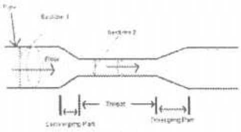
115 21-11-23 DA Nov.23

Scheme of Evaluation

Q No	Solution	Distribution of marks
	Part A	
1	Absolute Pressure = Atmospheric pressure +/- gauge pressure	2 marks
2	P=density x accelration due to gravity x pressure head	2 marks
3	 Venturimeter	2 marks
4	Impulse and reaction turbines	1 marks each
5	Specific speed is defined as the rotational speed (revolutions per minute) at which a hydraulic turbine would operate at best efficiency under unit head (one meter) and which is sized to produce unit power (one kilowatt).	2 marks
	Part B	
1	For an incompressible, frictionless fluid, the combination of pressure and the sum of kinetic and potential energy densities is constant not only over time, but also along a streamline: $p + \frac{1}{2}\rho v^2 + \rho g y = constant$	eqn - 3 marks terms - 1 mark each
2	steady - flow properties does not change with time unsteady - changes with time uniform - no change with respect to space non-uniform - chamges with space coordinates	3 marks 3 marks
3	**Water hammer** occurs **due to a sudden rise of pressure.** This sudden rise in the pressure can occur **because of the sudden closure of the valve** or other similar activities which suddenly stops the flow in. When suddenly the pipe gets closed then **entire kinetic energy is get converted into pressure energy** and generates a **high-pressure wave.** Propagation of these **high-pressure waves creates a sound in the pipe and imparts a large force** on the pipe wall due to that pipe can bust out. This phenomenon is called a water hammer.	6 marks
4	spark ignition compression ignition explanation	names - 2 marks 4 marks
5	**The main difference between fire tube and water tube boilers is, fire tube boilers are internally fired, and hot flue gases pass through the tube, and in the water tube boilers the hot flue gases do not pass through the tube, they surround the tube and water tube is externally fired boilers.** diagram	4 marks 2 marks
6	Francis turbine and Kaplan turbine	2 marks
	Runner **Draft tube** Penstock Tail race Guide vanes adjustable vanes	4 marks

7 impeller: rotating part

foot valve: one way type valve at the inlet from the sump

net head: sum of suction adn delivery head — 2 marks each

Part C

III

a *Data given:* — 1 mark

Pressure head (in meters of water), $h_w = 15\ m$ of water

Required:

To find (a) Pressure head, h_{oil}, in meters of oil of specific gravity 0.75

(b) Pressure head, h_m, in meters of mercury of specific gravity 13.6

(a) We have,

$$p = \gamma_w h_w = \gamma_{oil} h_{oil}$$

where, p = intensity of pressure in gage units in N/m^2

h_w = equivalent column of water in meters to exert the pressure intensity of p

γ_{oil} = specific weight of oil = (specific gravity of oil) x (specific weight of water)

$= 0.75 \times 9810\ N/m^3 = 7357.5\ N/m^3$

h_{oil} = equivalent column of oil of specific gravity 0.75, in meters, to exert the pressure intensity of p

$$\therefore h_{oil} = \frac{\gamma_w h_w}{\gamma_{oil}} = \frac{(9810 N/m^3)(15m)}{7357.5 N/m^3} = \mathbf{20\ m\ of\ oil}$$

4 marks

(b) We have,

$$p = \gamma_w h_w = \gamma_m h_m$$

where, p = intensity of pressure in N/m^2

γ_w = specific weight of water = 9810 N/m^3

h_w = equivalent column of water in meters to exert the pressure intensity of p

γ_m = specific weight of mercury = (specific gravity of mercury) x (specific weight of water)

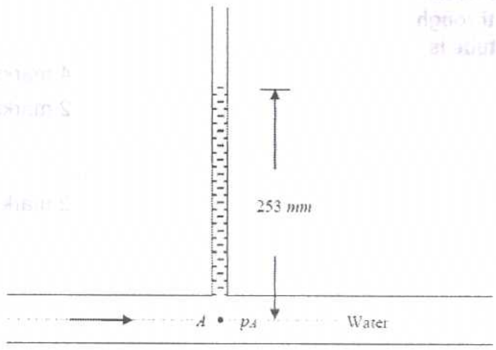
$= 13.6 \times 9810\ N/m^3 = 133416\ N/m^3$

h_m = equivalent column of mercury of specific gravity 13.6, in meters, to exert the pressure intensity of p

$$\therefore h_m = \frac{\gamma_w h_w}{\gamma_m} = \frac{(9810 N/m^3)(15m)}{133416 N/m^3} = \mathbf{1.1029\ m\ of\ mercury}$$

