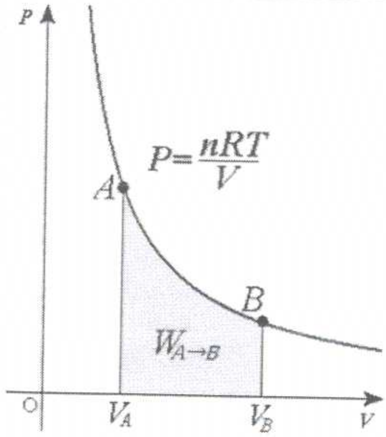
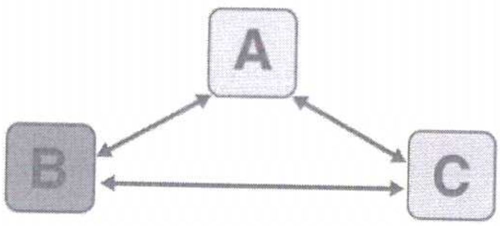
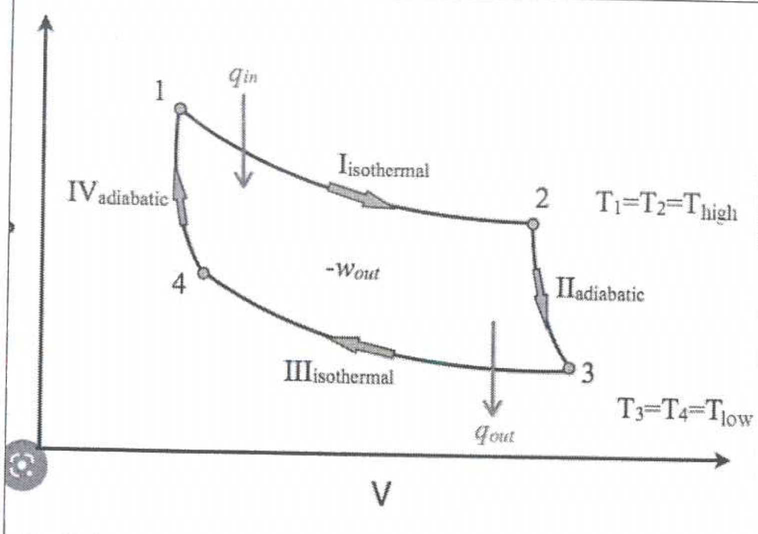
Scoring Indicators

