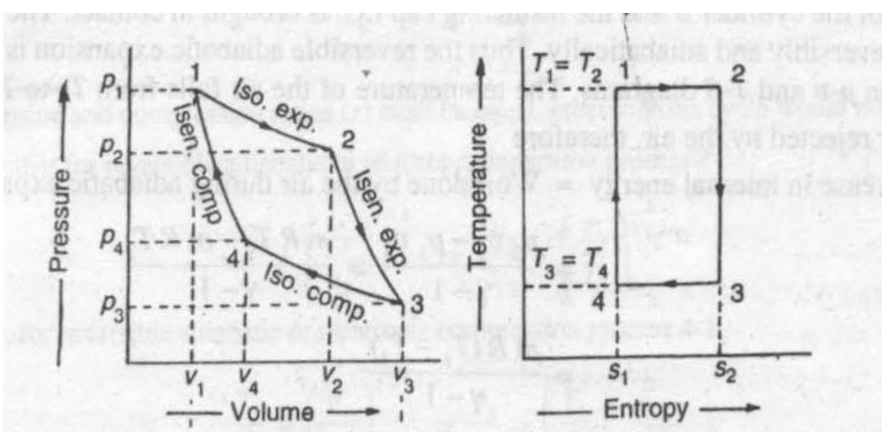
WINTER – 17 EXAMINATIONS

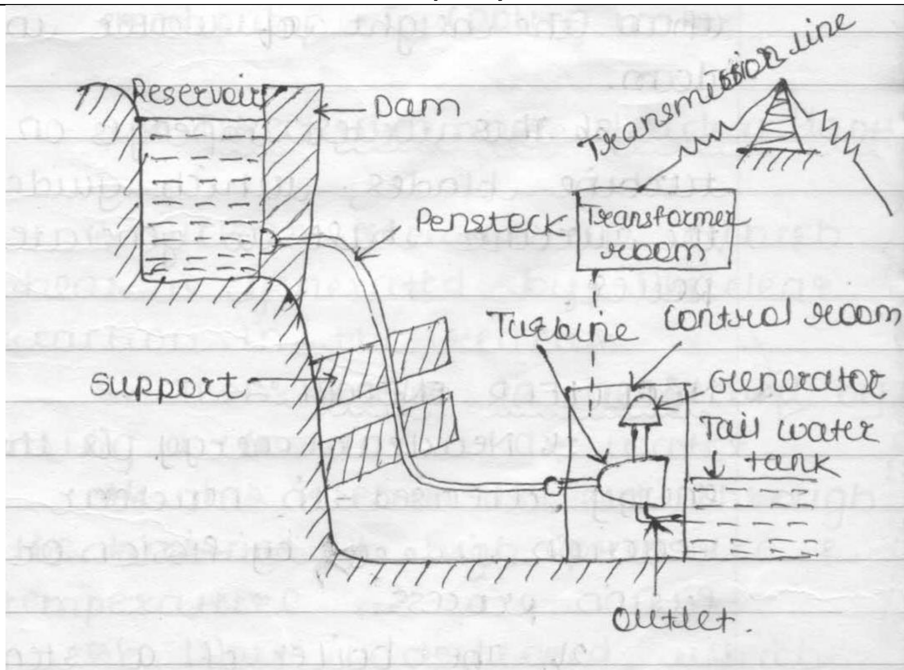
Subject Code: **17554** **Model Answer** Page No: ____/ N

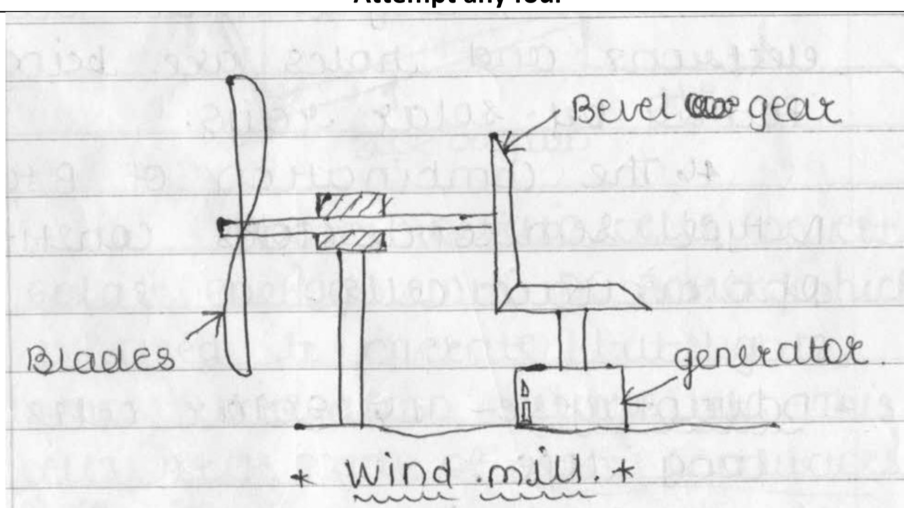
Important Instructions to examiners:

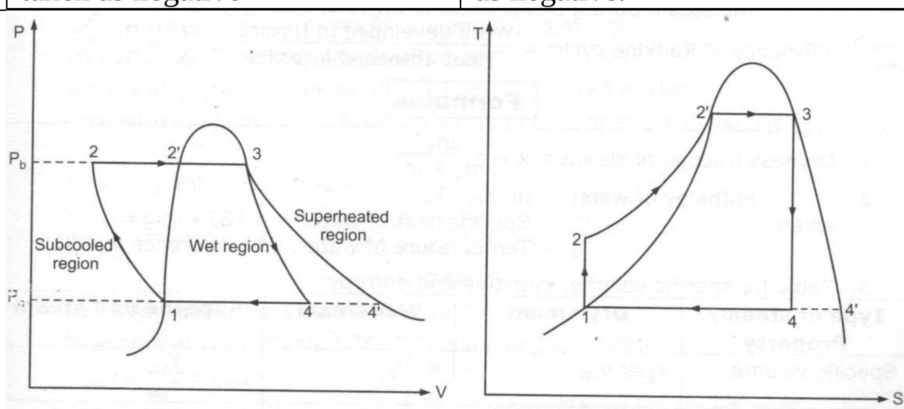
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling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

