WINTER – 19 EXAMINATION

Subject Name: Auto. Engine **Model Answer** Subject Code: 22308

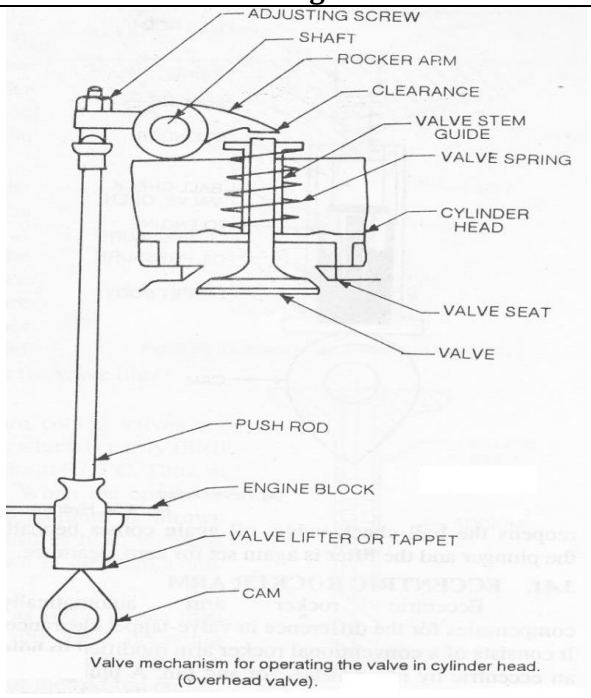
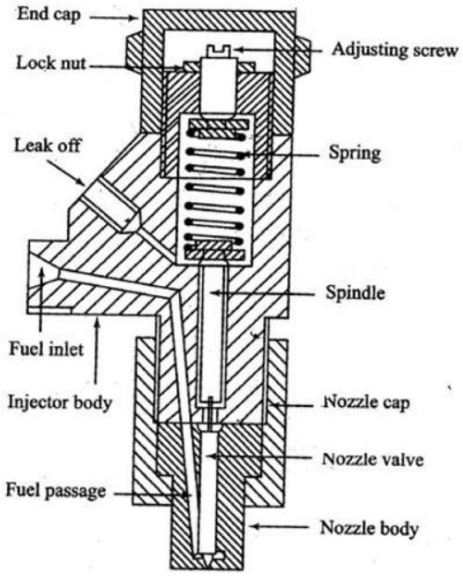
Important Instructions to examiners:

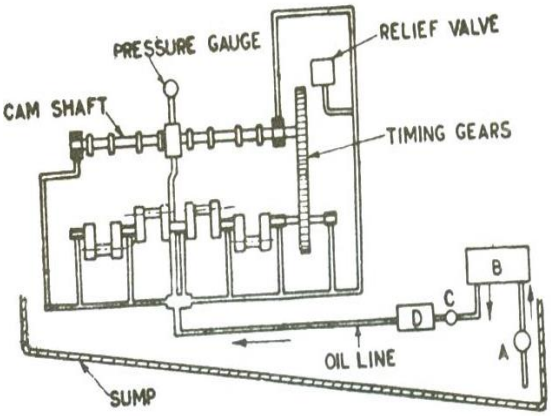
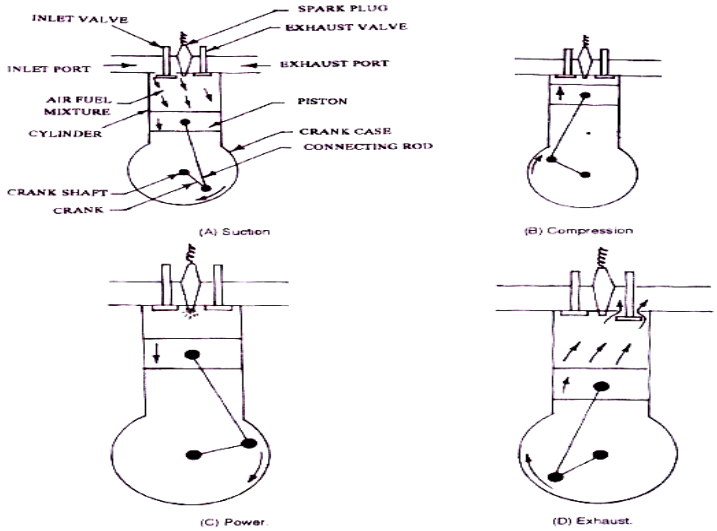
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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 judgement 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

