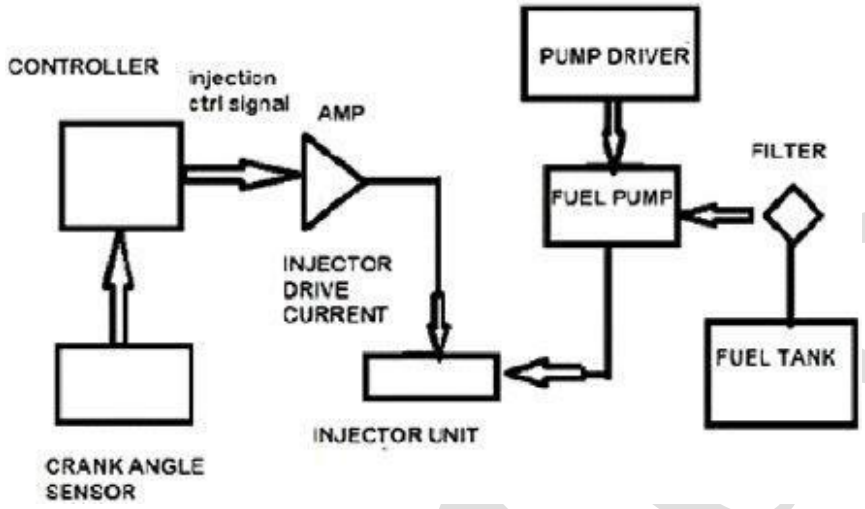
It is fitted to back of high-pressure pump and it controls the high pressure fuel delivery to the common rail. Excess fuel will return to the fuel tank.

	Common Rail (or) High Pressure Accumulator: Fuel is supplied to the common rail at high pressure from high pressure pump which stores it and distributes to the individual injectors. It also damps the vibration caused due to injection and pressure vibrations. Typical Volume of fuel held in Common rail is 16 to 20 cm^3 **Fuel Rail Pressure Sensor:** It monitors the pressure of fuel in the common rail and signals to the ECM **Rail Pressure Limiter Valve:** This valve fitted at common Rail will release the pressure if abnormal pressure is build up in the system. **(8M)**
2	**Discuss the following (i) Hybrid electric vehicle (HEV) and (ii) On-Board diagnostics (OBD). (13 M) (April/May 2017)** BTL5 **Answer: Page 6.13 & 6.1- Dr.S.Senthil** **Hybrid electric vehicle (HEV)** The addition of a battery-powered electric motor increases the fuel efficiency of hybrids in a number of ways. Like the switch that turns off your refrigerator's light bulb when the door is closed, "**idle-off**" is a feature that turns off your car's conventional engine when the vehicle is stopped, saving fuel. The battery provides energy for the air conditioner and accessories while the vehicle idles at stop lights or in traffic, and the electric motor can start the vehicle moving again. If needed, the conventional engine will reengage to provide more power for acceleration. "**Regenerative braking**" is another fuel-saving feature. Conventional cars rely entirely on friction brakes to slow down, dissipating the vehicle's kinetic energy as heat. Regenerative braking allows some of that energy to be captured, turned into electricity, and stored in the batteries. This stored electricity can later be used to run the motor and accelerate the vehicle. Plug-in hybrid vehicles combine a gas engine with an electric motor and battery. Having an electric motor also allows for more efficient engine design. This "**power assist**" feature helps reduce demands on a hybrid's gasoline engine, which in turn can be downsized and more efficiently operated. The gasoline engine produces less power, but when combined with electric motors, the system's total power can equal or exceed that of a conventional vehicle. The most efficient hybrids utilize "**electric-only drive**," allowing the vehicle to drive entirely on electricity and use less fuel. In hybrids that can't be plugged-in, electric-only drive is typically only utilized at low speeds and startup, enabling the gas or diesel-powered engine to operate at higher speeds, where it's most efficient. Most plug-in hybrids—which tend to have larger batteries and motors—can drive entirely on electricity at relatively high speeds for extended distances (typically 10 to 30 miles).