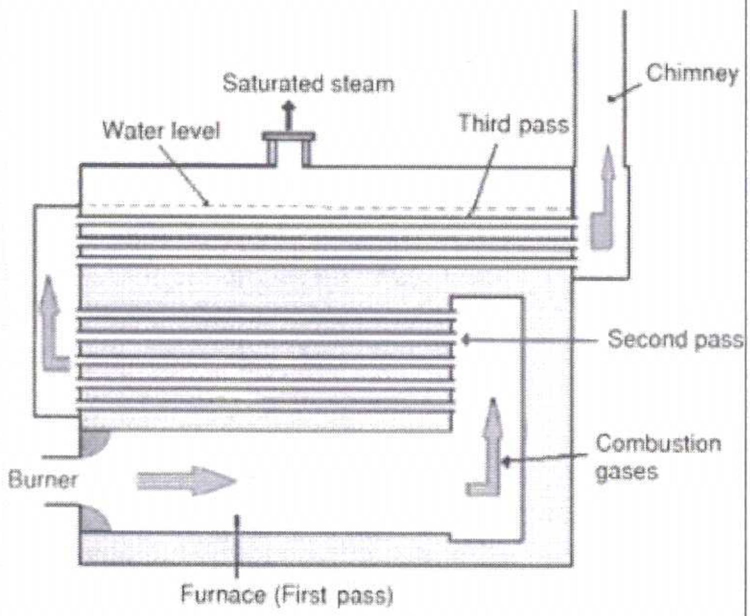
COURSE NAME : THERMAL ENGINEERING

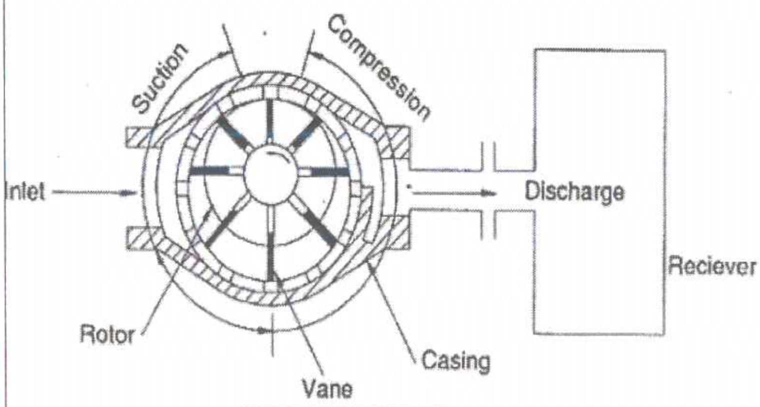
COURSE CODE : 4021

QID : 2103230224

Q No	Scoring Indicators	Split score	Sub Total	Total score
	PART A			9
I. 1	U+PV	1	1	
I. 2	Extensive properties	1	1	
I. 3	14.7 : 1	1	1	
I. 4	Otto cycle	1	1	
I. 5	14 : 1 to 22:1	1	1	
I. 6	Latent heat	1	1	
I. 7	Blow off cock	1	1	
I. 8	Roots blower, Vane blower, Screw compressor	1	1	
I. 9	LMTD = $\Delta T_1 - \Delta T_2 / (\ln \Delta T_1 / \Delta T_2)$ = (249-173.5) / ln(249/173.5) = 208.98K	1	1	
	PART B			24
II. 1	Charles law states that the volume of an ideal gas is directly proportional to the absolute temperature at constant pressure. Joule's law: This law states that the internal energy of a given quantity of a gas depends only on the temperature. Avogadro's law, also known as Avogadro's principle or Avogadro's hypothesis, is a gas law which states that the total number of atoms/molecules of a gas (i.e. the amount of gaseous substance) is directly proportional to the volume occupied by the gas at constant temperature and pressure.	3	3	
II. 2	Thermodynamic equilibrium, condition or state of a thermodynamic system, the properties of which do not change with time and that can be changed to another condition only at the expense of effects on other systems.	3	3	

II. 3		3	3	
II. 4	When a body 'A' is in thermal equilibrium with another body 'b', and also separately in thermal equilibrium with a body 'C', then body 'B' and 'C' will also be in thermal equilibrium with each other. This statement defines the zeroth law of thermodynamics. The law is based on temperature measurement 	3	3	
II 5		3	3	
II. 6	The mechanical efficiency of the internal combustion engine is defined as the ratio of the brake power delivered by the engine to the gross indicated power. The specific fuel consumption of an engine is the rate of fuel burnt	1 X 3	3	

	to produce a unit of thrust. $$\eta_{indicated} = \frac{\text{Indicated power}}{\dot{m}_f \times Cv}$$			
II.7	The process of throttling involves utilizing a throttle valve to change a high-pressure fluid into a low-pressure fluid. Throughout the throttling process, enthalpy is constant and work is negligible. And it is a very fast process so it is considered in an adiabatic process.	3	3	
II.8		3	3	
II. 9	**Solution :** Given Area of cross section, $A = 0.5\ m^2$ Thickness of the glass pane, $l = 6\ mm = 6 \times 10^{-3}\ m$ Absolute inside temperature of the glass, $T_1 = 23 + 273 = 296\ K$ Absolute outside temperature of the glass, $T_2 = 2 + 273 = 275\ K$ Thermal conductivity of glass, $k = 1\ W/mK$ Time for which heat flows, $t = 1\ hr = 3600\ s$	3	3	