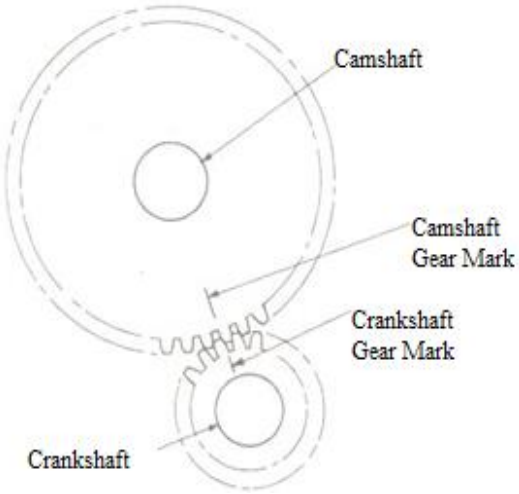
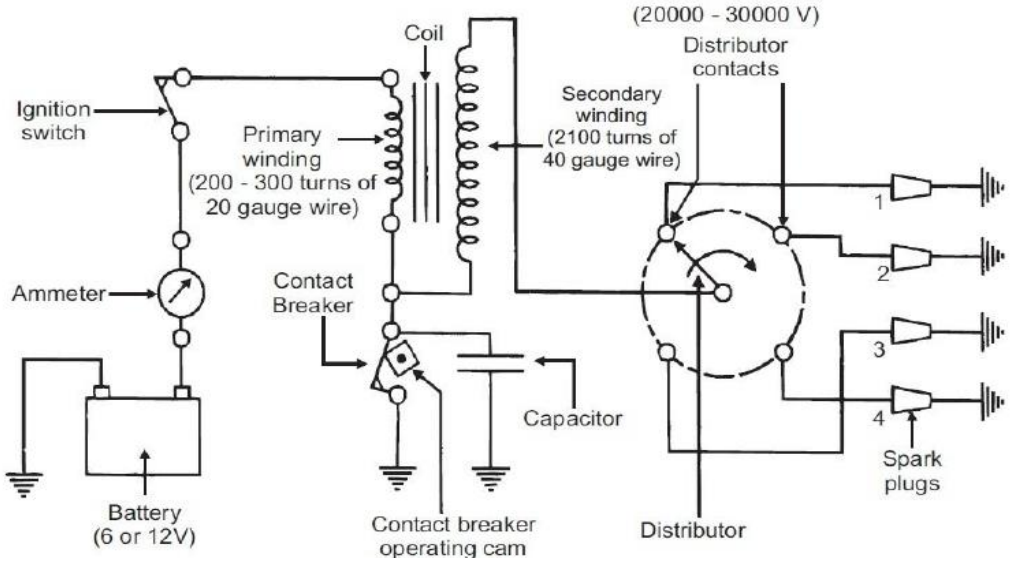
Q. N	SUB Q. N.	ANSWER	MARKING SCHEME
1		**Attempt any FIVE of the following.**	**10**
	a	**Define Clearance Volume and Swept Volume**	**02**
	Ans.	**Clearance Volume:** Clearance volume is a volume between the cylinder head and the piston top when the piston is at top dead center (TDC). OR It can also be defined as the volume of cylinder that is not swept by the piston. **Swept Volume:** The nominal volume swept by the working piston when travelling from one dead center to the other is called as displacement volume or Swept volume It is expressed in terms of cubic centimeter (cm3) and given by $V_s = A \times L = \frac{\Pi}{4} d^2 L$	01 Mark Each
	b	**State any four specifications of LMV Engine.**	**02**
	Ans.	Manufacturer: **Hyundai India Ltd.** 1) Type : 1.1 Ltr, 2) Nos. Of Valve: 4 Valve, 3) Nos. of Cylinder: 3 Cylinder, 4) Engine Cooling System: Water cooled, 5) Type of Fuel : Diesel 6) Cubic capacity: 1120 cc 7) Brake Power: 70 bhp at 6000rpm 8) Torque: 160 N-m ***(Any Other LMV or any other 4 Specifications should be given Similar Weightage)***	½ Mark Each
	c	**State the function of the following components. (i) Cam Shaft (ii) Crank Shaft**	**02**
	Ans.	**Camshaft:** The camshaft is a mechanical component of an internal combustion Engine. It opens and closes the inlet and exhaust valves of the engine at the right time, with the exact stroke and in a precisely defined sequence. **Crankshaft:** To translate the linear reciprocating motion of a pistons into the rotational motion required by the automobile.	01 Mark Each