Q. NO.	MODEL ANSWER	MARKS	TOTAL MARKS
1 A	**Attempt any six**	**6 x 2m**	**12m**
a)	Application based on solar energy 1) Energy generation 2) Water heater 3) Solar distillation	2m (any 2)	2m
b)	Renewable energy sources:- The resources that can be renewed by reproduction are called renewable resources. For example: air and water. Non renewable energy sources:- The resources that are present in fixed quantities are called non-renewable resources. For example- fossil fuels and minerals.	1m 1m	2m
c)	Zeroth law of thermodynamics this law states"When two system are each in thermal equilibrium separelty with a third system,then the two system are also in thermal equilibrium in each other" 	2m	2m
d)i	Internal energy It is is a energy posse by a body or system due to its molecular arrangement and motion of molecules.it is represented by u The totatal energy of system $E= mgh + ½(mv^2) +u$	1m	2m
ii	Entrropy It is a function of a quantity of heat which shows the possibility of conversion of that heat into work.	1m	
e)	Boiler Draught •It is defined as 'the force required to draw'. •It is also referred as, "the pressure difference necessary to draw the required quantity of air for combustion and to remove the flue gases from the boiler, exhausting to atmosphere	2m	2m
f)i	Dryness fraction or quality of wet steam. It is the ratio of the mass of actual dry steam, to the mass of same quantity of wet steam, and is generally denoted by 'x'. Mathematically, $x = mg/(mg+mf)$ Where mg = Mass of actual dry steam,	1m	2m

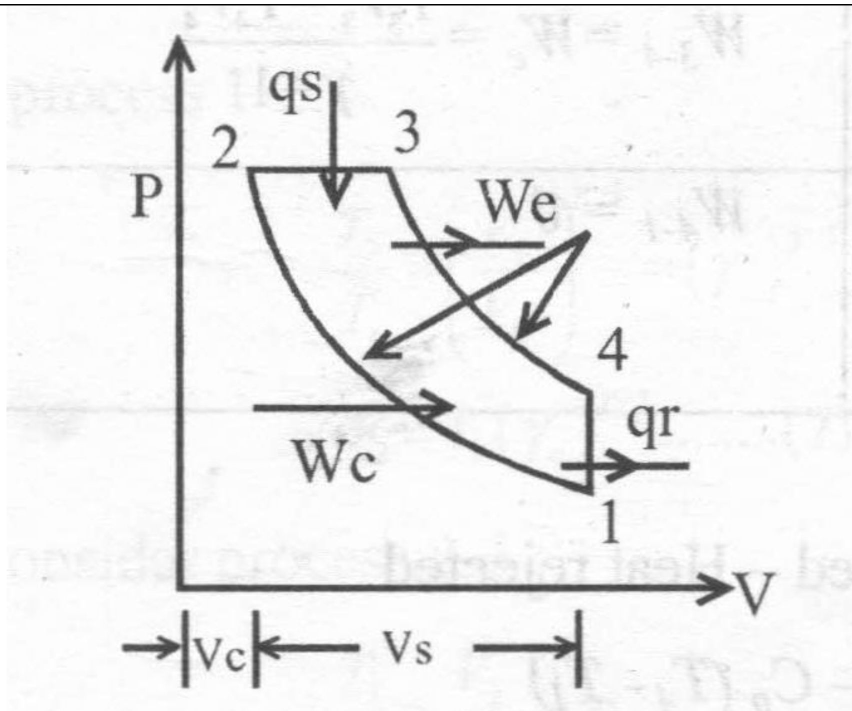
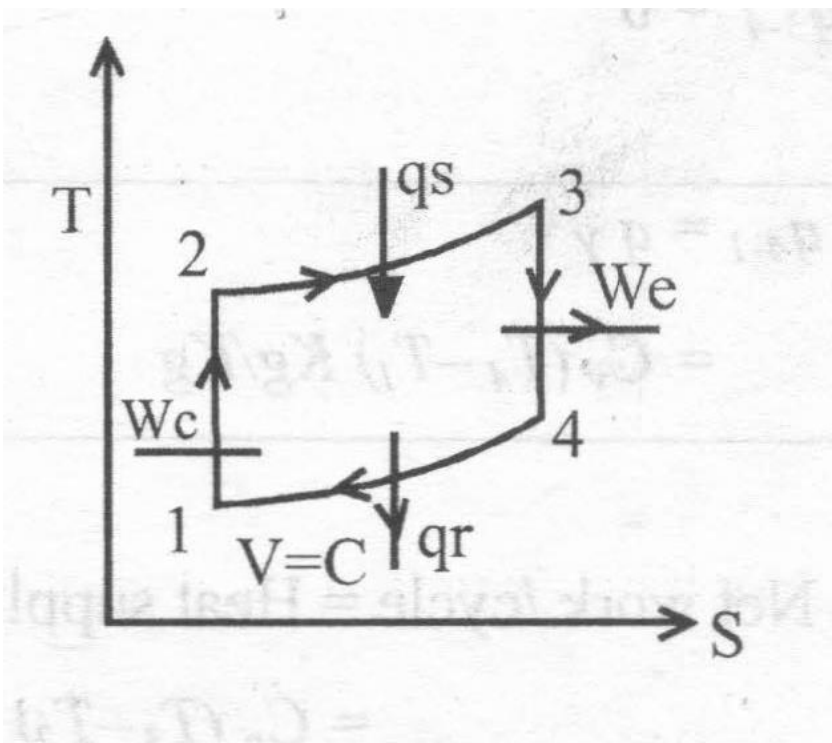
	mf = Mass of water in suspension, and m = Mass of wet steam = mg + mf The dryness fraction of dry saturated streams, X=1		
ii	Degree of superheat: Ti is difference between temperature of superheated steam and saturated steam. It is given by (T_{sup}-T_{sat})	1m	
g)	Importance of Steam Table •Steam table is available on pressure basis as well as temperature basis. •The various properties of steam like specific volume, specific enthalpy and entropy are tabulated in the steam table. These properties have been experimentally found and are used for calculation.	2m	2m
h)	Dalton'S Law of Partial Pressures It states "The pressure of the mixture of air and steam is equal to the sum of the pressures which each constituent would exert, if it occupied the same space by itself." Mathematically, pressure in the condenser containing mixture of air and steam, Pc=Pa+Ps Pa=, pressure in the condenser containing mixture of air and steam Pa = Partial pressure of air, and Ps = Partial pressure of steam.	1m 1m	2m
i)	 (a) p – v diagram. (b) T – S diagram.	2m	2m