	Different hybrids also use different types of "drivetrains," the mechanical components that deliver power to the driving wheels. **(8M)** **On-board diagnostics** (**OBD**) is an automotive term referring to a vehicle's self-diagnostic and reporting capability. OBD systems give the vehicle owner or repair technician access to the status of the various vehicle subsystems. The amount of diagnostic information available via OBD has varied widely since its introduction in the early 1980s versions of on-board vehicle computers. Early versions of OBD would simply illuminate a malfunction indicator light or "idiot light" if a problem was detected but would not provide any information as to the nature of the problem. Modern OBD implementations use a standardized digital communication sport to provide real- time data in addition to a standardized series of diagnostic trouble codes, or DTCs, which allow one to rapidly identify and remedy malfunctions within the vehicle. **(5M)**
3	**(i) Explain the characteristics of a common rail direct injection diesel engine. (ii) Discuss the method of obtaining pressure crank angle diagram. List down the parameters that can studied from the pressure crank angle diagram. (13 M) (Nov/Dec 2016)** BTL5 **Answer: Page 2.11 - Dr.S.Senthil** (i) (a) ***Fuel pressure independent of engine speed and load conditions.*** This allows for flexibility in controlling both the fuel injection quantity and injection timing and enables better spray penetration and mixing even at low engine speeds and loads. This feature differentiates the common rail system from other injection systems, where injection pressure increases with engine speed, as illustrated in. This characteristic also allows engines to produce higher torque at low engine speed—especially if a variable geometry turbocharger (VGT) is used. It should be noted that while common rail systems could operate with maximum rail pressure held constant over a wider angel of engine speeds and loads, this is rarely done. Fuel pressure in common rail systems can be controlled as a function of engine speed and load to optimize emission sand performance while ensuring engine durability is not com • *Lower fuel pump peak torque requirements.* As high-speed direct injection (HSDI) engines developed, more of the energy to mix the air with fuel came from the fuel spray momentum as opposed to the swirl mechanisms employed in older, IDI combustion systems. Only high-pressure fuel injection systems were able to provide the mixing energy and good spray preparation needed for low PM and HC emissions. Promised. • *Improved noise quality.* DI engines are characterized by higher peak combustion pressures and, thus, by higher noise than IDI engines. It was found that improved noise and low NOx emissions were best achieved by introducing pilot injection(s). This was most easily realized in the common rail system, which was capable of stable deliveries of small pilot fuel quantities over the entire load/speed range of the engine. **(8M)** **Method of obtaining pressure crank angle diagram:** There is several ways to obtain pressure versus crank angle traces. The first one is through experimental procedure. You will need an in-cylinder pressure sensor and an encoder. Using a Daq board you can acquire these data and, after some simple conversions that can be find in John B. Heywood (Internal combustion engines fundamentals), you will find P-V diagram. Be careful in integration of P-V diagram. A more-easier way to obtain Indicated Power is using engine modelling software's as for example Gt-Power, Avl-Boost, Ricardo Wave. These software's will require some geometric and flow data as inputs, but they can reach good agreement. Also, you can use friction work and brake work to find indicated power.

	Please, let me know more about what you are doing. I did not understand if you want to calculate Indicated Power of a real engine or you just want a method for generic engines. **(5M)**
4	**With a neat sketch explain in detail about gasoline direct engine. (13 M) (April/May 2016)** BTL5 **Answer: Page 6.32- Dr.S.Senthil** Gasoline direct injection (GDI) (also known as petrol direct injection, direct petrol injection, spark-ignited direct injection (SIDI) and fuel- startified injection (FSI), is a form of fuel injection employed in modern two-stroke and four-stroke gasoline engines. The gasoline is highly pressurized, and injected via a common rail fuel line directly into the combustion chamber of each cylinder, as opposed to conventional multipoint fuel injection that injects fuel into the intake tract or cylinder port. Directly injecting fuel into the combustion chamber requires high-pressure injection, whereas low pressure is used injecting into the intake tract or cylinder port. **(5M)** In some applications, gasoline direct injection enables a stratified fuel charge (ultra-lean burn) combustion for improved fuel efficiency, and reduced emission levels at low load. **(2M)** GDI has seen rapid adoption by the automotive industry over the past years, from2.3% of production for model year 2008 vehicles to just over 45% expected production for model year 2015.**(2M)** The major advantages of a GDI engine are increased fuel efficiency and high power output. Emissions levels can also be more accurately controlled with the GDI system. GDI engine operates into two modes 1) overall lean equivalence ratio composition during low load and low speed operation. 2) Homogeneous stoichiometric modeathigher loads and at all load sand higher speed. At medium load region charge is lean or stoichiometric. The combustion system is classified into air guided, wall guided and spray guided system. **(4M)**
5	**Discuss in detail about the heat release analysis in engines. (13 M) (April/May 2016)** BTL5 **Answer: Page 6.44- Dr.S.Senthil** There is substantial variation in the shape of the curve and the above relation fails to predict the total heat release values. The relation is used to predict the total heat release value and the results. The predicted values are compared with the calculated value obtained from the instantaneous heat release rate curve. The error between the values obtained and the actual heat release values are also indicated in the table. It can be observed from the table that the errors are higher for both very rich and very lean mixtures. **(5M)**