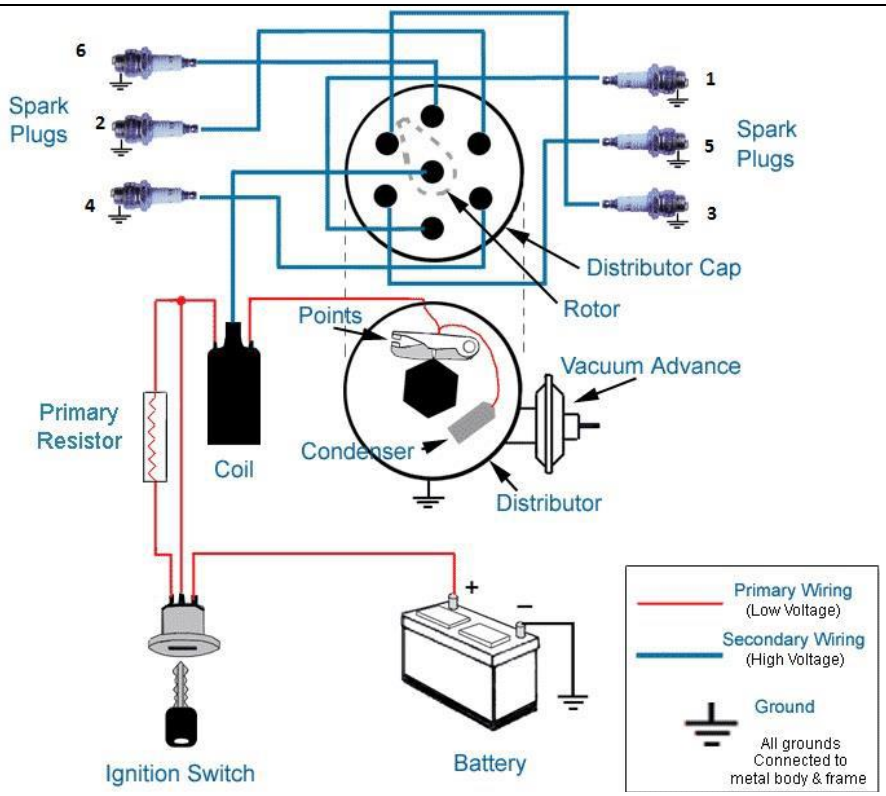
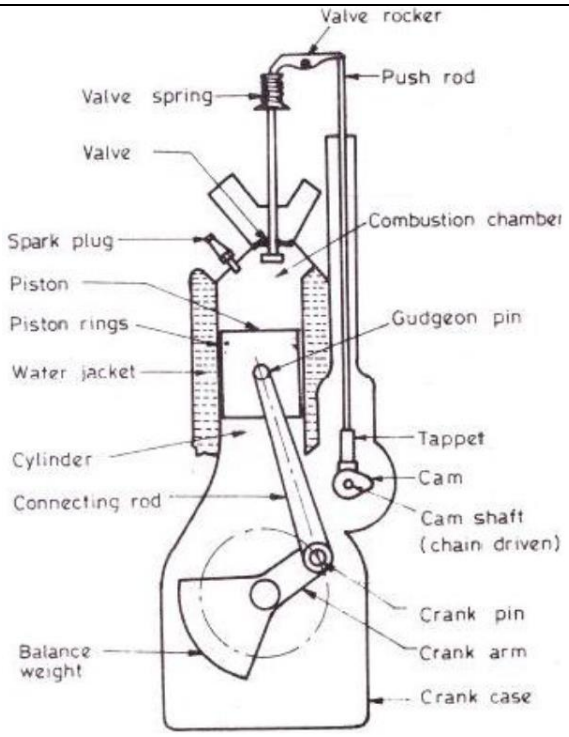
	d	**List four functions of Carburettor.**	**02**
	Ans.	1. To keep the small reserve of fuel at a constant head 2. To vaporize the fuel to prepare a homogeneous air fuel mixture. 3. To supply correct amount of the air fuel mixture at the correct strength under all conditions of load and speed.	01 Mark Each
	e	**List any four functions of exhaust system.**	**02**
	Ans.	1) The function of an exhaust 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) To keep back pressure minimum.	01 Mark Each
	f	**State any two limitations of engine cooling system.**	**02**
	Ans.	**Limitations of Engine Cooling System:** 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.	01 Mark Each
	g	**Define volumetric efficiency.**	**02**
	Ans.	Volumetric efficiency: Volumetric efficiency is an indication of the breathing ability of the engine and is defined as the ratio of the air actually induced at ambient condition to the swept volume of the engine. $\eta_v = \frac{\text{Volume flow rate of air in intake system}}{\text{Rate at which volume displaced by the piston}} = \frac{V_{actual}}{V_{swept}}$	02 Marks
2		**Attempt any THREE of the following.**	**12**
	a	**Compare 2-stroke and 4 – stroke engine (Any 4 Points)**	**04**
	Ans.		Any Four 01 Mark Each

