Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more importance. *(Not applicable for subject English and Communication Skills).*
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgment on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

1. A) Attempt **any SIX** of the following :	12
a) What is meant by scavenging ?	
Answer: **Scavenging:** *(Note: Suitable credit shall be given if only diagram is drawn)* Scavenging is process of removing the exhaust gases (combustible products) from the cylinder with help of incoming fresh charge in two stroke engine. During the downward movement of the piston the mixture in the crankcase is compressed and pushed into the cylinder through the transfer port, which pushes out the exhaust gases through the exhaust port at the same time filling the cylinder with new charge, is called cross- flow scavenging.  Figure: Scavenging	2
b) Give two applications of I.C engine.	2
Answer: *(Any two)* **Applications of I.C engine** 1) In Automotive – i) Two stroke engine – Mopeds, Scooters. ii) Four stroke engine – Light vehicles, Heavy vehicles. 2) Marine Application – Ships, Boat 3) Locomotive s – Railway 4) Stationery engines – For lifting water, Generator, Material handling system	2

c) State functions of – i) piston rings **ii)** Fly wheel	2
Answer: **i) Function of Piston rings:** *(Any one function 01 mark)* 1. To provide a pressure seal to prevent blow-by of burnt gases. 2. To form the main path for conduction of heat from the piston crown to the cylinder walls. 3. To control the flow of oil to the skirt and rings themselves in adequate quantity while preventing an excessive amount reaching the combustion chamber with consequent waste and carbonization. **ii) Functions of Flywheel:** *(Any one function 01 mark)* 1. Flywheel absorbs energy during power stroke and supplies it during remaining strokes. 2. Flywheel keeps the crankshaft rotating at the uniform speed throughout in spite of uneven power impulses of engine cylinders. 3. Flywheel carries the drive from the starting motors to crankshaft while the starting the engine.	1 1
d) What is air-fuel ratio? Define chemically correct A/F ratio.	2
Answer: **Air Fuel Ratio:** Air–fuel ratio (AFR) is the ratio of mass of air to mass of fuel. $AFR = \frac{mair}{mfuel}$ **Chemically correct A/F ratio**:- It is a ratio which has the correct amount of air and fuel to produce a chemically complete combustion event. For gasoline engines, the stoichiometric, A/F ratio is 14.7:1, which means 14.7 parts of air to one part of fuel.	1 1
e) What is firing order? State firing order for four cylinder engine.	2
Answer: **Firing order:** The sequence in which the power impulses occur in an engine is called the firing order. *Firing order for 4 cylinder engine.(Any one)* 1-3-4-2 **OR** 1-2-4-3 **OR** 1-4-3-2	1 1
f) Why additives are used in coolant? Give one example of coolant additive.	2
Answer: **Additives are used in coolant**: In cold climate, there is always a danger that water may get frozen. The volume of water when converted in ice increases, this may results in damage of entire system. This may result in bursting of radiator core and cylinder jackets. So to avoid freezing of the coolant additives are used. **Examples of additives**: *(Any one)* 1. Wood alcohol (Methyl alcohol) 2. Denatured alcohol (ethyl alcohol) 3. Glycerin. 4. Ethylene glycol 5. Propylene glycol 6. Mixture of alcohol and glycerin.	1 1

g) State the purpose of thermostat valve. — 2

Answer:

The purpose of thermostat valve:

1. To regulate the circulation of water in cooling system and to maintain the normal working temperature of the engine parts during different operating conditions.
2. To keep a rigid control over the cooling. It helps the engine to reach the operating temperature. as soon as possible after starting the engine — 2

h) Define :
i) Brake power
ii) Brake Thermal efficiency — 2

Answer:

i) Brake Power: The brake power (B.P.) is the power obtained at the engine flywheel is measured with the help of dynamometer , it is measured in kW — 1

$$B.P. = \frac{2\Pi NT}{60000} \text{ kW}$$

Where, N=Engine speed in R.P.M.
T=Torque in Newton meters (obtained from dynamometers test)

ii) Brake thermal efficiency: It is the ratio of energy in the brake power to the input fuel energy i.e. — 1

$$\text{Brake thermal efficiency} = \frac{\text{Brake power}}{\text{Mass of fuel x C.V.}} \times 100$$

i) State functions of exhaust manifold. — 2

Answer: **Functions of exhaust manifold:**

1) The function of an exhaust manifold is to expel the exhaust gases from the combustion chamber of each cylinder out to the atmosphere through the exhaust pipe after combustion stroke is completed. — 2
2) To keep back pressure minimum.

1. B) Attempt any TWO of the following : — 08

a) Compare 4-stroke and2- stroke engine (four points). — 4

Answer: **Comparison of 4-stroke and 2-stroke engine** *(Any four points)* — 4

Sr.	Four Stroke Engine	Two Stroke Engine
1	One **working stroke** for **every two revolutions** of the crankshaft.	One **working stroke** for **each revolutions** of the crankshaft.
2	Turning moment on the crankshaft is not even due to one working stroke for every two revolutions of the crankshaft. Hence **heavy flywheel** is required and engine runs unbalanced	Turning moment on the crankshaft is more even due to working stroke for each revolution of the crankshaft, hence **lighter flywheel** is required and engine runs balanced.
3	Engine is heavy.	Engine is light.
4	Thermodynamic cycle is completed in 4 strokes of piston or in two revolutions of crankshaft	Thermodynamic cycle is completed in 2 strokes of piston or in one revolutions of crankshaft
5	Volumetric efficiency is more.	Volumetric efficiency is less.

	6	Thermal efficiency is more.	Thermal efficiency is less.
	7	Engine design is complicated.	Engine design is simple.
	8	Less mechanical efficiency due to more friction on many parts.	More mechanical efficiency due to less friction on few parts.
	9	More output due to full fresh charge intake and full burnt gases exhaust.	Less output due to mixing of fresh charge with burnt gases.
	10	Engine runs cooler.	Engine runs hotter.
	11	Engine requires more space.	Engine requires less space.