	Amount of heat flows per second, $Q = \frac{kA(T_1 - T_2)}{l}$ $= \frac{1\times 0.5\times(296-275)}{6\times10^{-3}} = 1750\text{W}$ $\therefore$ Amount of heat transferred, $Q = 1750\times3600 = 63\times10^{5}\text{J}$ $= \mathbf{6300kJ}$			
II.10	Rotary vane compressors consist of a cylindrical casing, two openings - one suction and one discharge - and a rotor positioned eccentrically with respect to the casing. Compression occurs by refrigerant flowing into the chamber where, due to eccentric rotation, there is a reduction in the desired volume.  Vane Compressor	1 2	3	

<table>
<tr><td></td><td>PART C</td><td></td><td></td><td>4
2</td></tr>
<tr><td>I.</td><td>In thermodynamics, an isochoric process, also called a constant-volume process, an isovolumetric process, or an isometric process, is a thermodynamic process during which the volume of the closed system undergoing such a process remains constant.

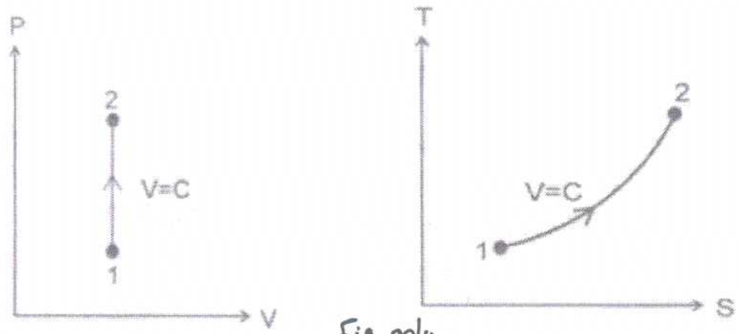


Fig only

An isobaric process is a process occurring at constant pressure. The first law of thermodynamic equation for the isobaric process remains the same as the pressure remains constant and because of the volume change, the system does work