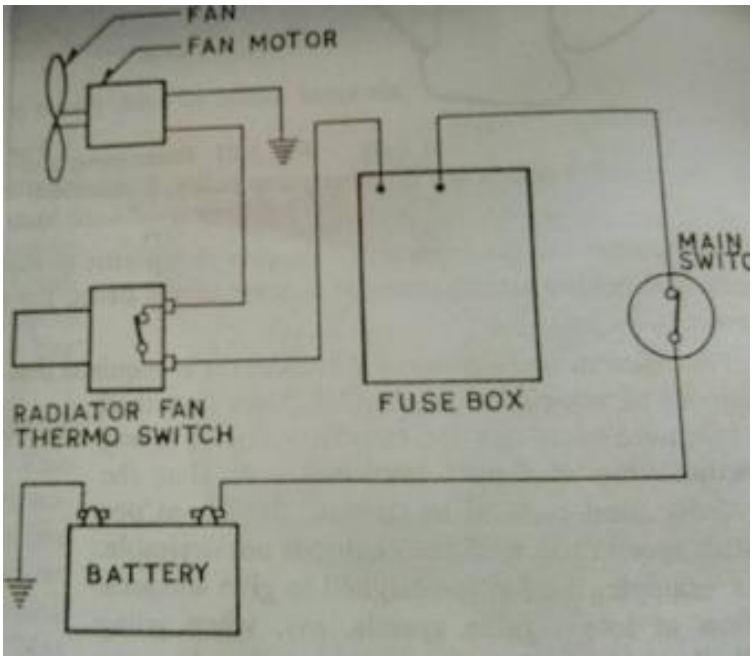
S. N.	Four Stroke Engine	Two Stroke Engine
1	One working stroke for every two revolutions of the crankshaft.	One working stroke for each revolutions of the crankshaft
2	Turning moment on the crankshaft is not even due to one working stroke for every two revolutions of the crankshaft. Hence heavy flywheel 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	Engine design is complicated	Engine design is Simple
5	More Cost	Less Cost
6	Less mechanical efficiency due to more friction on many parts.	More mechanical efficiency due to less friction on few parts.
7	More output due to full fresh charge intake and full burnt gases exhaust	Less output due to mixing of fresh charge with burnt gases.
8	Engine runs cooler	Engine runs hotter.
9	Engine is water/air cooled	Engine is air cooled
10	Engine requires more space.	Engine requires less space.

	b	**Explain the working of overhead valve arrangement with sketch.**	**04**
	Ans.	 **Figure: Overhead Valve Arrangement** **Overhead Valve Arrangement:** Figure shows the valve mechanism to operate the valve when it is in the cylinder head (in I and F head design). This type of mechanism requires two additional moving parts – the push rod and rocker arm. As the cam rotates, it lifts the valve- tappet or the lifter which actuates the push rod. The push rod rotates the rocker arm about a shaft- the rocker –arm shaft, or a ball joint in some designs to cause one end to push down on the valve stem to open the valve, thus connecting the valve port with the combustion chamber.	Expl. 02 Marks & Sketch 02 Marks
	c	**Describe the working of fuel injector with sketch.**	**04**
	Ans.	**Diesel Fuel Injector:**  **Figure: Diesel Fuel Injector** **Working:** The injector assembly consists of - i) a needle valve ii) a compression spring iii) a nozzle iv) an injector body When the fuel is supplied to lift the injection pump it exerts sufficient force against the spring to lift the nozzle valve, fuel is sprayed into the combustion chamber in a finely atomized particles. After, fuel from the delivery pump gets exhausted; the spring pressure pushes the nozzle valve back on its seat. For proper lubrication between nozzle valve and its guide a small quantity of fuel is allowed to leak through the clearance between them and then drained back to fuel tank through leak off connection. The spring tension and hence the valve opening pressure is controlled by adjusting the screw provided at the top.	Expl. 02 Marks & Sketch 02 Marks