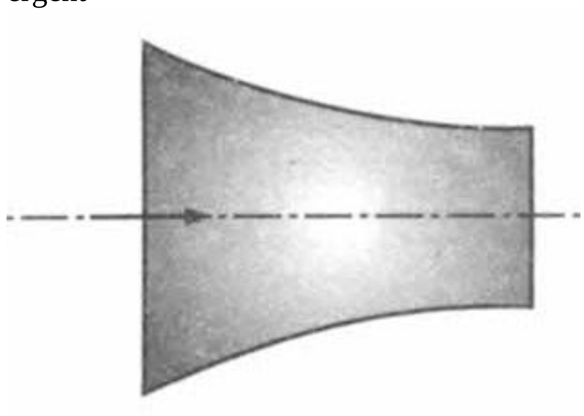
B	Attempt any two	4m x 2	8m
a)	 HYDRO-ELECTRIC POWER PLANT fig.shows a general lay-out of a hydro-electric power plant which consists of: (i)A dam constructed across a river to store water. (ii)Pipes of large diameters called penstocks, which carry water under pressure from the storage reservoir to the turbines. These pipes are made of steel or reinforced concrete. (iii)Turbines having different types of vanes fitted to the wheels. (iv)Tail race, which is a channel which carries water away from the turbines after the water has worked on the turbines. The surface of water in the tail race is also known as tail race.	2m(dia.) 2m(expl.)	4m
b)	**Point Function** They depend on the state only, and not on how a system reaches that state. All properties are point functions. Those properties, which cannot be located on graph by a point but are given by area or show on the graph **Path Function** Their magnitudes depend on the path followed during a process as well as the end states Work (W), heat (Q), Pressure, volume, enthalpy, internal energy are path functions When the two properties locate a point on graph (coordinates axes) then those properties are known as point function	**2m** **2m**	4m

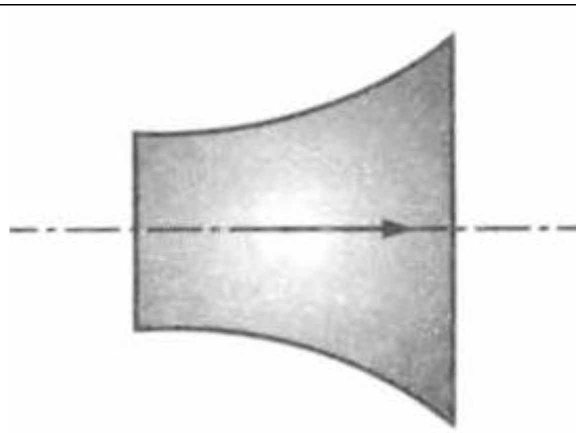
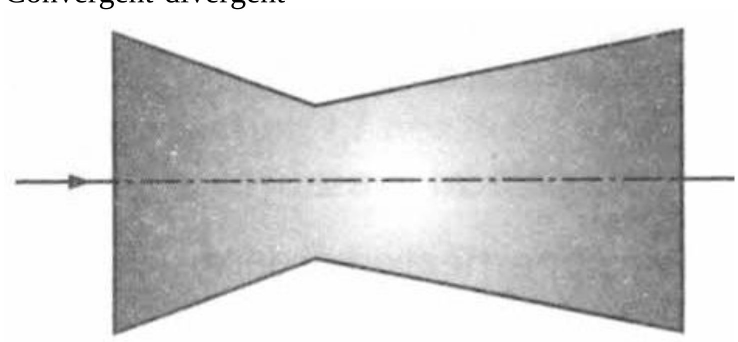
c)	Heat exchangers Heat exchanger is a device, which provides the surface area necessary to transfer of heat energy from one fluid to another fluid. Heat exchangers can be classified as follows: 1. According to nature of heat exchange process: (i) Direct contact type (ii) Indirect contact type: It is further classified as: (a) Recuperators (b) Regenerators 2. According to relative direction of fluid motion (i) Parallel flow (ii) Counter flow (iii) Cross-flow 3. According to design and constructional features (i) Concentric tubes (ii) Shell and tube (iii) Multiple shell and Tube passes	1m 3m(class.)	4m
2	**Attempt any four**	**4m x 4**	**16m**
a)	 Wind energy is kinetic energy associated with movement of large mass of air over the earth surface due to non uniform heating of the earth surface. 1.Wind energy is converted to mechanical energy by the wind mill 2.The wind approaching the blad move the wind mill shaft thereby rotating rotor of gerrtor which irduce electricity 3.It can also be used for water pumping,drinking and irrigation in rural area	2m(dia.) 2m(expl.)	4m
b)	Themodynamic system :- It is defined as a quantity of matter or region in space upon which attention is concentrated. In the analysis of a problem e.g boiler,turbine which is being analyse	2m (def.)	4m

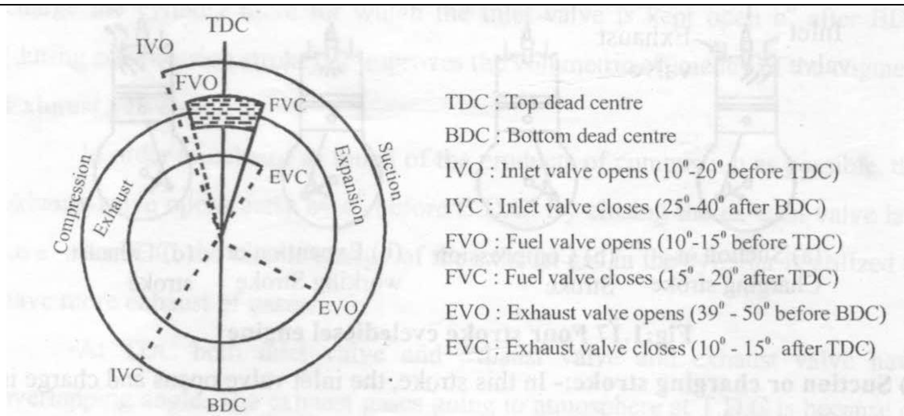
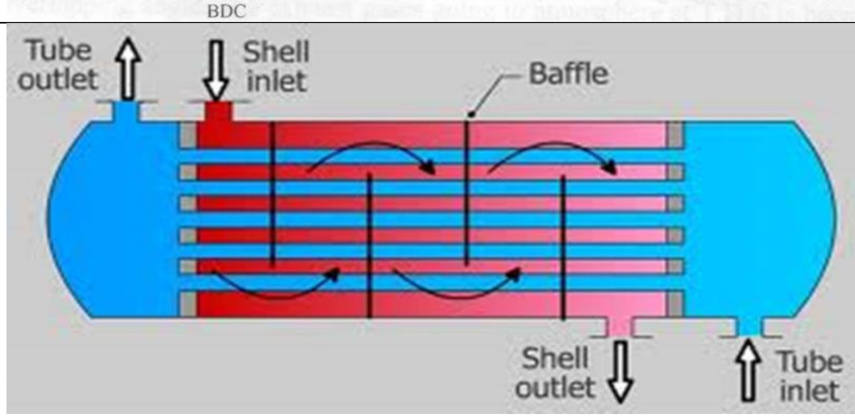
<table>
<tr><td></td><td>There are three type of system
1.Closed system e.g.Piston and cyclinder without valve
2.Open system e.g. turbine
3.Isolated system e.g.Gas enclosed in a issulated vessel,universe etc</td><td>2m(class. any two)</td><td></td></tr>
<tr><td>c)</td><td>
<table>
<tr><th>Heat</th><th>Work</th></tr>
<tr><td>1. Heat is defined as "the energy transferred, without transfer of massacross the boundaries, due totemperature difference between the system and surroundings".</td><td>1. In thermodynamics, work is defined as, "the energy transferred (without the transfer of mass) across the boundary of a system due to pressure difference that exists between system and surroundings"</td></tr>
<tr><td>2. It is low qrade enerqv</td><td>2. It is high grade energy</td></tr>
<tr><td>3. In a stable system, there is no restriction for the transfer of heat</td><td>3. In a stable system, there cannot be work transfer</td></tr>
<tr><td>4. It is denoted by letter 'Q'.</td><td>4. It is denoted by letter 'W'.</td></tr>
<tr><td>5. If heat is received by system, it is taken as positive and if heat is lost/rejected by system, it is taken as negative</td><td>5. If work is produced or developed, it is taken as positive. If work is consumed, it is taken as negatlve.</td></tr>
</table>
</td><td>1m for each point (any four)</td><td>4m</td></tr>
<tr><td>d)</td><td>