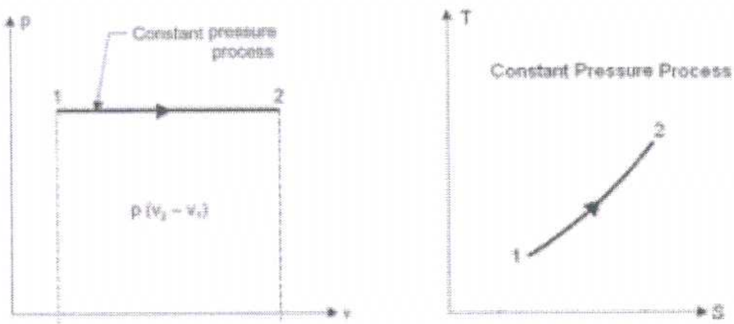


Fig only

The term "polytropic" was originally coined to describe any reversible process on any open or closed system of gas or vapor which involves both heat and work transfer, such that a specified combination of properties were maintained constant throughout the process.</td><td>7</td><td>7</td><td>7</td></tr>
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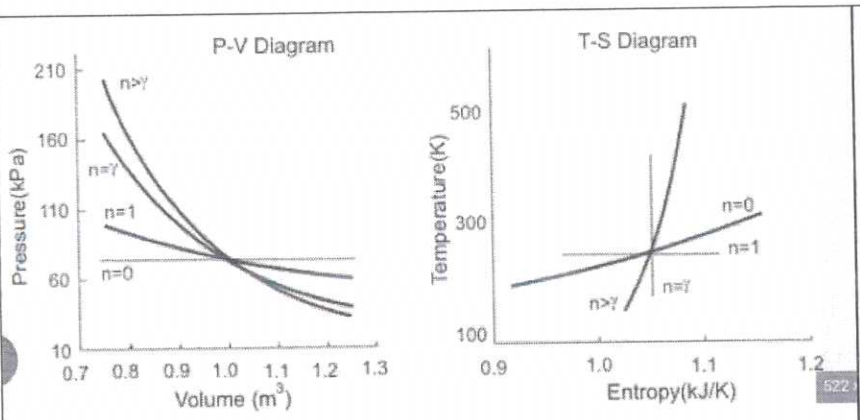
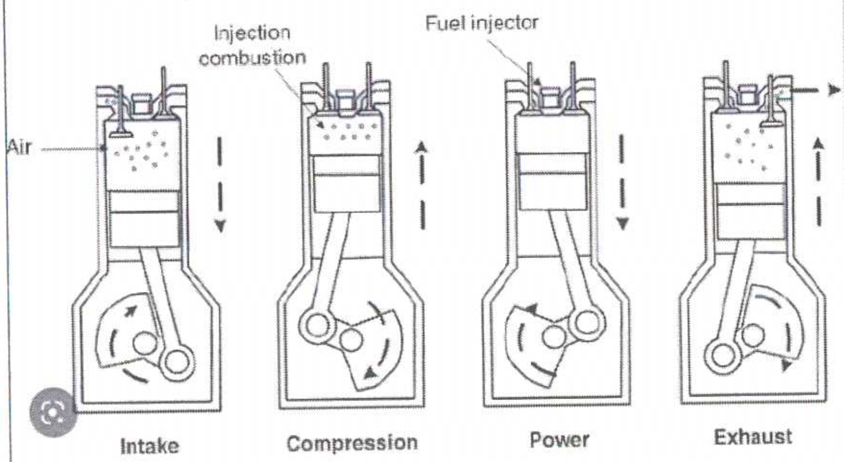
<tr><td></td><td>

Fig only</td><td></td><td></td><td></td></tr>
<tr><td>III. 2</td><td>**Solution** :Given
Mass of gas, $m = 2$ kg
Initial absolute temperature, $T_1 = 37 + 273 = 310$ K
Specific heat at constant volume, $c_v = 0.72$ kJ/kg K
Let the initial pressure is p_1 then final pressure is $2p_1$, since it is a constant volume process.
using Gay-lussac law, i.e., $\frac{p_1}{T_1} = \frac{p_2}{T_2}$
Final absolute temperature of the gas , $T_2 = \frac{p_2 T_1}{p_1} = \frac{2p_1 \times 310}{p_1} = 620\text{K}$
Final temperature of the gas, $t_2 = 620 - 273 = \mathbf{347^0C}$ (A
Work done during constant volume process is zero $W_{1\text{-}2} = \mathbf{0}$ (A
Using the relation for heat transferred in constant volume process, i.e., $Q_{1\text{-}2} = mc_v(T_2 - T$
$Q_{1\text{-}2} = 2 \times 0.72 \times (620 - 310) = \mathbf{446.4\ kJ}$ (A
transferred in constant volume process.</td><td>7</td><td>7</td><td>7</td></tr>
<tr><td>III. 3</td><td>**Four-stroke cycle (Diesel)**

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	Suction/Intake Stroke Intake stroke occurs when the air-fuel mixture is introduced to the combustion chamber. In this stroke, the piston moves from TDC (Top Dead Center – the farthest position of the piston to the crankshaft) to BDC (Bottom Dead Center – the nearest position of the piston to the crankshaft.) The movement of the piston towards the BDC creates a low-pressure area in the cylinder. The inlet valve remains to open a few degrees of crankshaft rotation after BDC. The intake valve then closes, and the air-fuel mixture is sealed in the cylinder Compression Stroke In compression stroke, the trapped air-fuel mixture is compressed inside the cylinder. During the stroke, the piston moves from BDC to TDC, compressing the air-fuel mixture. The momentum of the flywheel helps the piston move forward. Compressing the air-fuel mixture allows more energy to be released when the charge is ignited. The charge is the volume of compressed air-fuel mixture trapped inside the combustion chamber ready for ignition. The inlet and outlet valves must be closed to ensure that the cylinder is sealed, resulting in compression Power/Combustion Stroke The second rotation of the crankshaft begins when it completes a full rotation during the compression stroke. The power stroke occurs when the compressed air-fuel mixture is ignited with the help of a spark plug. Ignition or Combustion is the rapid, oxidizing chemical reaction in which a fuel chemically combines with oxygen in the atmosphere and releases energy in the form of heat. The hot expanding gases force the piston head away from the cylinder head. Exhaust Stroke As the piston reaches BDC during the power stroke, combustion is complete, and the cylinder is filled with exhaust gases. The exhaust valves open during this stroke, and the inertia of the flywheel and other moving parts push the piston back to TDC, forcing the exhaust gases through the open exhaust valve. At the end of the exhaust stroke, the piston is at TDC, and one operating cycle has been completed	3	7	7