b) With neat sketch describe working principle of four stroke petrol engine. 04

Answer: **Working of four stroke petrol engine:** 2

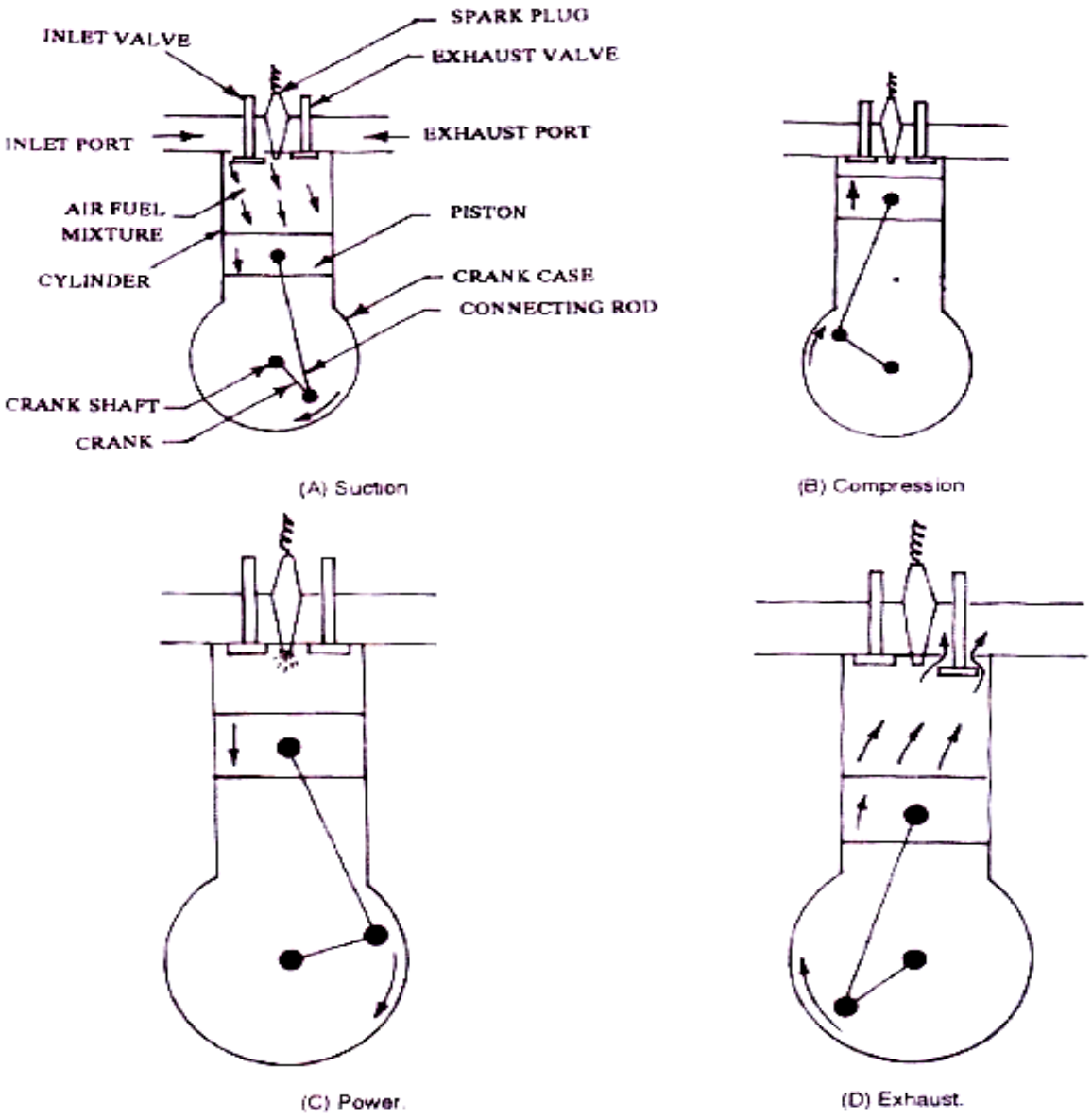
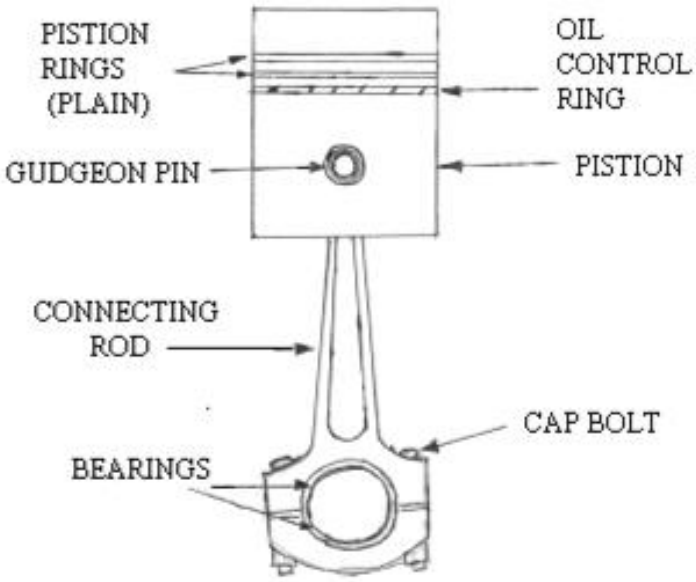
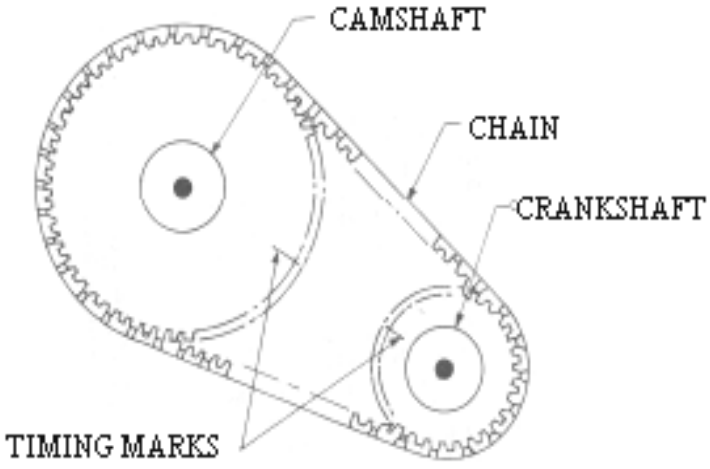
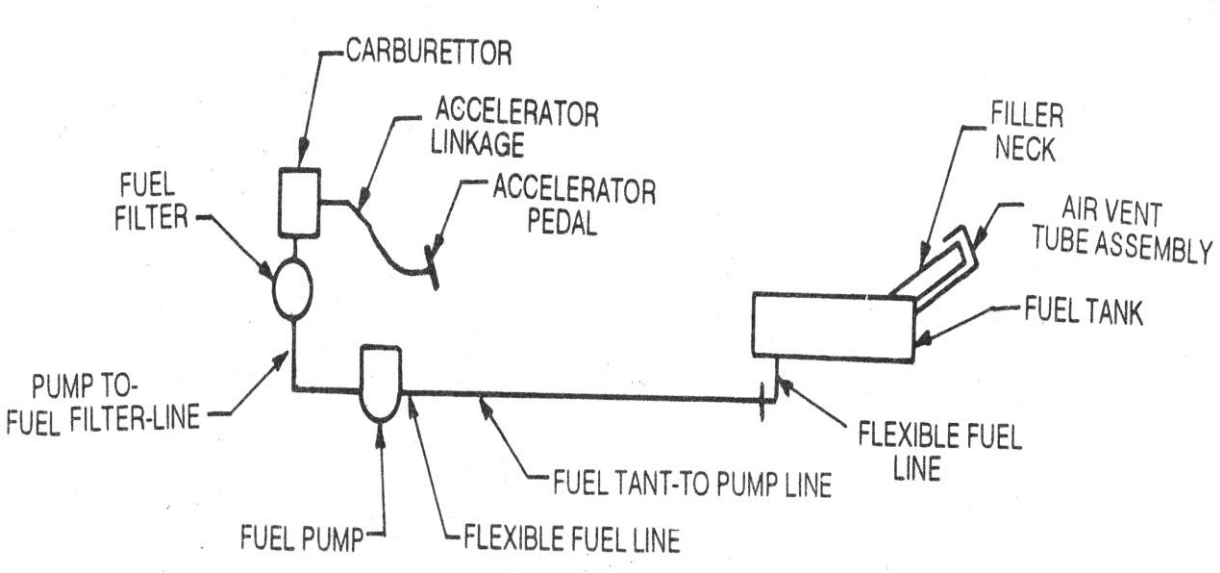
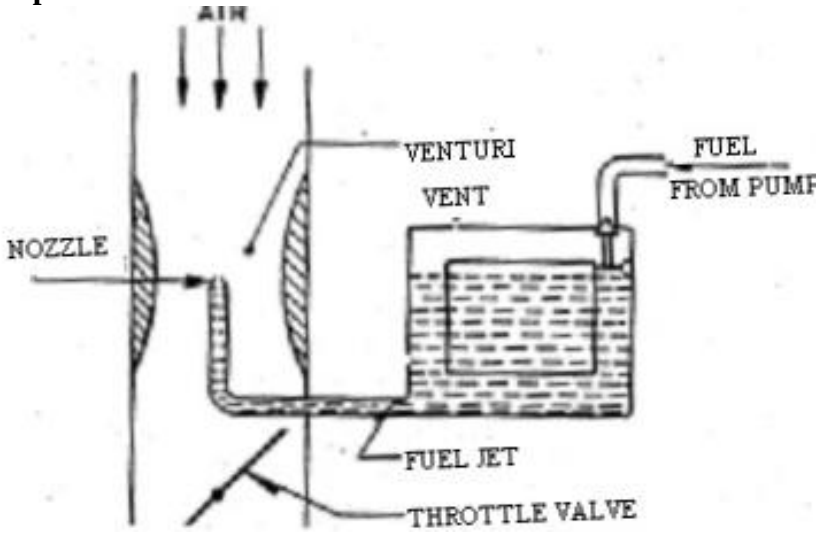


Figure: Working of 4-Stroke SI engine.