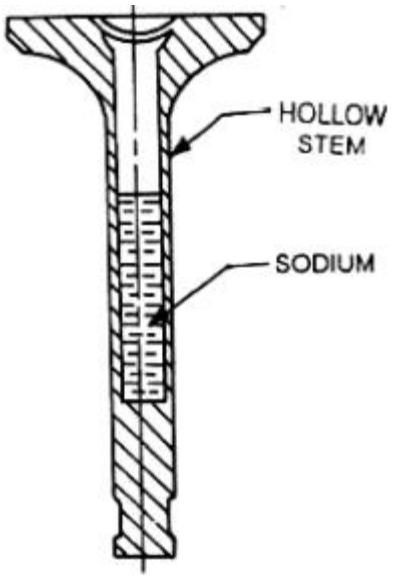
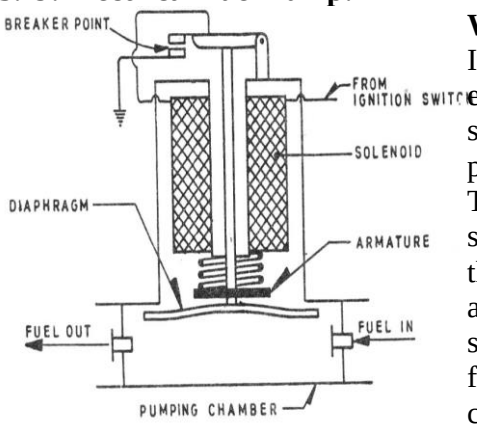
	d	**Elaborate the working of dry sump lubrication system with sketch.**	**04**
	Ans.	**Dry Sump Lubrication:**  **Figure: Dry Sump Lubrication** **Working of dry sump lubrication system:** In this system, the lubricating oil is not stored in oil sump .The oil from the sump is carried to a separate storage tank outside the engine cylinder block. The oil from sump is pumped by means of a scavenging pump through filter to the storage tank. Oil from storage tank. Oil from storage tank is pumped to the engine cylinder through oil cooler. Oil pressure may vary from 3 to 8 bar. Dry sump lubrication system is generally adopted for high capacity engines. The pressure relief valves are used to maintain the predefined pressure value inside the lubricating system	Expl. 02 Marks & Sketch 02 Marks
3		**Attempt any THREE of the following.**	**12**
	a	**Describe working principle of 4 – Stroke Petrol (Engine) with sketch**	
	Ans.	**Working of four stroke petrol 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 720^0.  **Figure: Working of Four Strokes Spark Ignition (SI) Engine**	*Any One Diagram 02 marks, Description 02 marks*

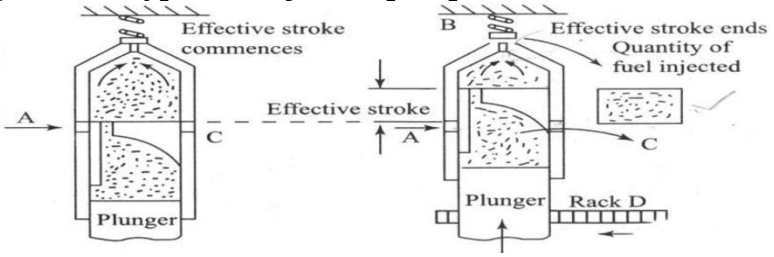
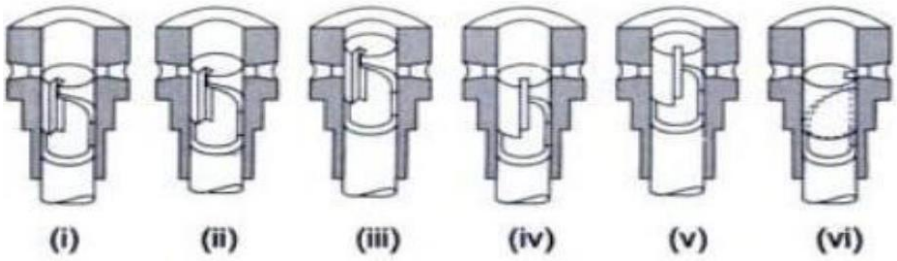
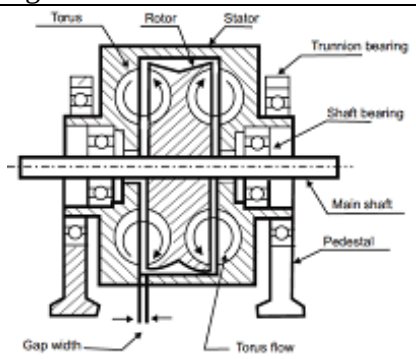
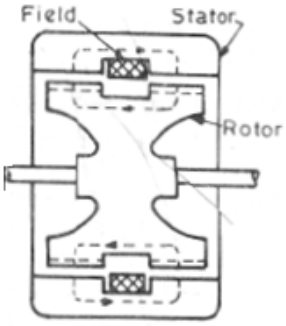
	b	**Describe the construction of gear drive of camshaft drive arrangement with sketch.**	**04**
	Ans.	**Gear Drive of Camshaft Drive:**  **Figure: Gear Drive of Camshaft Drive** Camshaft is driven by the crankshaft either by a pair of meshing gears (timing gears) or by means of a pair of timing sprocket 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.	Expl. 02 Marks & Sketch 02 Marks
	c	**Explain the working of battery ignition system with circuit diagram.**	**04**
	Ans.	**Battery Ignition System**:  **Figure: 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.	Expl. 02 Marks & Sketch 02 Marks