III. 4	**Solution** : Swept volume per cylinder $V_s = \frac{\pi}{4} d^2 l$ Compression ratio $r = \frac{V_s + V_c}{V_c} = \frac{315.08 + 63}{63} = 6$ Air standard efficiency $\eta = 1 - \frac{1}{r^{r-1}} = 1 - \frac{1}{(6)^{1.4-1}} = 0.512$ Then: Brake thermal efficiency = relative efficiency × air standard efficiency $\eta_{bth} = 0.5 \times 0.512 = 0.2562$ Brake power $BP = 2\pi NT$ $= 2\pi \times 3000 \times 64$ $= 1205760$ Nm/min $= 20096$ Nm/s $\simeq 21.1$ kW Brake power per cylinder $= \frac{21.1}{4}$ $= 5.025$ kW The brake power per cylinder is also given as $BP/\text{cylinder} = \frac{100 p_m L A n}{60}$ where p_m is mep in bar, L and A are the stroke length (m) piston area (m^2) respectively, n is the number of working strokes per minute. For a 4-stroke engine $n = \frac{N}{2}$ (N is the engine speed in rev/min) $\therefore 5.025 = \frac{100\, p_m \times 0.095 \times \frac{\pi}{4}(0.065)^2 \times \frac{3000}{2}}{60}$ Solution gives : Brake mean effective pressure $p_m = 6.38$ bar (b) Brake thermal efficiency $\eta_{bth} = \frac{BP}{m_f \times CV}$ That is : $0.2562 = \frac{21.1}{m_f \times 42000}$; $m_f = \frac{21.1}{0.2562 \times 42000}$ $= 1.96 \times 10^{-3}$ kg/s = **7.06 kg/hr**	7	7		7
III. 5	• In (a), the process is reversible isothermal gas expansion. In this process, the amount of heat absorbed by the ideal gas is q_{in} from				

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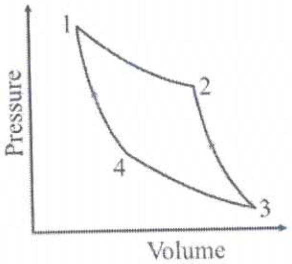
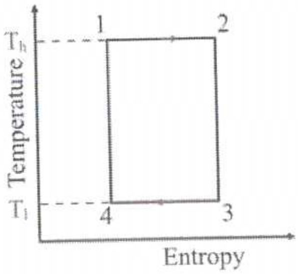
the heat source at a temperature of T_h. The gas expands and does work on the surroundings.

- In (b), the process is reversible adiabatic gas expansion. Here, the system is thermally insulated, and the gas continues to expand and work is done on the surroundings. Now the temperature is lower, T_l.
- In (c), the process is a reversible isothermal gas compression process. Here, the heat loss q_{out} occurs when the surroundings do the work at temperature T_l.
- In (d), the process is reversible adiabatic gas compression. Again the system is thermally insulated. The temperature again rises back to T_h as the surrounding continue to do their work on the gas

1-2 : Isothermal expansion
2-3 : Adiabatic expansion
3-4 : Isothermal compression
4-1 : Adiabatic compression