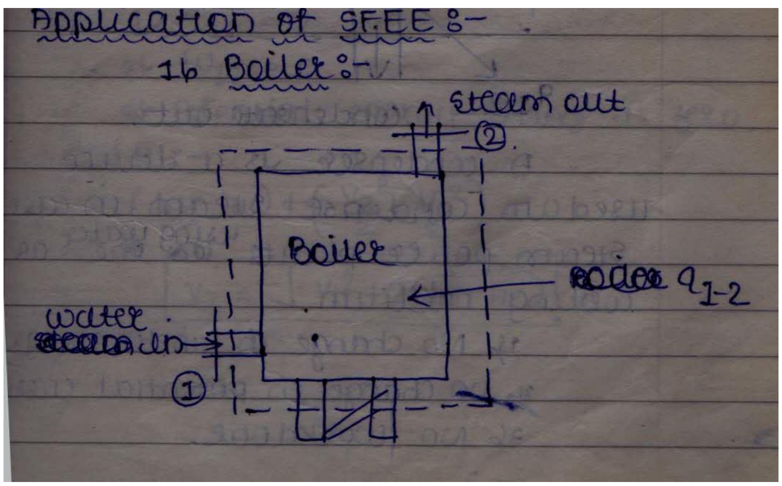
(a) Rankine cycle on P–V
(b) Rankine cycle on T–S diagram
</td><td>2m(each dia.)</td><td>4m</td></tr>
<tr><td>e)</td><td>1.According to the contents in the tube
a)Fire tube or smoke tube boiler, and (b) Water tube boiler
2.According to the position of the furnace
a) Internally fired boilers, and (b) Externally fired boilers
3.According to the axis of the shell
(a) Vertical boilers, and (b) Horizontal boiler
3. According to the number of tubes
(a) Single tube boilers, and (b) Multitubular boilers
5. According to the method of circulation of water and steam
(a) Natural circulation boilers, and (b) Forced circulation boilers.</td><td>4
(any 4)</td><td>4m</td></tr>
</table>

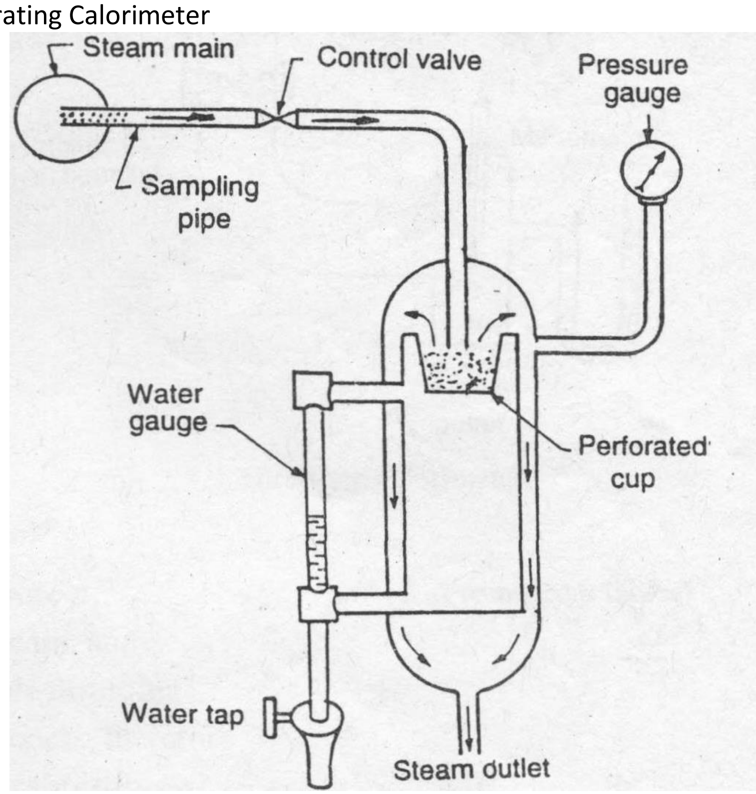
f)	qs 2 3 P We 4 qr Wc 1 V Vc Vs	2m	4m
	T qs 3 2 We Wc 4 1 V=C qr S	2m	

3	Attempt any four	4m x 4	16m
a)i	Thermodynamic state It can be defined as a exact condition of the system.The state can be defined by thermodynmicthen it is known as a cycle or cyclic process.	1m	4m
ii	Thermodynamic process "When a system changes its state from one equilibrium state to another equilibrium state, then the path of successivestates. through which the system has passes is known as Thermodynamic process	1m	
iii	Thermodynamic cycle When number of processes are performed on a system, in such a way that, final state is identical with initial state, it is known as thermodynamic cycle or cyclic process	1m	
iv	Thermodynamic Property It can be defined as "an observable charctristic of system ".It may be temperturemvolume and pressure etc	1m	
b)	Nozzle: A Steam nozzle is a passage of varying cross-section, which converts heat energy of steam into kinetic energy. The main use of steam nozzle in steam turbine is to produce a jet of steam with high velocity. The smallest section of nozzle is known as throat. Types of steam nozzle: 1. Convergent  2. Divergent	1m 1m 1m	4m