	d	**Sketch the high voltage connection between distributor and spark plugs of multi cylinder engine with direction of rotation of distributor shaft assembly. Label the sketch.**	**04**
	Ans.	 **Figure: High Voltage Connection between Distributor and Spark Plugs** *(**NOTE**: Equivalent credit should be given only distributor)*	Neat Sketch 02 Marks & Labels 02 Marks
4		**Attempt any THREE of the following.**	**12**
	a	**Show I.C. engine Nomenclature with neat sketch**	**04**
	Ans.	 **Figure: I.C. engine Nomenclature**	Neat Sketch 02 Marks & Labels 02 Marks

	b	**State the materials used for piston with justification.**	**04**
	Ans.	**Material used for Piston**: Cast Iron, Cast Steel, Forged Steel, *Cast Aluminum Alloys* and Forged Aluminum Alloy. ***Cast Aluminum Alloys* is the most commonly used material for piston because;** 1. Cast aluminium alloy is light and has good structural integrity. 2. Low manufacturing costs. 3. The low weight of aluminium reduces the overall mass and force necessary to initiate and maintain acceleration of the piston. 4. It allows to utilize more of the force produced by combustion to power the application.	Any One Material 01 Marks Justification 03 Marks
	c	**Select firing order for 4 – Cylinder engine with justification.**	**04**
	Ans.	**Firing orders for 4 cylinder engine:** 1-3-4-2 The firing order must be considered on the basis of engine vibrations and engine cooling. Also the firing order affects the balancing of engine. **Reasons for preferring 1-3-4-2 in 4 cylinder engine:** 1. The power impulses are evenly distributed and are 180 degree apart. Therefore the firing order for the engine is 1-3-4-2. 2. This balance load on two bearings would be further reducing the engine vibrations. 3. It is required to cool the portion of engine by changing the sequence. So that problem of overheating can be mitigated. 4. To provide sufficient travel time to exhaust gases. So that development of high back pressure would be avoided.	Correct Firing Order 01 Marks & Any Three Justification 01 Mark Each
	d	**Explain the working of electrically driven fan in cooling engine.**	**04**
	Ans.	 **Figure: Electrically Driven Fan Circuit** **Working of Electrically Driven Fan in Cooling Engine:** The fan is driven by a separate electric motor which is supplied with power directly from the electric circuit of the engine. A thermostat switch is placed at an appropriate place in the cooling system and depending upon the cooling system temperature it operates to switch to On or OFF the fan motor. It has been found that under ordinary condition only about 5 % of the time the fan motor remains in ON position, while 95% of the time it is off.	Sketch 02 Marks & Working 02 Marks