1. Suction stroke: During this stroke, inlet valve is open and exhaust valve is closed. The piston moves from TDC to BDC and crank shaft rotates through 180˚. The downward movement of the piston sucks air-fuel mixture in the cylinder from the carburetor through the open inlet valve. **2. Compression Stroke:** During compression stroke , the piston moves upward (from BDC to TDC) , thus compressing the charge. Both the inlet and exhaust valves remain closed during the compression stroke. **3. Power stroke or Working stroke:** At the end of the compression stroke the charge (air-fuel mixture) is ignited with the help of a spark plug located on the cylinder head. The high pressure of the burnt gases forces the piston towards BDC. Both the valves are in closed position. Of the four strokes only during this stroke power is produced. **4. Exhaust Stroke:** At the end of power stroke the exhaust valve opens and the inlet valve remains closed.. The piston move from BDC to TDC position which pushes the burnt gases outside the combustion chamber. Crankshaft rotates by two complete revolutions through 720˚.	2
c) Give four specifications of an engine of heavy motor vehicle.	04
Answer: *(Note: Credit should be given to any other suitable example)* Specifications of Engine for Ashok Leyland Comet **Manufacturer:** Ashok Leyland Limited, India. **Type :** Overhead valve, vertical diesel engine, 6 cylinder in line. **Bore :** 103.38 mm **Stroke :** 120.7 mm **Cubic capacity:** 6079 cc **Compression Ratio:** 16:1 **Brake Power:** 82.1 kW at 2400 rpm **Torque:** 369 Nm at 1600 rpm	4
2. Attempt any FOUR of the following :	16
a) Draw a neat sketch of piston and connecting rod assembly and label the parts.	4
Answer: *(Note: Proportionate Sketch -2 mark, correct labeling- 2marks)*  Figure: Assembly of piston and connecting rod.	4

b) State material and manufacturing method for following Engine components: i) Cylinder head ii) Piston iii) connecting rod iv) crankshaft	04
Answer: *(1/2 mark for any one material, 1/2 mark for manufacturing method)* i) **Cylinder Head:** Material: Gray cast iron, Aluminium alloy Manufacturing Method: Casting, forming. ii) **Piston:** Material: Aluminium alloy, Cast iron, Manufacturing Method: Casting or Forging iii) **Connecting rod:** Material: Forged steel, Aluminium alloy Manufacturing Method: Forging iv) **Crankshaft:-** Material: Alloy steel, SG iron. Manufacturing Method: Forging	4
c) Explain how camshaft speed is related to crankshaft speed.	04
Answer: **Relation between camshaft speed and crankshaft speed:**  Figure: Timing Chain Camshaft is driven by the crankshaft either by a pair of meshing gears (timing gears) or by means of a pair of timing sprocket connected by a chain. The cam shaft gear or sprocket has twice as many teeth as the gear or the sprocket on the crankshaft. This gives 1:2 gear ratio, the camshaft turns at half the speed of the crankshaft. Thus every two revolutions of the camshaft produce one revolution of the camshaft and one opening and closing of each valve in the four cylinder engine. The gear and sprocket maintain a definite time relationship between the camshaft and crankshaft to ensure opening the valves exactly at the correct time in relation to piston position.	1 3

d) Classify I.C. engine on the basis of : i) Operating cycle ii) type of fuel used iii) method of ignition iv) Arrangement of cylinders	04
Answer: **The I.C. Engines are classified as follows:** **i) Operating Cycle:-** a) Otto Cycle engine b) Diesel cycle engine c) Dual combustion cycle engine or semi-diesel cycle engine. **ii) Type of Fuel used :-** a) Petrol engine (or Gasoline engine) b) Diesel engine c) Gas engine **iii) Method of ignition:-** a) Spark ignition (S.I.) engine b) Compression ignition (C.I.) engine **iv) Arrangement of cylinders:-** a)Vertical engine b) Horizontal engine c) Radial engine d) V-engine e) Opposed cylinder engine	1 1 1 1
e) Draw a layout of pump feed fuel supply system for petrol engine and describe it.	04
Answer: **Layout of pump feed fuel supply system for petrol engine:**  The pump feed system is shown in the figure above. In this system, a steel pipe carries the fuel to the fuel pump which pumps it into the float chamber of the carburetor through a flexible pipe. If the fuel pump is mechanical, it has to be driven from the engine camshaft and hence placed on the engine itself. However electrically operated pump can be placed anywhere. It is mostly located at the rear in the fuel tank reducing the tendency of forming vapour lock. The system provides the fuel requirement at various engine speeds efficiently.	2 2

f) Describe with sketch working of simple carburattor.	04
Answer: **Working of simple carburettor:**  Figure: Simple Carburettor. During suction stroke air is drawn through the venturi (venturi is a tube of decreasing cross section area). When air passing through the venturi increases velocity of air and decreases pressure of air. The pressure in float chamber is atmospheric pressure and the same is maintained with the help of vent. This pressure differential called carburetor depression. So the fuel from the float chamber is feed to a discharge jet. This jet or nozzle delivers a spray of gasoline into the airstream which is passing through venturi same time it mixes with the air. This air fuel mixture enters into the cylinder through the intake manifold. The rate of fuel flow into the venturi tube depends upon the engine speed and load of engine	2 2
3. Attempt any FOUR of the following:	16
a) Describe construction and working of overhead valve operating mechanism.	4
Answer: **Overhead Valve:** Valves in the head are operated either by tappet rods extending up the side of the cylinders, or by means of an overhead camshaft. **Construction:** Figure shows overhead valve mechanism to operate the valve when it is in the cylinder head (in I and F head design). This type of mechanism consists of camshaft, valve lifter, push rod, rocker arm and valve. The camshaft and push rod are located in cylinder block while the rocker arm is located in the cylinder head. **Working:** As the cam rotates 180^0, it lifts the valve- tappet or the lifter which actuates the push rod. The push rod rotates the rocker arm about a shaft or a ball joint in some designs. This causes one end of the arm to push down the valve to open it. The valve is opened and the valve port is connected with the combustion chamber. As the cam rotates further 180^0 the valve spring closes the valve and the push rod is pushed back to its original position.	1 1

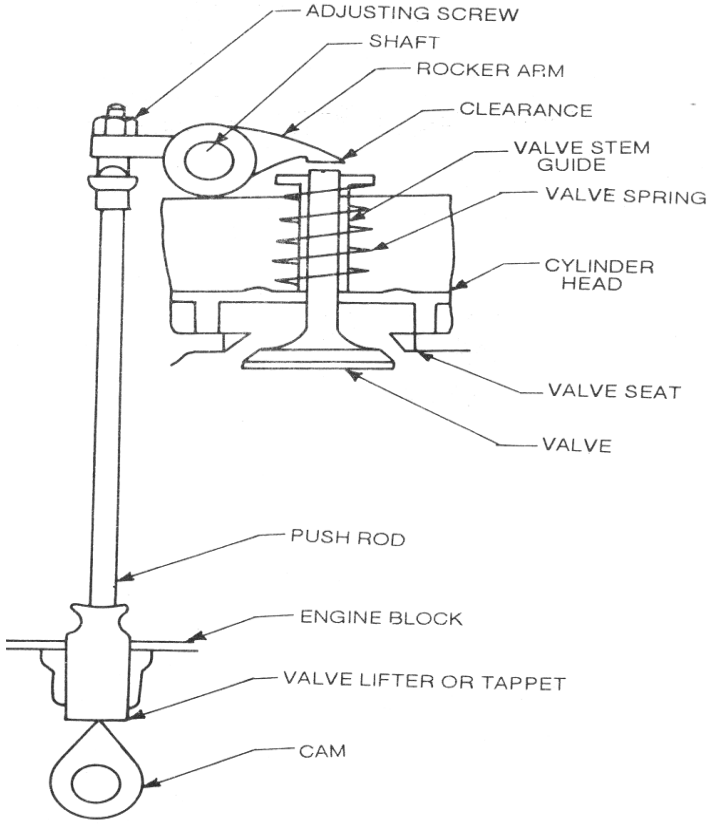


Figure: Overhead valve operating mechanism — 2

b) Distinguish between dry and wet liners. — 04

Answer: *(Any four one mark each)* — 4

Dry liners	Wet liners
1) Dry liner is **not in direct contact** of cooling water hence it is known as "dry liner".	1) Wet liners is in **direct contact** with cooling water on the outside and hence is Known as "wet liner".
2)It is **difficult to replaced**	2)It is **easy to replaced**
3) **No leak proof joint** is provided in the case of dry liner.	3)A leak proof joint between the cylinder casting and the liner has to be provided
4)In dry liners the **casting of cylinder block is complicated**	4)In wet liners the **casting of cylinder block is very simplified**
5) A cylinder block with dry liners is generally more **robust**.	5)A cylinder block with wet liners is **less robust** as compare to dry liner
6)For perfect contact between the liner and the block casting in case of dry liner, very **accurate machining of block and outer liner surface** is required,	6) Where as there is **no such necessity** in case of wet liner.
7) A dry liner **cannot be finished accurately** before fitting because of the shrinkage stresses produced.	7) A wet liner **can be finished accurately** before fitting.

c) Draw and describe port timing diagram for two stroke S.I. engine.	04

Answer:

The combustion process for the two stroke engine goes through various processes. Following are the steps for combustion:

1) At 60 before hitting BDC the piston uncovers the exhaust port (EO), and the exhaust leaves the cylinder chamber while attaining atmospheric pressure. This is the end of the power stroke.