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<td>III. 6</td>
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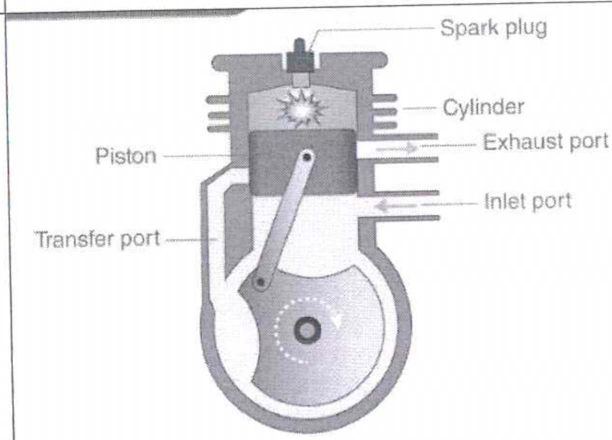

Down Stroke

The piston moves from TDC (Top-Dead-Center) to BDC (Bottom-Dead-Center) letting the fresh air enter the combustion chamber. The fresh air-fuel mixture gets into the combustion chamber through the crankcase. In this stroke, the crankshaft makes the rotation of 1800.
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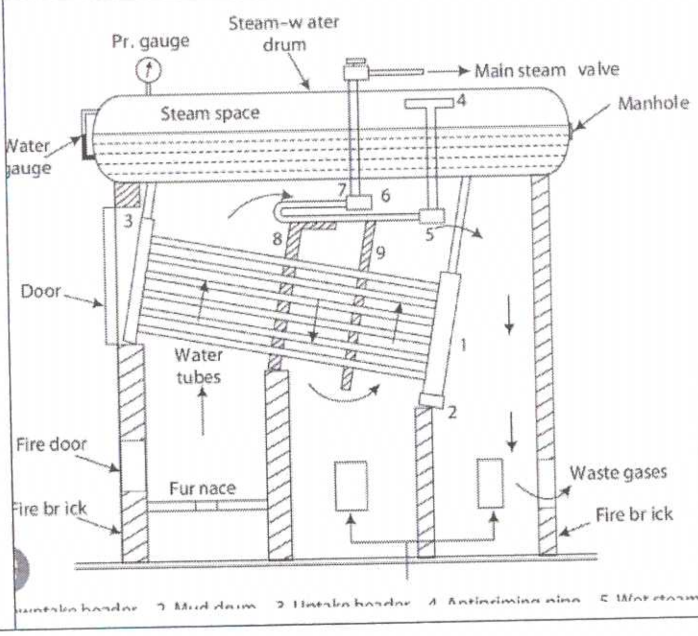
	<u>Up Stroke</u> The piston is pushed from BDC to TDC. As a result, the fuel-air mixture gets compressed and the spark plug ignites the mixture. The mixture expands and the piston is pushed down. The inlet port is open during the upstroke. While the inlet port is opened, the mixture gets sucked inside the crankcase. When the mixture is pushed up into the combustion chamber during the previous upstroke, a partial vacuum is created as no mixture is left behind in the crankcase. This mixture is ready to go into the combustion chamber during downstroke but remains in the crankcase until the piston goes up to TDC. In this stroke, the crankshaft makes the rotation of 1800. From the 2nd downstroke onwards the exhaust gases get expelled out from one side while a fresh mixture enters into the combustion chamber simultaneously due to a partial vacuum created in the combustion chamber after the removal of exhaust gases. This is the beauty of the engine. Both things happen at the same time which makes it a 2-stroke engine. The exhaust gases are expelled from the 2nd downstroke onwards from one side while simultaneously a fresh mixture of air and fuel is injected into the combustion chamber due to the partial vacuum created in the combustion chamber after the removal of exhaust gases			
III. 7		7	7	7