	e	**A four stroke engine with four cylinders, bore 80 mm and stroke 100 mm was tested at 3500 rpm and following data were recorded:** **Fuel Consumption = 300 gm/minute,** **Indicated Mean Effective Pressure= 1 MPa,** **Engine Torque Developed = 140 N – m** **If calorific value of fuel used is 42000kJ/kg., Calculate(i) I. P. (ii) Mechanical Efficiency (iii) Brake Thermal Efficiency.**	04
	Ans.	Given Data; Nos. of Stroke = 4, Nos. of Cylinder = 4 RPM = 3500 ***For Four Stroke Engine, N' = N/2 = 3500/2 = 1750 rpm*** Bore Diameter = 80 mm = 0.08 m $\text{Area} = A = \frac{\pi}{4}D^2 = \frac{\pi}{4}0.08^2 = 5.026\times10^{-3}\,m^2$ Stroke Length = 100 mm = 0.1 m $\text{Fuel cunsumption} = m_f = 300\text{gm/minu te} = \frac{300}{1000\times60} = 5\times10^{-3}\,kg/\text{sec}$ Indicated Mean Effective Pressure, P_i= 1 MPa = 1 x 10^6 N/m^2 Engine Torque Developed = 140 N – m C_v = 42000kJ/kg Find (i) Indicated Power = ? (ii) Mechanical Efficiency = ? (iii) Brake Thermal Efficiency=? **Solution:** (i) I.P. of the engine $\text{I.P.} = \frac{nP_iLAN'}{60\times1000}\text{kW}$ $= \frac{4\times1\times10^6\times0.1\times5.026\times10^{-3}\times1750}{60\times1000} = 58.64kW$ **I.P. of the engine = 58.64 kW** (ii) Mechanical efficiency $\text{B.P.} = \frac{2\pi N T}{60\times1000}$ $\text{B.P.} = \frac{2\times3.14\times3500\times140}{60\times1000} = 51.31\,\text{kW}$ $\eta_{mech} = \frac{\text{B.P.}}{\text{I.P.}}\times100\%$ $= \frac{51.31}{58.64}\text{ X }100$ $\eta_{mech} = 87.5\%$ **Mechanical efficiency = 87.5 %** iii) Brake thermal efficiency $\eta_{Bth} = \frac{\text{B.P.}}{m_f\times\text{c.v.}}\times100\%$ $= \frac{51.31}{5\times10^{-3}\times42000}\times100$ $\eta_{Bth} = 24.44\%$ **Brake thermal efficiency = 24.44 %**	01 Mark 01 Mark 01 Mark 01 Mark

5		**Attempt any TWO of the following.**	**12**
	a	**Statement: Valve Cooling is necessary in some I. C. Engine. Justify the statement by giving reasons and explain its working with sketch.**	**06**
	Ans.	 **Figure: Sodium Cooled Valve** **Reasons:** Exhaust valve temperature in modern engine is as high as 750˚C. Thus cooling of exhaust gas becomes very important. Cooling water jackets are arranged near the valves for valve cooling. In many cases nozzles are directed towards hot spot caused by the exhaust valve. **Working:** In heavy duty engine, sodium cooled valves are used, the working of this valve is stated below – A sodium cooled valve has a hollow stem, which is partly filled by metallic sodium. Sodium melts at 97.5˚C. Thus at operating temperature sodium is in liquid state. When engine runs, valve moves up and down, thus sodium is thrown upward in hotter part of valve. There it absorbs heat, which is later given to cooler stem as it falls back to stem again. This keeps the valve head cool.	Reasons 02 Marks + Figure 02 Marks + Working 02 Marks
	b	**Explain the working of S. U. Electrical Fuel Pump with sketch.**	**06**
	Ans.	**S. U. Electrical Fuel Pump:**  **Figure: S. U. Electrical Fuel Pump** **Working of Electric Fuel Pump:** It consists of a diaphragm which is operated electrically. By turning on the ignition switch, the solenoid winding generates magnetic flux, which pulls the armature and the diaphragm moves up. The upward movement of the diaphragm creates suction, and the fuel is drawn into the chamber through the inlet valve. But as soon as the armature moves up it disconnects the electric supply, the magnetic flux dies and the armature falls down, causing the diaphragm to move to create pressure in the pump chamber. This causes the outlet valve to open and inlet valve to close. The fuel goes out to the carburetor. The downward movement of the armature again sets electric supply to the solenoid, and the same process is repeated, the pump continues to operate until the ignition switch is turned off.	Sketch 03 Marks & Working 03 Marks