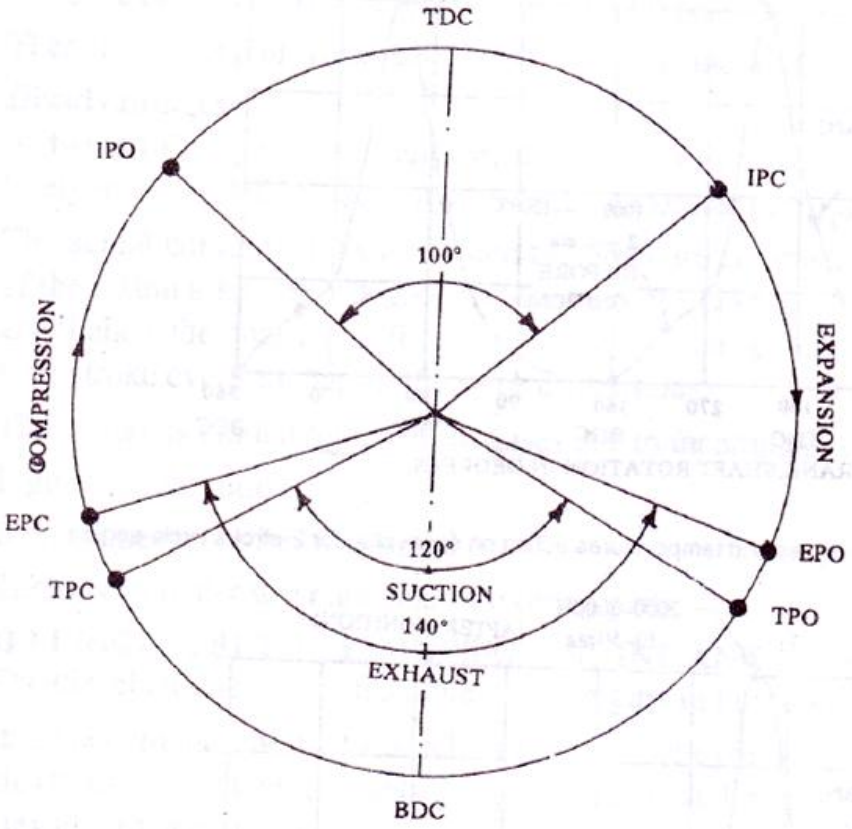
2) At 5-10 later the inlet port (IO) will open and the charge that was compressed by the crankcase will flow into the main chamber and mix with some exhaust residual. Some charge will leave the exhaust port. The deflector will aid in a way that it will divert the cross flow of charge from the inlet port into the exhaust port. 2

3) At about 55 after BDC, with the piston moving up, the inlet port will now close (IC). There will be some back flow of charge from the inlet port into the crankcase.

4) At 60 after BDC the exhaust port will close (EC) and the piston will now compress the charge through its upward movement.

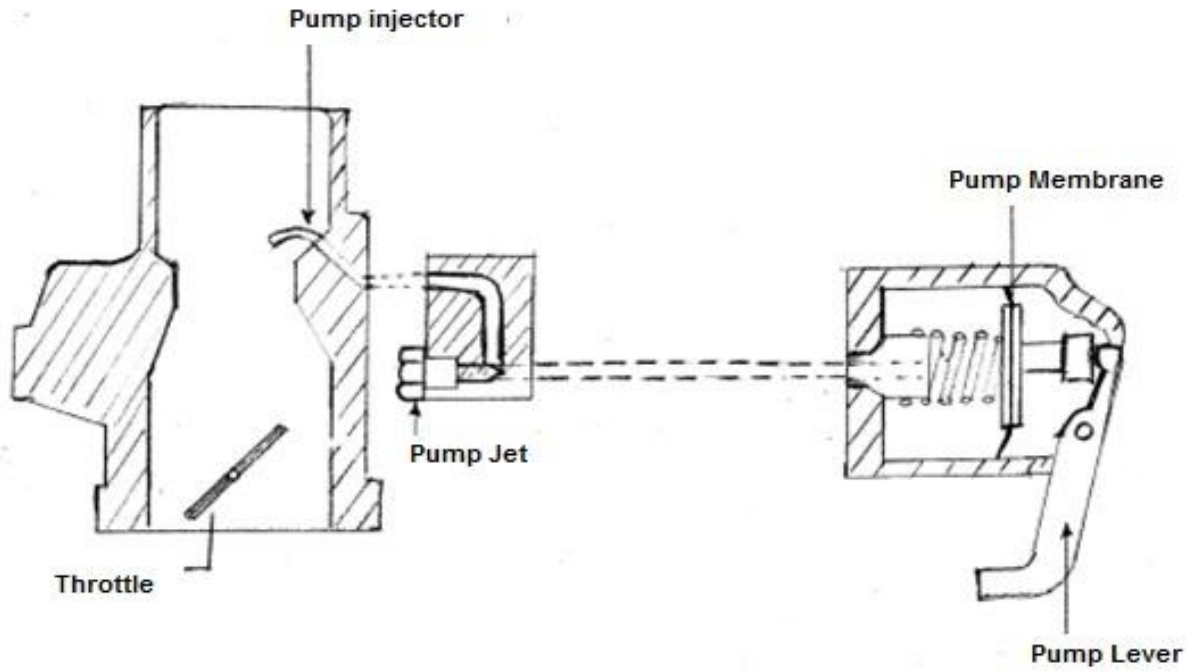
5) At 60 before TDC the crankcase port will open (CO) and allow charge to flow into the crankcase. The charge will flow into the crankcase since the pressure in the crankcase is below the ambient pressure.

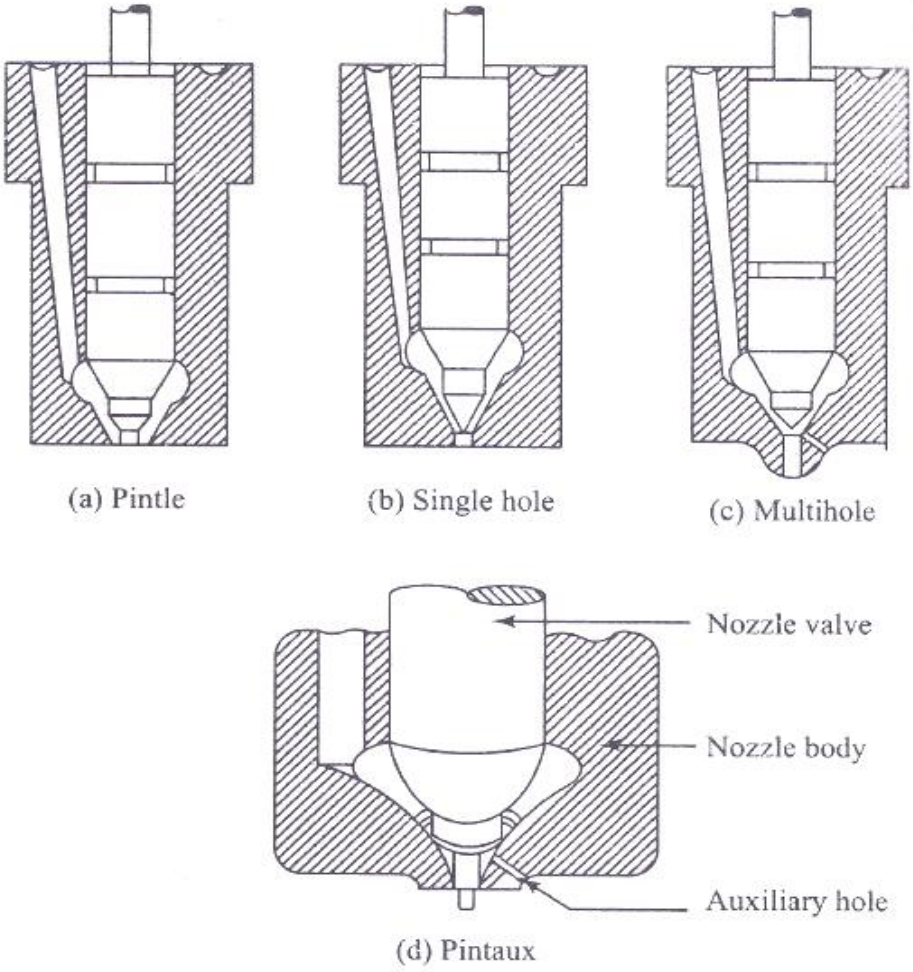
6) When the piston is within 10-40 before TDC the charge will be compressed enough to be at a high temperature. Then combustion will follow with flame initiation from the spark plug. In this process work is done by the engine on the air and fuel mixture. The power stroke starts when the piston hits TDC and continuous until the exhaust port opens in step (1).