	(4M) **(4M)**
6	**With a neat sketch explain the operation of an electronic fuel injection system used in a S.I engine. (7 M)** (**April/May 2015)** BTL-5 **Answer: Page 6.44- Dr.S.Senthil** **Electronic injection** Because mechanical injection systems have limited adjustments to develop the optimal amount of fuel into an engine that needs to operate under a variety of different conditions (such as when starting, the engine's speed and load, atmospheric and engine temperatures, altitude, ignition timing, etc.) electronic fuel injection (EFI) systems were developed that relied on numerous sensors and controls. When working together, these electronic components can sense variations and the main system computes the appropriate amount of fuel needed to achieve better engine performance based on a

	stored "map" of optimal settings for given requirements.in 1953, the Bendix Corporation began exploring the idea of an electronic fuel injection system as a way eliminate the well-known problems of traditional carburetors. **(4M)**  **Figure . Electronic fuel injection** system **(3M)**
7	**Discuss the method of obtaining the rate of heat transfer from engines. (6 M)** BTL-5 **Answer: Refer class notes** In diesel engines, fuel is often injected into the engine cylinder near the end of the compression stroke, just a few crank angle degrees before top dead center. The liquid fuel is usually injected at high velocity as one or more jets through small orifices or nozzles in the injector tip. It atomizes into small droplets and penetrates into the combustion chamber. The atomized fuel absorbs heat from the surrounding heated compressed air, vaporizes, and mixes with the surrounding high-temperature high-pressure air. As the piston continues to move closer to top dead center (TDC), the mixture (mostly air) temperature reaches the fuel's ignition temperature. Rapid ignition of some premixed fuel and air occurs after the ignition delay period. This rapid ignition is considered the start of combustion (also the end of the ignition delay period) and is marked by a sharp cylinder pressure increase as combustion of the fuel-air mixture takes place. Increased pressure resulting from the premixed combustion compresses and heats the unburned portion of the charge and shortens the delay before its ignition. It also increases the evaporation rate of the remaining fuel. Atomization, vaporization, fuel vapor-air mixing, and combustion continue until all the injected fuel has combusted. **(6M)**
8	**Discuss about the HCCI engines. (13 M)** (**April 2014)** BTL-5 **Answer: Page 6.44- Dr.S.Senthil** **Homogeneous charge compression ignition**(**HCCI**) is a form of internal combustion in which well-mixed fuel and oxidizer (typically air) are compressed to the point of auto-ignition. As in other forms of combustion, this exothermic reaction releases energy that can be transformed in an engine into work and heat.

HCCI combines characteristics of conventional gasoline engine and diesel engines. Gasoline engines combine *homogeneous charge* (HC) with *spark ignition* (SI), abbreviated as HCSI. Diesel engines combine *stratified charge* (SC) with *compression ignition* (CI), abbreviated as SCCI.

As in HCSI, HCCI injects fuel during the intake stroke. However, rather than using an electric discharge (spark) to ignite a portion of the mixture, HCCI raises density and temperature by compression until the entire mixture reacts spontaneously.

Stratified charge compression ignition also relies on temperature and density increase resulting from compression. However, it injects fuel later, during the compression stroke. Combustion occurs at the boundary of the fuel and air, producing higher emissions, but allowing a leaner and higher compression burn, producing greater efficiency. **(6M)**

Controlling HCCI requires microprocess or control and physical understanding of the ignition process. HCCI designs achieve gasoline engine-like emissions with diesel engine-like efficiency.

HCCI engines achieve extremely low levels of oxides of nitrogen emissions (NO_x) without a catalytic converter. Hydrocarbons (unburnt fuels and oils) and carbon monoxide emissions still require treatment to meet automobile emissions control regulations. **(4M)**

Recent research has shown that the hybrid fuels combining different reactivities (such as gasoline and diesel) can help in controlling HCCI ignition and burn rates. RCCI, or reactive its controlled compression ignition, has been demonstrated to provide highly efficient, low emissions operation over wide load and speed ranges. **(3M)**

Part*C

1 **Write a short note on data acquisition system. (15 M)** (**April 2014)** BTL5