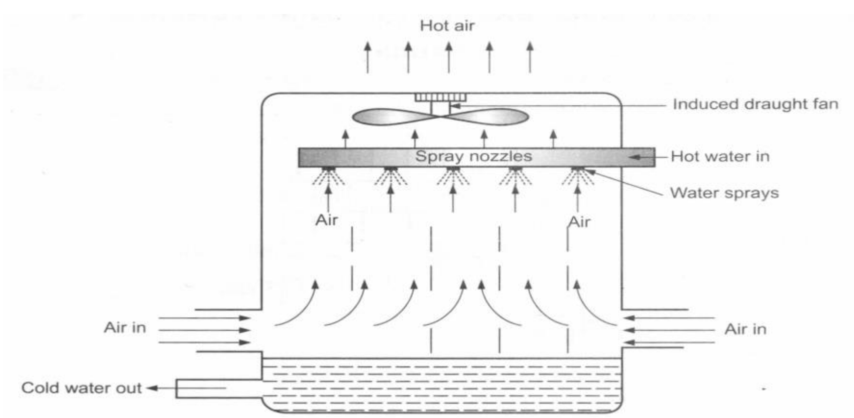
	 3. Convergent-divergent 	1m	
c)	Sources of Air into the Condenser:- The following are the main sources through which the air may enter into the condenser: 1.The dissolved air in the feed water enters into the boiler, whicfri rn enters into the condenser with the exhaust steam. . 2. The air leaks into the condenser, through various joints, due to high vacuum pressure in the condenser. 3. In case of jet condensers, dissolved air with the injection water enters into the condenser	4m	4m
d)	Following factors respnisible for preignition: 1) High compression ratio 2) Overheated spark plug point 3) Incandescent carbon deposit in cylinder wall 4) Overheated exhaust valve 5) It may occur due to faulty timing of spark production.	2m	4m

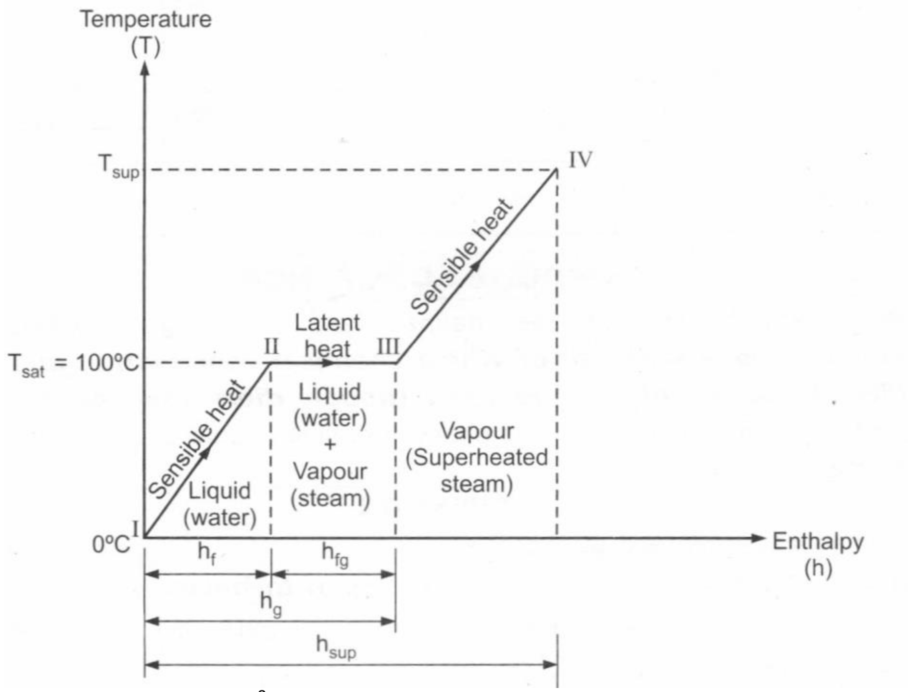
	Effect of preignition 1. Reduce useful work per cycle 2. Increase heat losses from engine 3. Reduction in thermal efficiency. 4. Subject the engine components to excessive pressure	2m	
e)		4m	4m
f)	 Working:- A shell and tube heat exchanger is a class of heat exchanger designs. It is the most common type of heat exchanger in oil refineries and other large chemical processes, and is suited for higher-pressure applications. As its name implies, this type of heat exchanger consists of a shell (a large pressure vessel) with a bundle of tubes inside it. One fluid runs through the tubes, and another fluid flows over the tubes (through the shell) to transfer heat between the two fluids. The set of tubes is called a tube bundle, and may be composed of several types of tubes: plain, longitudinally finned, etc. Two fluids, of different starting temperatures, flow through the heat exchanger. One flows through the tubes (the tube side) and the other flows outside the tubes but inside the shell (the shell side). Heat is transferred from one fluid to the other through the tube walls, either from tube side to shell side or vice versa. The fluids can be either liquids or gases on either the shell or the tube side. In order to transfer heat efficiently, a large heat transfer area should be used, leading to the use of many tubes. In this way, waste heat can be put to use. This is an efficient way to conserve energy.	2m(dia.) 2m(expl.)	4m

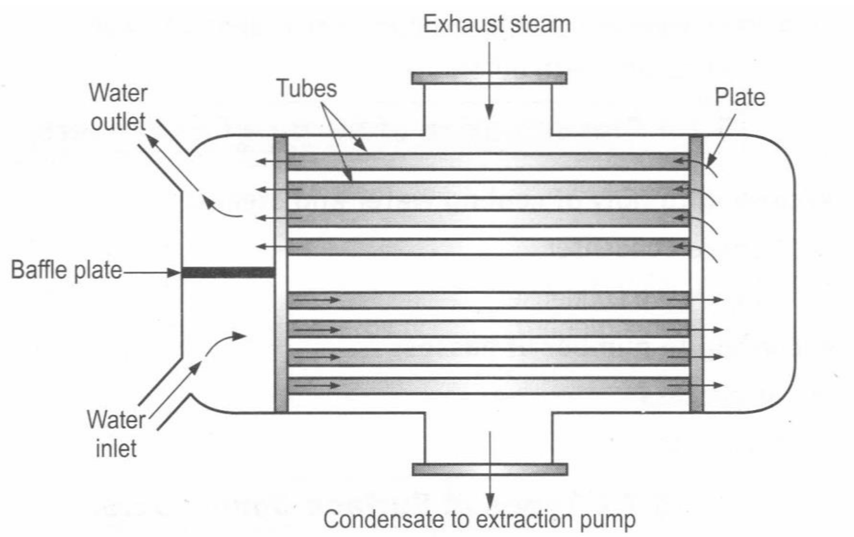
4	Attempt any four	4m x 4	16m
a)	**Kelvin - Planck Statement**. According to Kelvin-Planck 'It is impossible to construct an engine working on a cyclic process, whose sole purpose is to convert heat energy from a single thermal reservoir into an equivalent amount of work. **Clausius Statement**. According to Clausius statement "It is impossible for a self acting machine working In a cycLic process, to transfer heat from a body at a lower temperature to a body at a higher temperature without the aid of an external agency.	2m 2m	4m
b)	SFEE: $h_1+V_1^2/2+gZ_1+q_{12}= h_2+V_2^2/2+gZ_2+W_{12}$ i)For boiler  It is a device which supplies heat to water and generates steam. 1) No change in kinetic energy 2) No change in potential energy 3) No work done. SFEE $q_{12}=h_2-h_1$	1m 3m	4m