IPO – Inlet port opens
IPC – Inlet port closes
EPO – Exhaust port opens
EPC – Exhaust port closes
TPO – Transfer port opens
TPC – Transfer port closes. 2

Figure: Port timing diagram.

d) Describe acceleration pump circuit used in solex carburettor	04
Answer: Acceleration pump circuit: When an engine at a particular speed is given a sudden acceleration, a flat spot is produced in the carburetor. In this case, the engine generally stalls and then after some time it catches up and accelerates. This happens when the engine is running bellow 50 kmph. To ensure maximum torque an acceleration pump is attached as shown in the figure. A lean mixture is resulted due to faster increase of air flow than the supply of petrol through the main jet when the throttle is rapidly opened. During the short period of opening the throttle , a pump gives an extra injection of petrol through it to increase the mixture strength. The pump is either engaged by change in vacuum or through a mechanical link with throttle.  Figure: Acceleration Circuit for Solex Carburettor.	2 2
e) State four requirements of fuel injection system.	04
Answer: Requirements of fuel injection system *(Any two)* 1) **Metering** – The fuel injection system must measure the fuel supplied to the engine very accurately as fuel requirements vary from low to high engine speeds. 2) **Time**- Fuel injection system must supply the fuel at the proper time according to engine requirement 3) **Pressure**- The fuel injection system must pressurize the fuel to open the injection nozzle to inject fuel into the combustion chamber. 4) **Atomize**- The fuel must be atomized when it is supplied to the combustion chamber since atomized fuel will burn easily. 5) **Distribution**- In case of multi cylinder engine the distribution of metered fuel should be same to all cylinders. 6) **Control, start and stop injection-** The injection fuel must start and end quickly.	4

f) Sketch types of fuel injector nozzles.	04
Answer: **Types of fuel injector nozzles:** *(Any two-each carry 2 marks)*  	4
4. A) Attempt any FOUR of the following.	12
a) Sketch ' Battery ignition system' and describe its working..	4
Answer: **Battery ignition system':** Figure shows line diagram of battery ignition system for a 4-cylinder petrol engine. It mainly consists of a 6 or 12 volt battery, ammeter, ignition switch, auto-transformer (step up transformer), contact breaker, capacitor, distributor rotor, distributor contact points, spark plugs, etc. **Working** : When the ignition switch is closed and engine is cranked, as soon as the contact breaker closes, a low voltage current will flow through the primary winding. It is also to be noted that the contact breaker cam opens and closes the circuit 4-times (for 4 cylinders) in one revolution. When the contact breaker opens the contact, the magnetic field begins to collapse. Because of this collapsing magnetic field, current will be induced in the secondary winding and because of more turns of secondary, voltage goes up to 28000 - 30000 volts. This high voltage current is brought to centre of the distributor rotor. Distributor rotor rotates and supplies this high voltage current to proper spark plug depending upon the engine firing order. When the high voltage current jumps the spark plug gap, it produces the spark and the charge is ignited-combustion starts-products of combustion expand and produce power.	2

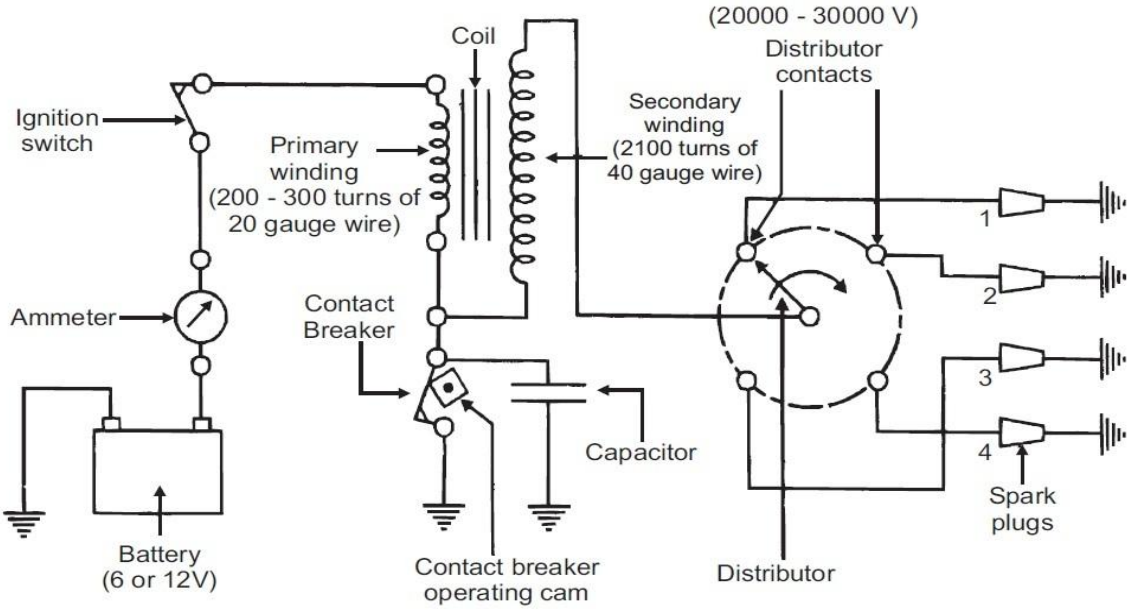


Figure : Schematic Diagram of Coil/Battery Ignition System — 2

b) List components of exhaust system and describe it's working. — 04

Answer:

Components of exhaust system: — 2

i) Exhaust manifold.
ii) Exhaust pipe.
iii) Muffler.
iv) Tail or outlet pipe.

Working:

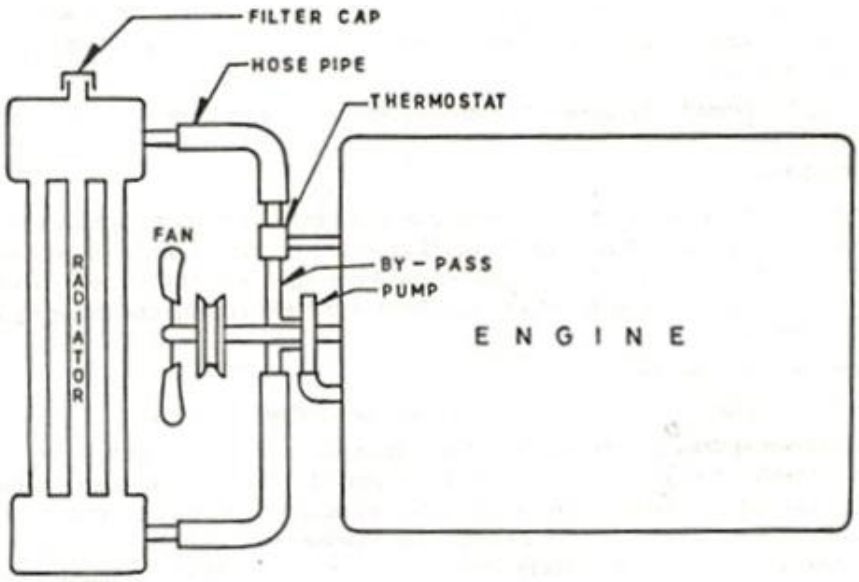
The exhaust system collects the exhaust gases from the cylinder and conducts them to the rear of the vehicle, where they are discharged to atmosphere. It consist of exhaust manifold, muffler and a tail or outlet pipe. The exhaust manifold is a tube for carrying the exhaust gases away from the engine cylinder. It collects the gases from the exhaust ports of the various cylinders and conducts them to central exhaust passage. A muffler is connected between the exhaust manifold and tail outlet. The function of the muffler is to reduce the pressure of the exhaust gases sufficiently to permit them to be discharged to the atmosphere silently. The tail or outlet pipe helps to direct the gases to escape to the atmosphere at the rear of the vehicle. — 2