	c	**Draw sketches showing fuel metering in the inline type F. I. P. and explain its working.**	**06**
	Ans.	**Fuel Metering in inline type fuel injection pump**:  **OR**  **Figure: Various positions of the plunger.** The position of the plunger in the fuel injection pump can be varied by means of a control rod having a rack and pinion arrangement. By operating this rod, the position of the plunger can be changed, and by changing the position of the plunger, the supply to the injection nozzle can either be increased or stopped. When the supply to the injection nozzle is stopped, the engine is also stopped. In Fig., (i) is the position of the plunger when it is at the bottom stroke. The position of the plunger when it is closing both the ports is shown in (ii). The maximum amount of supply is shown in (iii). Only at this position is the plunger working at full load. The position of the plunger at (iv) shows a normal load. The position at (v) shows a part load. The position at (vi) shows that no fuel is being supplied to the injector; i. e. the engine has stopped.	Sketch 03 Marks & Explanation 03 Marks
6		**Attempt any TWO of the following.**	**12**
	a	**Explain the working principle of the following dynamometers with suitable sketches, if necessary: (i) Hydraulic Dynamometer. (ii) Eddy Current Dynamometer.**	**06**
	Ans.	**(i) Hydraulic Dynamometer:** In principle, hydraulic dynamometer construction is similar to that of a fluid flywheel. Hydraulic dynamometer consists of an impeller or inner rotating member coupled to the output shaft of the engine. The impeller in this dynamometer rotates in a casing filled with a fluid**.**  **Figure: Hydraulic Dynamometer** **(ii) Eddy Current Dynamometer:** Crankshaft connected to rotor when rotor rotates Eddy current are produce in stator due to magnetic flux set up by the passage of field current in electro magnets these Eddy current oppose the rotor motion thus loading the engine**.**  **Figure: Eddy Current Dynamometer**	

	b	**Explain the selection of lubricating oil on the basis of viscosity and service rating.**	**06**
	Ans.	Selection of Lubricating Oil: **1. On the basis of Viscosity :** • Lubricating Oils Classify in terms of Viscosity at -18^{0}C or in cold climates. a) SAE 5W b) SAE 10W c) SAE 20 W • Lubricating Oils Classify in terms of Viscosity at 99^{0}C or in hot climates. a) SAE 20 b) SAE 30 c) SAE 40 d) SAE 50 **2. On the basis of Service Rating :** • C- series a) CA: Use in gasoline and naturally aspirated diesel engine operated on low sulphur fuel. b) CB: Use in gasoline, naturally aspirated diesel engine operated on high sulphur fuel. c) CC: Use for lightly supercharge diesel engine. d) CD: Use in highly turbo-charge diesel engine. • S- series a) SA : Mineral oil , may contain anti-formant and poor point de-present b) SB: Mineral oil , containing additive impart sum oxidation stability & anti- scuff Protection c) SC, SD & SC**:** Meets automotive manufactures specifications.	03 Marks 03 Marks
	c	**An I. C. Engine develops a brake power of 26.1 kW. Following observations were made during a trial:** **Power required to motor the engine = 4.5 kW** **Cooling water circulated = 7.5 kg / min.** **Specific Heat of Water = 4.187 kJ/kgK** **Petrol Consumption = 200gm/ minute** **Temperature rise of cooling water = 50^{0}C** **If calorific value of petrol is 46,000 kJ/kg. Draw heat balance sheet for the test on percentage basis.**	**06**
	Ans.	**Given Data:-** Mass of Fuel,; mf = 200 gm/ min. B.P. = 26.1 kW Mass of cooling water = mw= 7.5 kg/ min Mw = 7.5 kg/min Cpw = 4.187 kJ/kgK ΔTw = 50^{0}C C. V. 46,000kJ/kg Power required to motor the engine = 4.5 kW **Solution:** Mass of Fuel; mf =200/1000= 0.2 kg/ min. Input Heat = mf x CV = 0.2 x 46000=9200 KJ/min Heat Converted into BP= 26.1 X 60 =1566 kJ/min Cooling water heat $= \dot{m}_w \times cp_w \times \Delta T_w$	Calculations 03 Marks & Heat Balance Sheet 03 Marks

Cooling Water Heat = 7.5 X 4.187 X 50 = 1570.125 kJ/min

Heat Required to motor.(Frictional Power) the engine = 4.5 X 60 = 270 kJ/min

Heat unaccounted = heat input – (heat to BP + heat to cooling + heat to motor the engine)
= 9200 – (1566 +1570.125 + 270) = 5793.875KJ/min

Heat balance sheet

Parameter	**Value (kJ/min)**	**Percentage (%)**
Input Heat	**9200**	**100**
Heat goes to B. P.	**1566**	**17.03**
Heat goes to cooling water	**1570.125**	**17.06**
Heat goes to motor the engine.(Frictional Power)	**270**	**02.94**
Unaccounted heat loss	**5793.875**	**62.97**