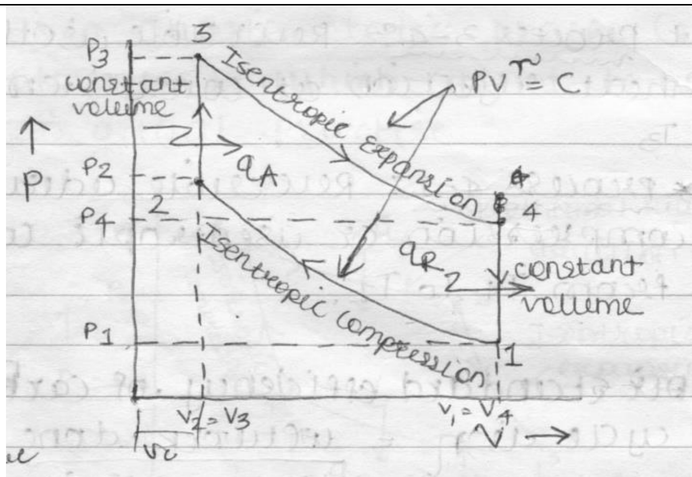
<table>
<tr>
<td>c)</td>
<td>
<table>
<tr><th>Heat Engine</th><th>Heat Pump</th></tr>
<tr><td>1. It is a work developing device</td><td>1. It is a work absorbing or consuming device.</td></tr>
<tr><td>2. It obeys Kelvin-Plank's statement of second law of thermodvnamics.</td><td>2. It obeys Clausius statement of second law of thermodynamics.</td></tr>
<tr><td>3. In heat engine, heat is supplied from heat source or a hot body and work is produced with rejection of some quantity of heat to the heat sink or cold body.</td><td>3. In heat pump, heat is pumped from heat sink or a cold body and is supplied to hot body, on consuming external work supplied.</td></tr>
<tr><td>4.Its performance is measured in terms of "efficiency".</td><td>4.Its performance is measured in terms of "coefficient of performance".</td></tr>
<tr><td>5. $\eta_E = \frac{Q_2 - Q_1}{Q_2}$</td><td>5. $(COP)_P = \frac{Q_2}{Q_2 - Q_1}$</td></tr>
<tr><td>6. $\eta_E = \frac{T_2 - T_1}{T_2}$ for carnot engine</td><td>6. $(COP)_P = \frac{T_2}{T_2 - T_1}$ for carnot heat pump.</td></tr>
<tr><td>7.Efficiency is always less than 100%.</td><td>7.COP of heat pump is always greater
than 1.</td></tr>
</table>
</td>
<td>1m each point(any four)</td>
<td>4m</td>
</tr>
<tr>
<td>d)</td>
<td>Separating Calorimeter


</td>
<td>2m dia.</td>
<td>4m</td>
</tr>
</table>

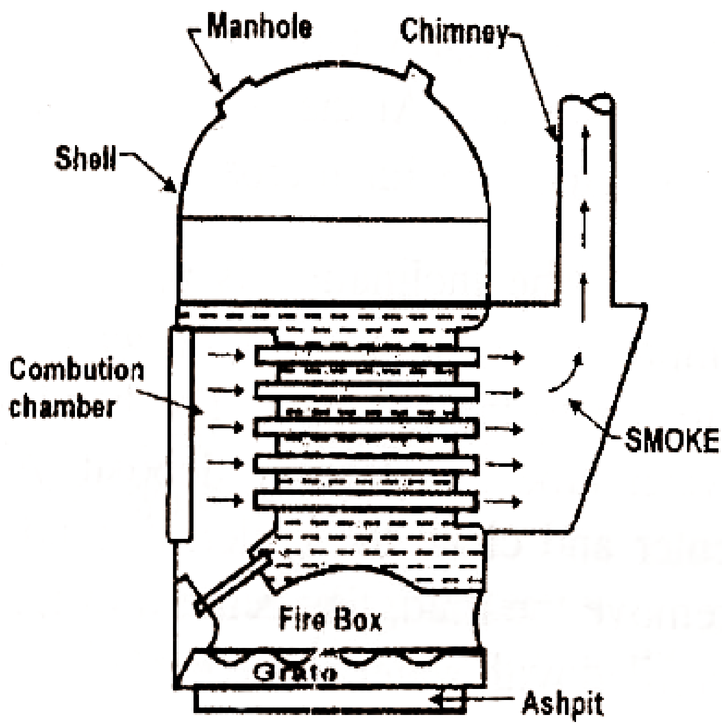
	The separating calorimeter is used to determine the dryness fraction of steam by mechanically separating the water particles from the wet steam. The wet steam enters at the top of the calorimeter through a control valve as shown in Fig. It strikes the perforated cup and thereby undergoes a quick reversal of directions of motion. The water particles, due to their greater moment of Steam main inertia, tend to move on, and consequently get separated from the mixture. The separated water collects at the bottom of the inner chamber, and its amount may be determined by the graduated water gauge. The amount of dry steam leaving the outer chamber of the calorimeter may be measured by condensing it in a weighed quantity of cold water or alternatively by reading the pressure gauge which is calibrated in terms of rate of steam flow for this purpose. Let m= Mass of water collected in a certain time, M = Mass of dry steam passing in the same time, and x = Dryness fraction of wet steam. We know that dryness fraction, $x = \frac{\text{Mass of dry steam}}{\text{Mass of wet steam}} = \frac{M}{M+m}$	2m(expl.)	
e)	**Induced draught cooling tower:-**  • Working of this cooling tower is same as that of forced draught type. • Only difference is that, the circulation of air is produced by means of fans placed at the top of tower. i.e. air enters at the bottom due to vacuum created inside cooling tower. • It is also called as mechanical draught cooling tower.	2m (dia.) 2m (expl.)	4m