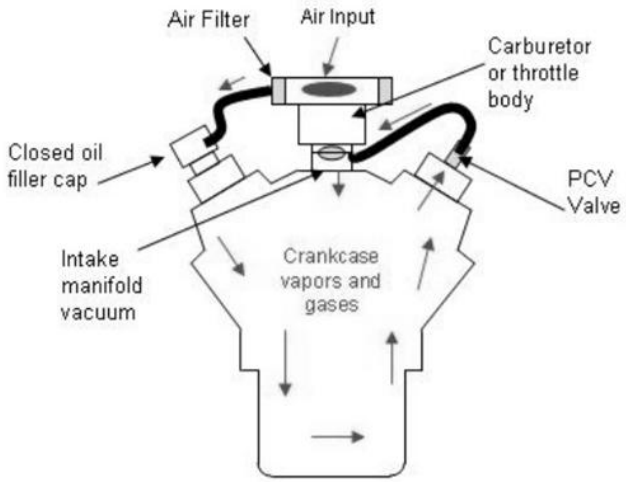
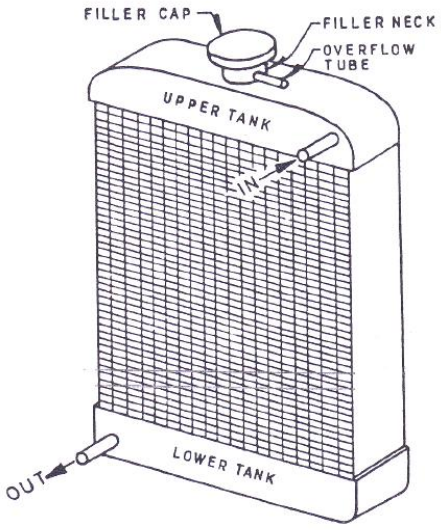
c) Explain the need of cooling system. Write two limitations of cooling system. — 04

Answer: **Need of cooling system:**

The cooling system is needed to keep the engine from not getting so hot as to cause problems and yet to permit it to run hot enough to ensure maximum efficiency of the engine.

During the process of converting the thermal energy to mechanical energy, high temperatures are produced in the cylinders because of combustion process. A large portion of this heat is transferred to the cylinder head and walls, piston and valves. Unless this excess heat is carried away and these parts are adequately cooled, the engine will be damaged. So the adequate cooling system must be provided to prevent the damage of mechanical parts as well as to obtain maximum performance of the engine. — 2

Limitations of cooling system: *(Any four)* 1. This is a dependent system in which water circulation in the jackets is to be ensured. 2. Power absorbed by the water pump is more and it affects the output of the engine. 3. Cost of the system is considerably high. 4. System requires considerable maintenance. 5. The failure of the system results in serious damage to the engine.	2
d) Sketch the layout of liquid cooling system and write function of four major components.	04
Answer: **Layout of liquid cooling system:** *(Sketch- 2 marks, function of each component -1/2 mark)*  **Figure: Liquid cooling system** **Parts of cooling system**: *(Any Four)* 1) **Radiator :-** The function of radiator is to absorb the heat and cool the hot water coming out of the engine. 2) **Thermostat**:- When the engine is started form cold, thermostat valve prevents the flow of water from engine to radiator so that the engine readily reaches to its normal working temperature. 3) **Water pump**:- The water pump sucks the water from the bottom tank of the radiator and circulates it to the header tank with pressure. Thus it helps to increase the cooling efficiency. 4) **Cooling Fan**:- To blow the atmospheric air over the radiator to produce desired cooling. 5) **Pressure Cap**:- It is used to maintain high pressure in the system.	2 2
e) State four essential properties of lubricating oil.	04
Answer: Essential properties of lubricating oil: *(Any four)* 1) Viscosity 2) Flash Point 3) Resistance to corrosion 4) Physical stability 5) Pour point 6) Adhesiveness 7) Chemical Stability 8) Cleanliness 9) Resistance agents extreme pressure	4

f) Explain what is meant by positive crankcase ventilation.	04
Answer: **Positive Crankcase Ventilation System** Since water vapour in exhaust and blow by gases enter crankcase due to various reasons there is every chance that these contaminants will cause sludge and corrode metal parts. Therefore a mean of removing these contaminants before they can act on the oil is essential. In Positive Crankcase Ventilation system the un-burnt gases are re-circulated into the combustion chamber and burnt with the fresh charge. Another reason of using crankcase ventilation is to relieve any pressure build-up in the crankcase which may cause crankshaft seal leakage	2
 Figure: PCV system.	1
The figure shows the intake manifold return PCV system. It has a tube leading from the crankcase or else the rocker arm cover through a flow control valve into the intake manifold usually just below the carburetor. To provide proper ventilation of the interior of the engine, fresh air is usually drawn through a rocker arm cover opposite that containing the PCV system	1
5. Attempt any FOUR of the following :	16
a) Draw labeled sketch of radiator and describe its construction.	04
Answer: **Construction of Radiator:**  Figure:- Radiator	2

A radiator consists of an upper (or header) tank core and the lower (or collector) tank. Besides, an overflow pipe in the header tank and drain pipe in the lower tank are provided. Hot coolant from the engine enters the radiator at the top and is cooled by the cross – flow of air, while flowing down the radiator. The coolant collects in the collector tank from where it is pumped to the engine for cooling.

Tubular type cores are most commonly used to increase the area for heat transfer from coolant to the cooling air. Core tube as well as the fins are made from thinnest possible material. Tubes are made from 0.1 mm to 0.3 mm sheet where as fins are made from about 0.1 mm thick material. The materials used for radiator should be resistance to corrosion possess higher thermal conductivity and from easily apart from having adequate strength. Copper and yellow brass is the widely used materials for radiators. Aluminum is also used from weight and cost consideration some late model radiators have plastic tanks with aluminum core. 2

b) Draw layout of pressure lubrication system and describe its working . 04

Answer: **Working:-**

In the pressure lubrication system oil pump takes the oil from the wet sump through strainer and delivers it through a filter to the main oil gallery at a pressure of 200 to 400 kPa. The oil pressure is controlled by means of a pressure-relief valve situated in the filter unit or the pump housing. From the main gallery the oil goes through the drilled passages to main bearings from where some of the oil after lubricating the main bearings falls back to the sump, some is splashed to lubricate cylinder walls while the rest goes through a hole to the crank pin from where a hole in the lubricating connecting rod web leads it to the gudgeon pin . 2

After lubricating gudgeon pin bearings the oil falls back or effects ring lubrication. The oil that falls on cylinder walls drains back into the oil pan and is recalculated through lubricating system.