4 marks

b



2 marks

Let the pressure at point A in the centerline of the pipeline be p_A

Atmospheric pressure, $p_{atm} = \gamma_w h$

Atmospheric pressure, $p_{atm} = \gamma_w h$

where γ_w = specific weight of water = 9810 $N\,m^{-3}$

h = column of water equivalent of atmospheric pressure = 10.3 m

Hence, $p_{atm} = (9810\ N\,m^{-3}) \times (10.3\ m) = 101043\ N\,m^{-2}$ 2 marks

In gauge units:

$p_A = \gamma_w h_A$

where γ_w = specific weight of water = 9810 $N\,m^{-3}$
h_A = rise of water in the piezometer measured from the point A
= 253 mm = 0.253 m 1 mark

Hence, $p_A = (9810\ N\,m^{-3}) \times (0.253\ m) = 2482\ N\,m^{-2}$ (gauge)

Absolute pressure at A = atmospheric pressure + gauge pressure at A
= $101043\ N\,m^{-2} + 2482\ N\,m^{-2}$
= $103525\ N\,m^{-2}$ 1 mark

IV

a *Given:* $h_{CCl_4} = 20$ cm = 0.2 m; $\rho_{CCl_4} = 1.596$ g/cm³ drawing - 2 marks

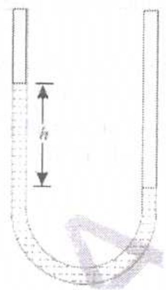
$= 1.596 \times 10^3$ kg/m³

$\rho_{Hg} = 13.6 \times 10^3$ kg/m³ Data given - 1 mark

Pressure drop, $\Delta p = \rho_{CCl_4} g h_{CCl_4}$ Pressure drop - 3 marks

$= 1.596 \times 10^3 \times 9.81 \times 0.2$ N/m²

$= 3131.3$ N/m² or Pa = **3.131 kPa** (Ans.)



The difference in level with mercury,

$$h_{Hg} = h_{CCl_4} \times \frac{\rho_{CCl_4}}{\rho_{Hg}} = 0.20 \times \frac{1.596 \times 10^3}{13.6 \times 10^3}$$

$= 0.02347$ m or **2.347 cm** (Ans.) 3 marks

b Specific gravity of water, S1 = 1

Specific gravity of mercury, S2 = 13.6

Height of water in the left limb,

$h_1 = 40$ mm = 0.04 m diagram - 2 marks

Height of mercury in the left limb,

$h_2 = 100$ mm = 0.1 m

Let, h = Pressure in the pipe in terms of head of water (*below* the atmosphere).

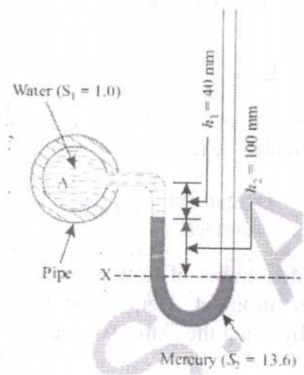
Equating the pressure heads above the datum line X–X, we get:

$$h + h_1 S_1 + h_2 S_2 = 0$$

or, $h = -(h_1 S_1 + h_2 S_2)$

$= -(0.04 \times 1 + 0.1 \times 13.6)$

$= -1.4$ m of water h - 2 marks



Pressure p is given by:

$p = wh$

$= 9.81 \times (-1.4)$ kN/m²

$= -13.73$ kPa

$=$ **13.73 kPa (vacuum) (Ans.)** p - 2 marks

V

a

$$Q = C_d \frac{A_1 A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$$ 2 marks

$$A_1 = \frac{\pi}{4} \times 0.19^2 = 0.0284\ \text{m}^2$$ 1 mark

$\frac{7500 \times 10^{-3}}{} = \frac{0.96 \times 0.0284\, A_2}{} \sqrt{2 \times 9.81 \times 8}$ Solving A_2 = 0.0098 m²