f)	Applications of heat exchanger:- a) Dairy industry. (b) Food industries. (c) Refrigeration and air-conditioning. (d) Steam and gas turbine power plants. (e) Internal combustion engines. (f) Milk chiller of pasteurizing plant	4m(any four)	4m
5	**Attempt any two**	**8m x 2**	**16m**
a)	FORMATION OF STEAM AT CONSTANT PRESSURE  Let 1 kg of water at o^{0}C and at atmospheric pressure is to be converted into steam. The heat is added to the water in followin stages. 1. I-II: • The water at o0 C is heated to 1oo^{0}C i.e. boiling point of water at atmospheric pressure. The temperature rise can be sensed by thermometer, therefore the heat added is called as sensible heat of water (fluid) and denoted by hf. • Also, no phase change occurs, i.e. water (liquid phase) will exist. 2. II - III: • Now the water in liquid phase at 100^{0}c is further heated, but as the water is in saturated state, its temperature does not increase, but liquid is transformed or vapourized to vapour form i.e. phase changes from liquid to gas. • The heat added during this cannot be sensed by thermometer and therefore called as latent heat of vapourization of water, denoted by hfg. 3. III-IV:	4m(dia.) 2m 2m	8m

	• Now, the steam is in dry saturated state i.e. no moisture is present in the steam. When heat is further added to dry saturated vapour, it is converted into superheated steam. • Temperature of superheated steam is called as superheated temperature.		
b)	Two Pass Surface Condensers  • In surface condenser, the cold water flows through the tubes and the steam passes over the tubes. Fig. shows a two pass surface condenser. • It consists of a horizontal cylindrical shell, having cover plates at the ends. • The cylindrical shell comprises of number of parallel brass tubes. • A baffle plate is used to divide the water box into two sections. • The cold water enters the shell at the lower half section and after passing through the tubes, comes out from the upper half section. • The exhaust steam enters the shell from the top side and passes over the tubes to get condensed. • The condensate is finally removed by an extraction pump. • Due to the reason that, steam flows in a direction right angle to the direction of flow of water and in the downward direction, this type of surface condenser can be called as cross-surface condenser and down flow type.	4m (dia.) 4m(expl.)	8m

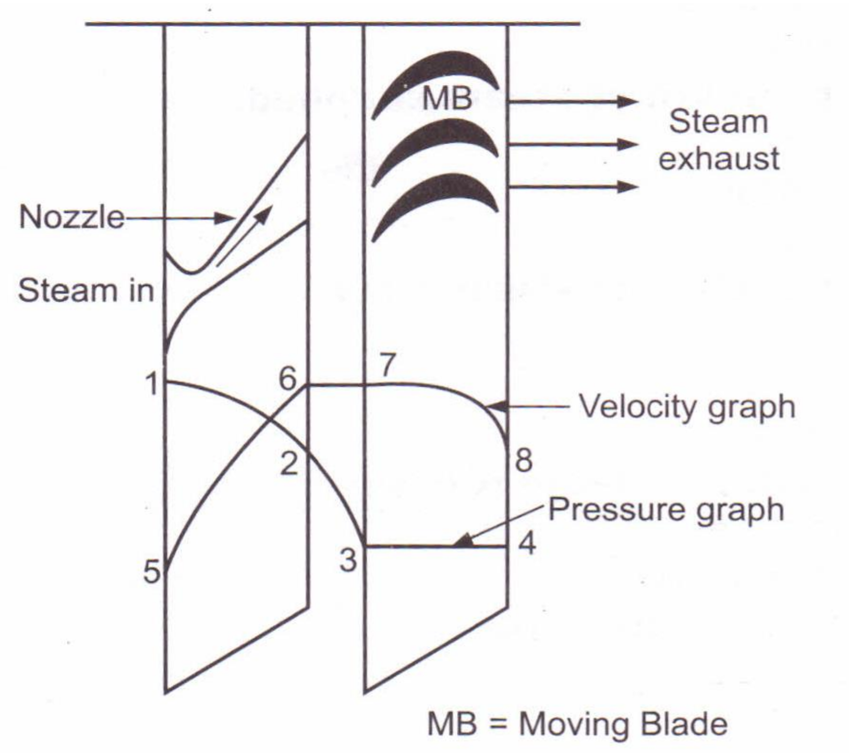
c)	 Given data :- $r_c = 8$ $P_1 = 1$ bar $T_1 = 18^{\circ}C$ $= 18 + 273 = 291$ K $q_A = 250$ KJ/kg. To find, (i) Maximum Temp. (T_3) (ii) Air standard efficiency (iii) Workdone per cycle (iv) Heat rejected during the cycle Sol^n :- (i) $\frac{T_1}{T_2} = \left(\frac{V_2}{V_1}\right)^{\gamma-1} = (r_c)^{\gamma-1}$ $\frac{291}{T_2} = (8)^{(1.4-1)}$ $T_2 = 668.54$ K $\therefore$ Heat supplied $= mC_v(T_3 - T_2)$ $250 = 1 \times 0.71(T_3 - 668.54)$ $\therefore T_3 = 1020.65$ K	2m	8m