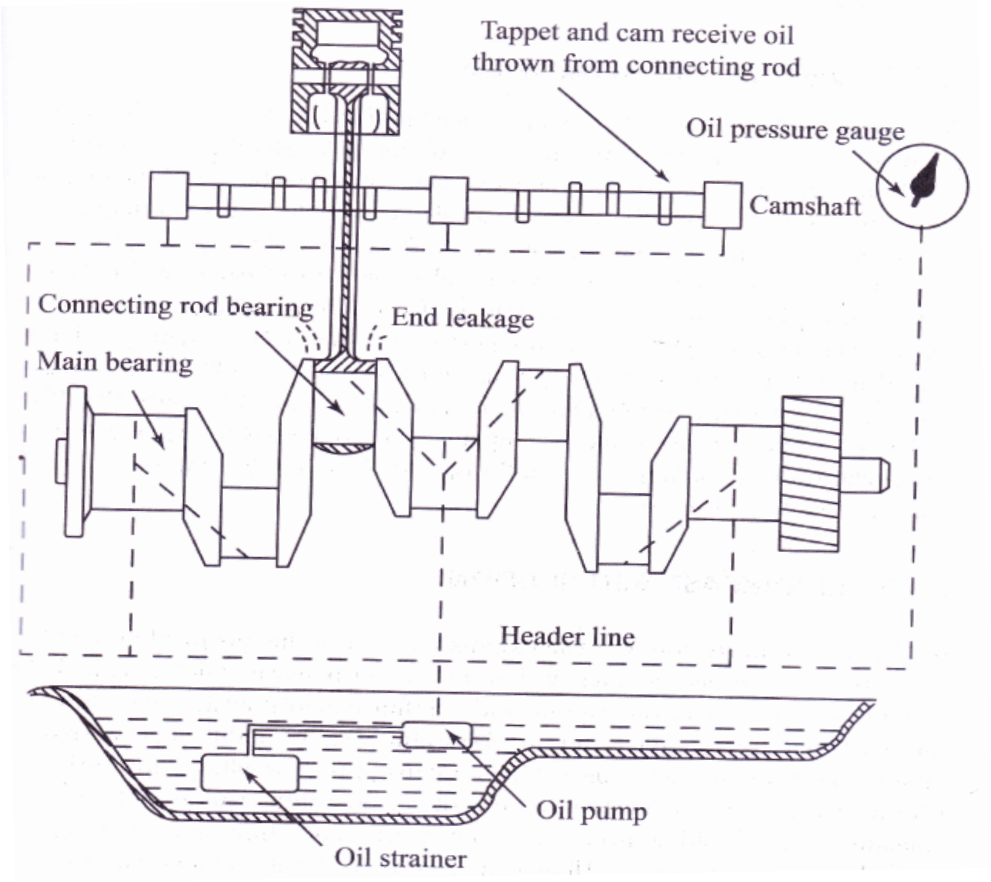


Figure:- Pressure Lubrication System 2

c)State functions of – i) Oil pump ii) oil filter iii) Pressure regulator iv) oil pressure gauge.	04
Answer: **Functions of**: *(one mark each)* i) **Oil pump**:- To supply oil under pressure to the various engines parts ii) **Oil filter**: - To remove the impurities from oil & consequently to avoid permanent damage to any or more running part of engine. iii) **Pressure regulator**: To maintain the predefined pressure value inside the lubricating system. iv) **Oil pressure gauge**:- To indicate the oil pressure in the lubricating system and bring it to notice that whether pressure falls below the predefined value.	1 1 1 1
d) Write I.C. Engine nomenclature.	04
Answer: **I.C. Engine nomenclature.** *(any four)* 1.**Top dead centre** (T.D.C.):- The piston is in its top most position i.e. the position closest to the cylinder head 2.**Bottom dead centre** (B.D.C.):-The position position farthest from the cylinder head 3. **Bore** : Diameter of the engine cylinder is referred to as the bore. 4. **Stroke**: Distance travelled by the piston moving from T.D.C. to the B.D.C. is called stroke. 5. **Clearance volume**: The volume of cylinder (including the combustion chamber) above the piston when it is in the T.D.C. position. 6. **Piston displacement :**This is the volume swept by the piston in moving from T.D.C. to B.D.C. this is also called swept volume If 'd' is the cylinder bore and 'S' the stroke the piston displacement Vs is given by $V_s = \frac{\pi}{4} d^2 . S$ 7. **Engine capacity**: this is piston displacement or the swept volume of all the cylinders if 'n' is the numbers of cylinders and V_s is the piston displacement then engine displacement or engine capacity V_d is given by $V_d = n \times V_s$ 8. **Compression Ratio**: This indicates the extent to which the charge in the engine is compressed this is calculated as the ratio of the volume above the piston at B.D.C. to the volume above the piston at T.D.C. if r is the compression ratio then $r = \frac{V_s + V_c}{V_c}$ **OR**	4

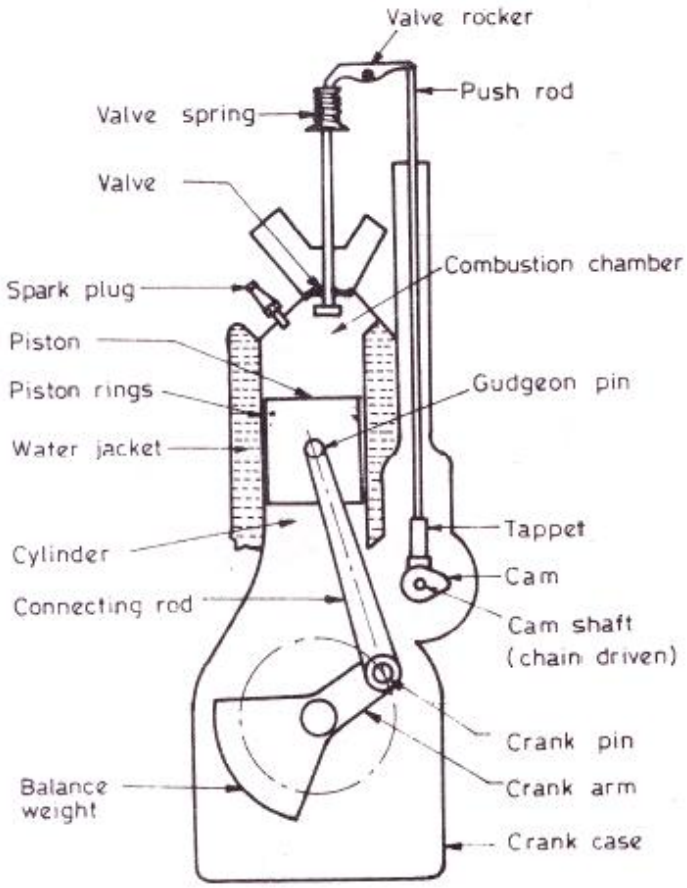


Figure: Engine Nomenclature

4

e) Describe working principle of eddy current dynamometer. 04

Answer: **Working principle of eddy current dynamometer**: *(Sketch - 1mark, Description-3 marks)*

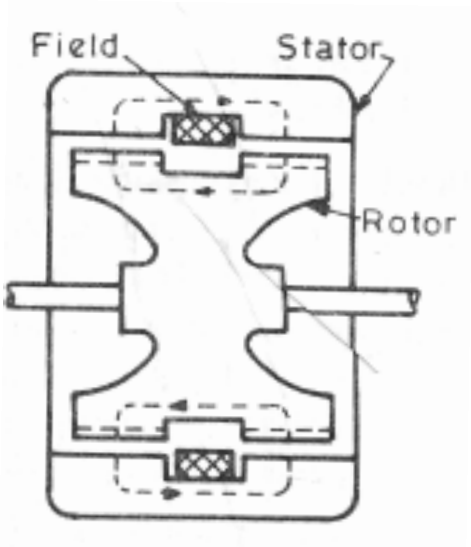


Figure: Working principle of Eddy current dynamometer
(Note: Credit should be given to suitable diagram)