Answer: Page 6.30- Dr.S.Senthil

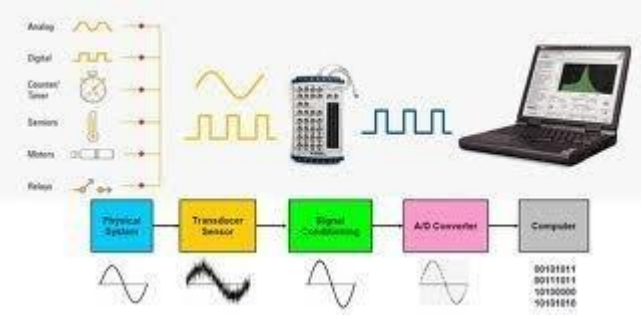
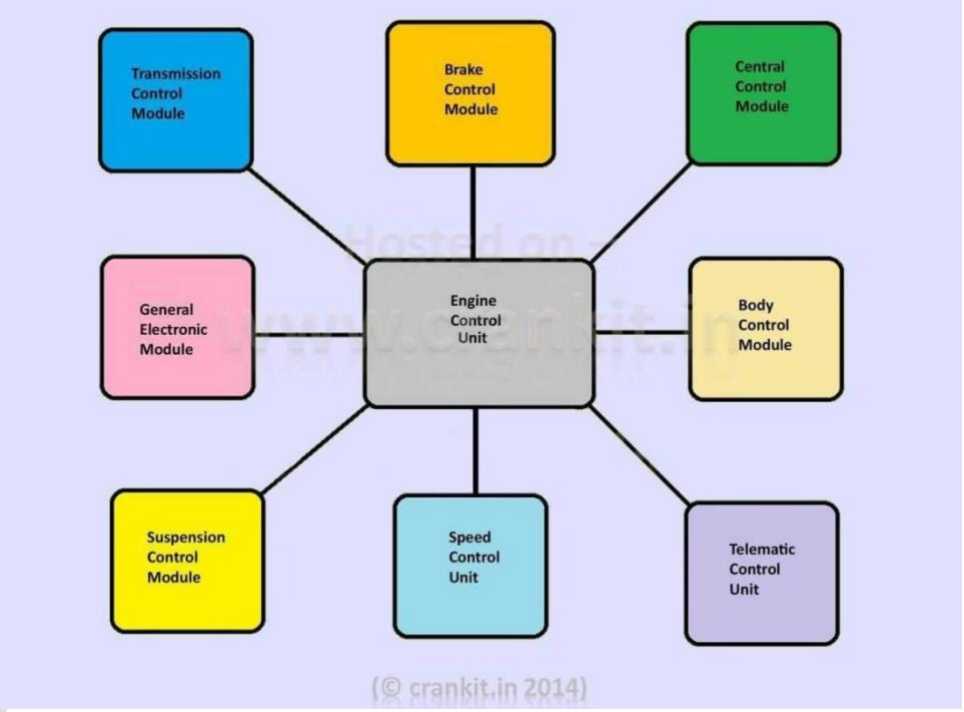


Figure- data acquisition system **(5M)**

A data acquisition system is a device designed to measure various parameters. The purpose of the data acquisition system is generally the analysis of the data and the improvement in accuracy of measurements. The data acquisition system is normally electronics based, and it is made of hardware and software. The hardware part is made of sensors, signal conditioners & data acquisition card and computer. The data acquisition system increases efficiency of measurement and lowers the cost for test, through easy to integrate software like Visual Basic. With this system, Engineers cause graphical

	representation to meet their specific needs – very different from the conventional and traditional measurements. Additionally, data acquisition system capitalized on the ever-increasing performance of personal computers. In test, measurement, and control, the system experiences up to a 10 times increase inefficiency at a fraction of the cost, in a fraction of time, of traditional measurement system. . **(10M)**
2	**Explain the electronic engine management system used in modern engines. (15 M) (Dec 2013)** BTL5 **Answer: Page 6.30- Dr.S.Senthil** An engine control unit (ECU), also commonly called an engine control module (ECM), is a type of electronic control unit that controls a series of actuators on an internal combustion engine to ensure optimal engine performance. It does this by reading values from a multitude of sensors within the engine bay, interpreting the data using multidimensional performance maps (called lookup tables), and adjusting the engine actuators. Before ECUs, air-fuel mixture, ignition timing, and idle speed were mechanically set and dynamically controlled by mechanical and pneumatic means. **(5M)** If the ECU has control over the fuel lines, then it is referred to as an Electronic Engine Management System(EEMS).The fuel injection system has the major role to control the engine's fuel supply. The whole mechanism of the EEMS is controlled by a stack of sensors and actuators.  Figure- Engine management system **(5M)** **Engine management system** • Technology Outline the Engine Management System (EMS) is responsible for controlling the amount of fuel being injected and for adjusting the ignition timing. • Electronic Fuel Injection System. • Air Induction System/Control.

	6. Fuel Delivery System/Control. 7. Electronic Control System. **8.** The Air Induction System.	**(5M)**