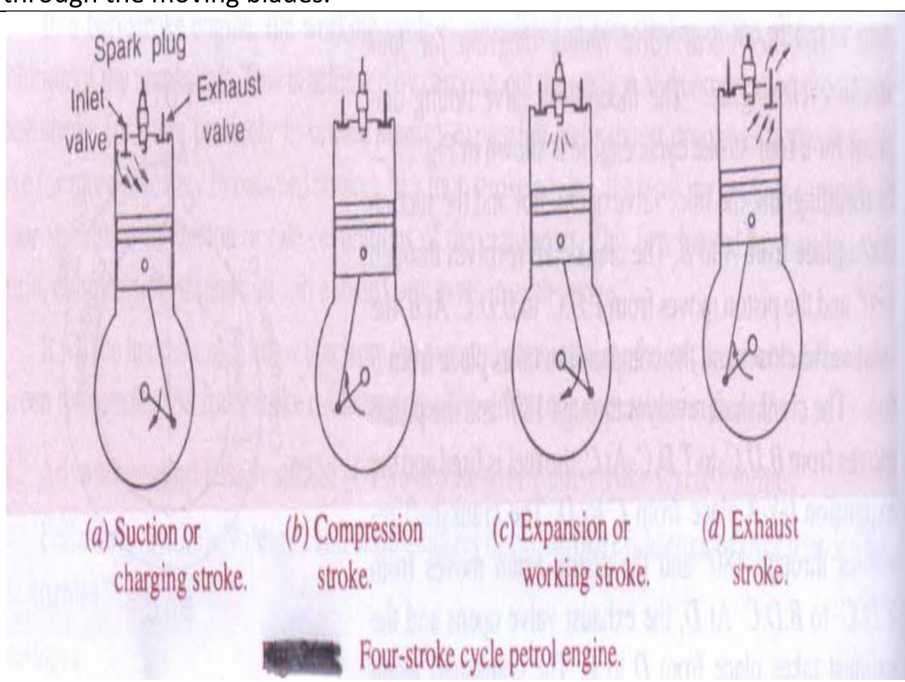
	(ii) Air standard efficiency :— $\eta = 1 - \frac{1}{r_c^{\gamma-1}}$ $= 1 - \frac{1}{8^{(1.4-1)}}$ $= 0.5647$ $\boxed{\eta = 56.47\%}$	2m	
	(iii) Work done per cycle :— Heat rejected $(q_R) = m c_v (T_4 - T_1)$ $\therefore \frac{T_3}{T_4} = (r_c)^{\gamma-1}$ $\therefore \frac{1020.65}{T_4} = (8)^{1.4-1}$ $\therefore T_4 = 444.26\ K$ $\therefore q_R = m c_v (T_4 - T_1)$ $= 1 \times 0.71 (444.26 - 291)$ $\boxed{q_R = 108.81\ kJ/kg}$ heat rejected	2m	
	(iv) $\therefore \eta = \frac{\text{Work done}}{\text{heat supplied}} =$ $0.5647 = \frac{\text{work done}}{250}$ $\boxed{W.D = 141.175\ kJ/kg}$	2m	

<table>
<tr><td>6</td><td>Attempt any two</td><td>8m x 2</td><td>16</td></tr>
<tr><td>a)</td><td>Cochran boiler:


Cochran Boiler (Elevation)
Construction and Working:
• It consists of an external cylindrical shell and a firebox. The shell and firebox are both hemispherical.
• The hemispherical crown of the boiler shell gives maximum space and strength to withstand the pressure of steam inside the boiler.
• The hemispherical crown of the firebox is useful for resisting intense heat.
• A short pipe connects the firebox and the combustion chamber.
• The flue gases from the combustion chamber flow to the smoke box through a number of smoke tubes.
• While passing through the tube, the flue gases reject the heat to water and thus water is heated resulting into steam formation.
• The gases from the smoke box pass to the atmosphere through a chimney. The combustion chamber is lined with firebricks on the shell side.
• A manhole near the top of the crown on the shell is provided for cleaning.
• At the bottom of the firebox, there is a grate and the coal is fed through the fire hole. If the boiler is used for oil firing, no grate is</td><td>4m(dia.)

4m(expl.)</td><td>8m</td></tr>
</table>

	provided, but thebottom of the firebox is lined with firebricks and is fitted at the fire hole. • Cochran boilers are used, where the floor space available is less.		
b)	Impulse turbine  Construction: It consists of mainly three components. 1. Nozzle: • It is a circular guide-way, which guides the steam to flow in the designed direction and velocity. • It also regulates the flow of steam. • It is kept very close to the blades to minimize the losses due to windage. 2. Runner and blades: • It consists of circular disc fixed to a horizontal shaft. On the periphery of the runner, numbers of blades are fixed uniformly. • The steam jets strike on the blades, which move in the direction of the jet. This movement of the blades makes the runner to rotate. • The surface of the blades is made smooth to minimize the frictional losses. • It has been observed that, the blades do not wear out equally with the time. A few of them get worn out and damaged early. Therefore, the blades are bolted to the runner disc, for easy replacement of worn out blades. 3. Casing: • It is an air-tight metallic case, which contains the turbine runner and blades. It controls the movement of steam from the blade to the	4m(dia.) 2m	8m

	condenser, and does not permit it to move into the space. It also acts as a safeguard of runner against any accident. Working: • Fig shows the working of Impulse turbine • The top portion of figure shows one set of nozzles, which is followed by a ring of moving blades. • As the name indicates, the power is generated by the impulsive force of high velocity steam jets. • These high velocity jets are obtained due to expansion of steam in the stationary nozzles only. The steam then passes through moving blades with no further pressure drop, but a gradual decrease in velocity. • After striking the high velocity steam jets over the curved blades mounted on the wheel, the direction and hence momentum of velocity jets is changed, which produces a force on wheel. This force causes the shaft to rotate. • The lower part of the diagram shows the approximate changes in pressure and velocity during the flow of steam through the turbine. • The pressure of steam jet is reduced in the nozzle and remains constant whilepassing through the moving blade. • The velocity of steam is increased in nozzle, and is reduced while passing through the moving blades.	2m	
c)	 Four-stroke cycle petrol engine. Four-stroke Cycle Petrol Engine It is also known as Otto cycle. It requires four strokes of the piston to complete one cycle of operation in the engine cylinder. The four strokes of a petrol engine sucking fuel-air nixture (petrol mixed with proportionate quantity of air in the carburettor known as charge) are described below 1. Suction or charging stroke. In this stroke, the inlet valve opens and charge is suckedinto the cylinder as the piston moves downward from top	4m (dia.) 4m(expl.)	8m

	dead centre (T.D.C.). It continues till thepiston reaches its bottom dead centre (B.D.C.) as shown in Fig. (a). 2. Compression stroke. In this stroke, both the inlet and exhaust valves are closed and the charge is compressed as the piston moves upwards fromB.D.C. to T.D.C. As a result of compression the pressure and temperature of the charge increases considerably (the actual values depend upon the compression ratio). This completes one revolution of the crankshaft. The compression stroke is shown in Fig. (b). 3.Expansion or working stroke. Shortly before the piston reaches T.D. C. (during compresssion stroke), the charge is ignited with the help of a spark plug. It suddenly increases the pressure and temperature of the products of combustion but the volume, practically, remains constant. Due to the rise in pressure, the piston is pushed down with a great force. The hot burnt gases expand due to high speed of the piston. During this expansion, some of the heat energy produced is transformed into mechanical work. It may be noted that during this working stroke, as shown in Fig. (c), both the valves are closed and piston moves from T.D.C. to B.D.C.		