2

The details of eddy current dynamometer are shown in figure. It consists of a stator on which are fitted a

number of electromagnets and a rotor disc made of copper or steel and coupled to the output shaft of the engine. When the rotor rotates eddy currents are produced in the stator due to magnetic flux set up by the passage of field current in the electromagnets. These eddy current oppose the motion, thus loading the engine. These current are dissipated in producing heat so that this type of dynamometer also requires some cooling arrangement. The torque is measured exactly as in other types of absorption dynamometer i.e. with the help of a movement arm. The load is controlled by regulating the current in the electromagnets.	2
f) Why actual valve timing diagram is different than theoretical valve timing diagram? explain.	04
Answer: **Actual valve timing diagram is different than theoretical valve timing diagram:** Valve timing is the regulation of the points in the cycle at which the valves are set to open and Close. As described in the ideal cycle inlet and exhaust valves open and close at dead centres, but in actual cycles they open or close before or after dead centres to achieve maximum volumetric efficiency and reduce the pumping losses as explained below. **(a) Mechanical factor.** The poppet valves of the reciprocating engines are opened and closed by cam mechanisms. The clearance between cam, tappet and valve must be slowly taken up and valve slowly lifted, at first, if noise and wear is to be avoided. For the same reasons the valve cannot be closed abruptly, else it will 'bounce' on its seat. (Also the cam contours should be so designed as to produce gradual and smooth changes in directional aceleration). Thus the valve opening and closing periods are spread over a considerable number of crankshaft degres. As a result, the opening of the valve must commence ahead of the time at which it is fully opened (i.e., before dead centres). The same reasoning applies for the closing time and the valves must close after the dead centres. **(b) Dynamic factor.** Besides mechanical factor of opening and closing of valves, the actual valve timing is set taking into consideration the dynamic effects of gas flow.	4
6. Attempt any TWO of the following:	16
a) What is meant by engine testing? Describe the method of calculate friction power using Morse test.	08
Answer: **Engine testing:** It is a process in which the engine is tested for various parameters for improved performance. The pupose of testing an IC engine is - 1. To determine the information which cannot be calculated by calculations. 2. To confirm validity the data used in design 3. To satisfy the customer regarding the performance of the engine. There are enormous parameters so it becomes difficult to account them while designing an engine. So it becomes necessary to conduct certain tests on the engine and determine the measures to be taken to improve the engines performance is called engine testing. **Morse test to determine the Frication Power:** In this method the BP of whole engine is first of all measured at a certain speed and load with the help of dynamometer. Then from total number of cylinders of the engine one of the cylinders is cut out by short circuiting the spark plug or by disconnecting the injector. The output is measured by keeping the speed constant. The difference in the outputs is measure of the indicated power of disconnecting cylinders. Thus for each cylinder the IP is obtained and then is added together to find the total IP of the engine. Where BP = Brake power IP = Indicated power FP = Frictional power	2 6

Let F.P. of cylinder 1,2,3,4 be F1, F2, F3, F4 respectively.
Then total FP of engine = F1+F2+F3+F4
Let IP of cylinder 1 2 3 and 4 be $I_{1,}$ I_2 I_3 & I_4 respectively.
The total IP of engine is given by,

$$= I_1 +, I_2 + I_3 + I_4$$

The total BP of engine when all cylinders are working

$$BP = \text{Total IP} - \text{Total FP}$$

$$B = (I_1 +, I_2 + I_3 + I_4) - (F1+F2+F3+F4) \text{----------1}$$

When cylinder 1 is cut off, the BP developed by the remaining three cylinders,

$$B_{1 =} (0 +, I_2 + I_3 + I_4) - (F1+F2+F3+F4) \text{----------2}$$

Subtracting (2) from (1) we get

$$B - B_1 = I_1$$

Therefor IP of cylinder 1

$$I_1 = B - B_1$$

Similarly ,

IP of cylinder 2, $I_2 = B - B_2$
IP of cylinder 3, $I_3 = B - B_3$
IP of cylinder 4, $I_4 = B - B_4$
Total IP of Engine= $I_1+I_2+I_{3+}I_4$

Friction Power = I.P – B.P

b) In a test a 2- stroke cylinder diesel engine, following observations were made: 08
Bore -75mm, Stroke -90mm, Engine speed =1200rpm, Mean effective pressure = 7.5bar, Mean brake Diameter = 1m, Neat Brake load= 500 N, Fuel consumption = 4.08kg/hr, Calorific value of diesel =42000 kJ/kg
Calculate –

i) Mechanical efficiency
ii) Brake thermal efficiency

Answer: Given data :

No of stroke = 2
No of cylinders, n =1
Bore = D = 75mm = 0.075m, Stroke = L= 90mm = 0.09m, Speed = N= 1200rpm .....Two stroke
IMEP = P = 7.5 bar = 7.5×10^5 N/m^2

$$\text{Fuel consumption} = m_f = 4.08\text{kg/hr} = \frac{4.08}{60\times60} = 0.00113 kg/\text{sec}$$

C.V. = 42000kJ/kg
Net Brake load = w = 500 N

$$\text{Radius of Drum} = R = \frac{d}{2} = 0.5\text{m}$$

(i) Mechanical efficiency

$$\text{B.P.} = \frac{2\pi N T}{60} \qquad 1$$

$$T = \text{Net brake load} \times \text{Radius of Drum}$$

$$= 500 \times 0.5 = 250\text{N.m}$$

$$\text{B.P.} = \frac{2\times3.14\times1200\times250}{60} = 31400\frac{\text{Nm}}{\text{Sec}} = 31400\frac{\text{J}}{\text{sec}} \qquad 1$$

$= 31.400$ KJ/sec 1

$$I.P = \frac{nPLAN}{60}$$

$$= \frac{1 \times 7.5 \times 10^5 \times 0.09 \times (\frac{\pi}{4} \times 0.075^2) \times 1200}{60}$$

$= 5964.117$ J/sec

$= 5.96$ kJ/sec 1

$$\eta_{mech} = \frac{B.P.}{I.P.} \times 100\% \quad 1$$

$$= \frac{31.4}{5.96} \text{ X } 100$$

$\eta_{mech} = 532.2\%$ 1

Mechanical efficiency = 532.2 %

ii) Brake thermal efficiency

$$\eta_{Bth} = \frac{B.P.}{m_f \times c.v.} \times 100\% \quad 1$$

$$= \frac{3.14}{0.00113 \times 42000} \times 100$$

$\eta_{Bth} = 66.16\%$ 1

Brake thermal efficiency = 66.16%

c) A trial is conducted on a 4 –stroke 4 cylinder petrol engine which develops a brake of 14.58 kW, following observations are noted – 08

i) Power required to motor the engine 5kW
ii) Cooling water supplied = 10 kg/ min
iii) Sp. Heat of water = 4.187kJ/kgK.
iv) Fuel consumption =2 kg/hr.
v) Temperature rise of cooling water =40^0 C
If calorific value of petrol is 45000 kJ/kg, draw heat balanced sheet for the test on kJ /min basis.

Answer: **Given Data:-**

Number of stoke - 4
Number of cylinder = n = 4
B.P. = 14.58 kW = 14.58kJ/sec= 14.58 X 60 kg/min
= 874.8 KJ/min
F.P = 5kW= 5kJ/sec = 5 X 60 kJ/min
= 300kJ/min

$\dot{m}_w = 10 kg/\min$

$Cp_w = 4.187$kJ/kgk

$\dot{m}_f = 2$kg/hr $= \frac{2}{60} = 0.0334 kg/\min$

$\Delta t_{water} = 40^0$C

C.V. = 45000kJ/kg

Solution:

$$\text{Input Heat} = \dot{m}_f \times \text{C.V}$$

$$= 0.0334 \times 45000 = 1500 \frac{\text{kJ}}{\text{min}}$$ 1

Percentages of input heat Converted in to. $\text{B.P.} = \frac{\text{B.P.}}{\text{Input Heat}} \times 100 = \frac{374.8}{1500} \times 100\,\%$ 1

$$= 58.32\%$$

$$\text{Cooling water heat} = \dot{m}_w \times cp_w \times \Delta T$$ 1

$$= 10 \times 4.187 \times 40 = 1674.8 \frac{\text{kJ}}{\text{min}}$$

Percentage of input heat goes to cooling water $= \frac{\text{cooling water Heat}}{\text{I/P Heat}} \times 100\%$

$$= \frac{1674.8}{1500} \times 100$$

$$= 111.65\%$$ 1

$$\text{I.P} = \text{F.P} + \text{I.P.}$$

$$= 14.58 + 5$$

$$= 19.58\text{Kw} = 19.58\ \text{kJ/Sec} = 19.58 \times 60\ \text{kj/min}$$

$$= 1174.8\text{kJ/min}$$ 1

Percentage of input heat converted I.P. $= \frac{\text{I.P}}{\text{Input Heat}} \times 100\,\%$

$$= \frac{1174.8}{1500} \times 100$$

$$= 78.32\%$$ 1

Heat balance sheet

Parameter	Value (KJ/min)	Percentage %
Input Heat	1500	100
Heat goes to B.P.	874.8	58.32
Heat goes to cooling water	1674.4	111.65
Heat goes to I.P.	1174.8	78.32

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