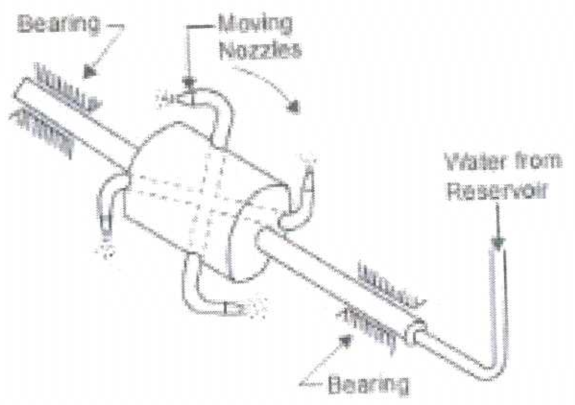
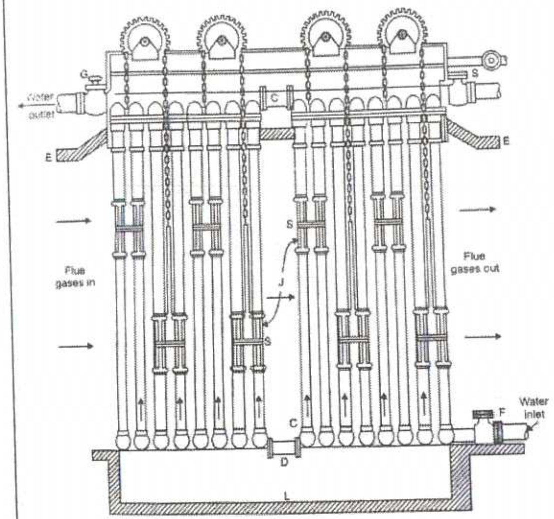
<table>
<tr><td>III. 8</td><td>

Fig. 1.17. Reaction Turbine.</td><td>4</td><td>7</td><td>7</td></tr>
<tr><td></td><td>A reaction turbine is constructed of rows of fixed blades and rows of moving blades. The fixed blades act as nozzles. The moving blades move as a result of the impulse of steam received (caused by a change in momentum) and also as a result of expansion and acceleration of the steam relative to them.</td><td>3</td><td></td><td></td></tr>
<tr><td>III. 9</td><td>
</td><td>4</td><td>7</td><td>7</td></tr>
<tr><td></td><td>The Economizer in Boiler works on the principle of Heat Transfer. Heat transfer usually takes place from high temperature to low temperature. In the case of Boilers, flue gases or exhaust from the boiler outlet are at high temperature and water that needs to be preheated is at low temperature.</td><td>3</td><td></td><td></td></tr>
<tr><td>III.</td><td>Principle of Water Level Indicator. The working principle of a water</td><td></td><td></td><td></td></tr>
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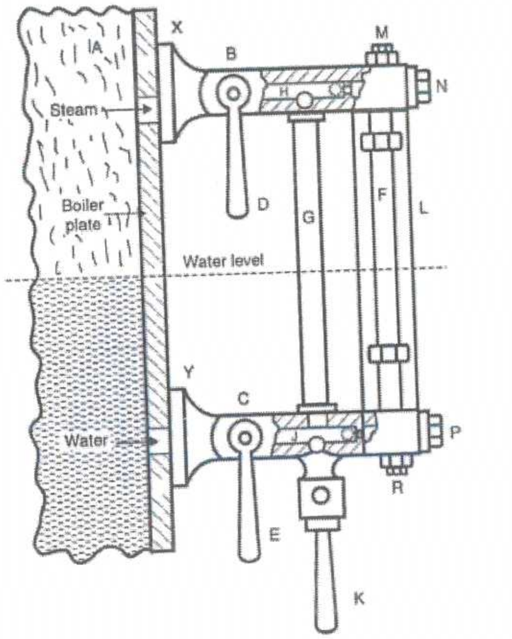
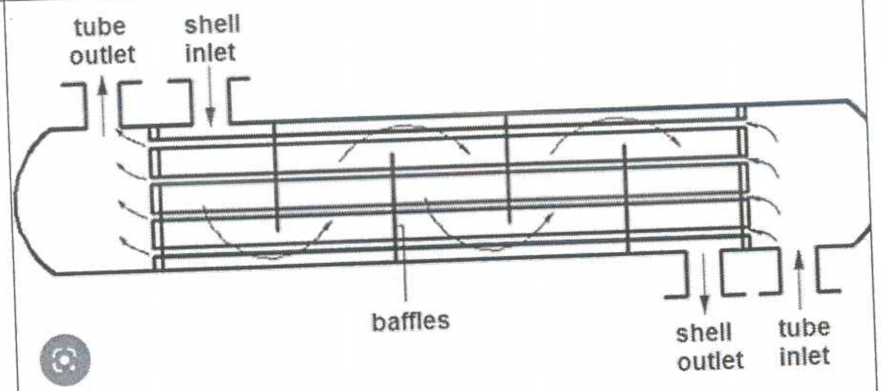
10	level indicator is actually quite simple. Water level indicators work by using sensor probes to indicate water levels in a storage tank. These probes send information back to the control panel to trigger an alarm or indicator.  *A* = End plate of boiler *B* and *C* = Hollow gun metal castings *D* and *E* = Cocks *F* = Gauge glass *G* = Hollow metal column *H* and *J* = Two balls *K* = Drain cock *L* = Guard glass *M, N, P, R* = Screwed caps *X, Y* = Flanges	3 4	7	7
III. 11	 A shell and tube heat exchanger is a device where two working fluids exchange heat by thermal contact using tubes housed within a cylindrical shell. The fluid temperature inside the shell and tube are different and this temperature difference is the driving force for temperature exchange.	4 3	7	7

III. 12

Solution : Given

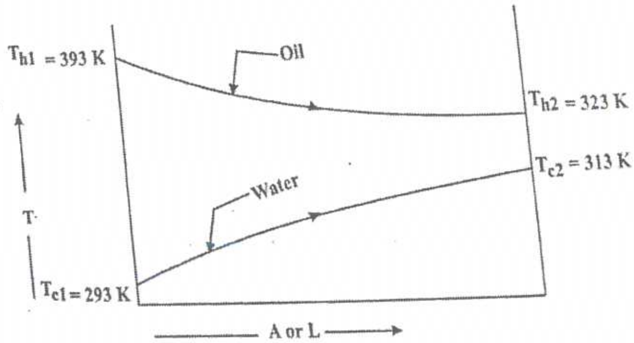
Inlet absolute temperature of oil, T_{h1} = 120+273 = 393 K

Outlet absolute temperature of oil, T_{h2} = 50+273 = 323 K

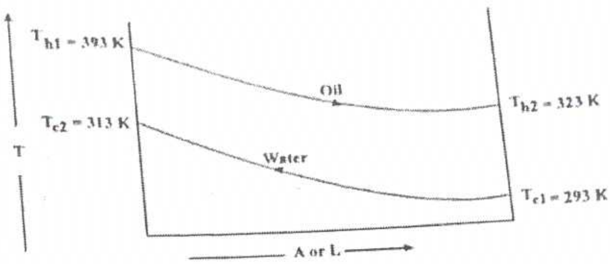
Inlet absolute temperature of cooling water, T_{C1} = 20+273 = 293 K

Outlet absolute temperature of cooling water, T_{c2} = 40+273 = 313K

Refer Fig 9.9 (a) and (b)



(a) Parallel flow



(b) Counter current

Fig. 9.9

i) Parallel flow heat exchanger

$\Delta T_1 = T_{h1} - T_{C1}$ = 393 − 293 = 100K

$\Delta T_2 = T_{h2} - T_{C2}$ = 323 − 313 = 10K

$$\text{LMTD},= \frac{\Delta T_1 - \Delta T_2}{ln\frac{\Delta T_1}{\Delta T_2}} = \frac{100-10}{ln\frac{100}{10}} = 39.0865\ \text{K} = \mathbf{39.0865^oC}$$

(ii) Counter current heat exchanger.

$\Delta T_1 = T_{h1} - T_{C2}$ = 393 − 313 = 80 K

$\Delta T_2 = T_{h2} - T_{C1}$ = 323 − 293 = 30 K

$$\text{LMTD}, = \frac{\Delta T_1 - \Delta T_2}{ln\frac{\Delta T_1}{\Delta T_2}} = \frac{80-30}{ln\frac{80}{30}} = 50.9773\text{K} = \mathbf{50.9773^oC}$$

7 7 7