60 $\quad \sqrt{0.0284^2 - A_2^2}$ $\sqrt{2 \times 9.81 \times 6}$, Solving $A_2 = 0.0098$ m

1 marks

Let the diameter be d, $\frac{\pi}{4} \times d^2 = 0.0098$

$$\therefore \quad d = \sqrt{\frac{4 \times 0.0098}{\pi}} = 9.9 \text{ cm}$$

2 marks

b

Venturimeter can be used to measure the flow rates of all incompressible flows

It is installed in pipeline only and the accelerated flow thru the apparatus is subsequently decelerated to the original velocity at the outlet of the venturimeter

The flow velocity is measured by noting the pressure diff. bet. the inlet & throat

Venturimeter has excessive length

3 marks - 1 each for 1 point

Orificemeter is generally used to measure the flow rate of liquids

The entire potential energy of the fluid is converted to kinetic energy,and the jet discharges freely into the open atmosphere

The discharge velocity is measured by noting the pressure diff. bet. Vena contracta and inlet pipeline

The length of orificemeter is short and hence it can be used in a wide variety of application

3 marks - 1 each for 1 point

VI

a

Density of water, $\rho = 998\ kg\ m^{-3}$

Kinematic viscosity of water, $\nu = 1 \times 10^{-6}\ m^2 s^{-1}$

Dynamic viscosity of water, $\mu = \nu\rho = 1 \times 10^{-6} \times 998 = 0.000998\ N s\ m^{-2}$

Mean velocity of flow, $V = 2\ m\ s^{-1}$

Diameter of tube, $D = 30\ mm = 30 \times 10^{-3} = 0.030\ m$

Cross-sectional area of pipe, $A = \frac{\pi}{4}D^2 = \frac{\pi}{4}(30x10^{-3})^2 = 0.707143 \times 10^{-3}\ m^2$

Pressure gradient per unit length, $\frac{\Delta p}{L} = ?$

Data given - 2 marks

Rate of flow, $Q = A\ V = (0.707143 \times 10^{-3}) \times 2 = 1.414286 \times 10^{-3}\ m^3 s^{-1}$

To determine whether the flow is laminar or turbulent, let us compute the Reynolds number of flow.

$$Re = \frac{\rho VD}{\mu} = \frac{998x2x0.030}{0.000998} = 60000$$

1 mark

As Reynolds number of flow is more than 2000, the type of flow occurring in the pipe is turbulent. Hence, the loss of head due to pipe friction can be computed by using the Darcy-Weisbach's equation.

Darcy-Weisbach's equation: $h_f = \frac{4fL}{D}\frac{V^2}{2g}$

1 mark

where f = friction factor $= \frac{0.079}{Re^{1/4}} = \frac{0.079}{60000^{1/4}} = 0.005$

2 marks

$$h_f = \frac{4x0.005xL}{0.030} x \frac{2^2}{2x9.81}$$

1 mark

$$\Rightarrow \frac{h_f}{L} = \frac{4x0.002}{0.030} x \frac{2^2}{2x9.81} = 0.136\ m\ m^{-1}$$

$$\Rightarrow \frac{\left(\frac{\Delta p}{\gamma}\right)}{L} = 0.136\ m\ m^{-1}$$

$$\Rightarrow \frac{\Delta p}{L} = 0.136\gamma = 0.136x9810 = 1333.333\ N\ m^{-2}\ m^{-1} = 1.333\ kN\ m^{-2}\ m^{-1}$$

2 marks

b

$$\frac{1}{2}\rho v_1^2 + \rho g h_1 + P_1 = \frac{1}{2}\rho v_2^2 + \rho g h_2 + P_2$$ 2 marks

Since the height does not change (h_1=h_2), the height term can be subtracted from both sides.

$$\frac{1}{2}\rho v_1^2 + P_1 = \frac{1}{2}\rho v_2^2 + P_2$$ 2 marks

Algebraically rearrange the equation to solve for v2 and insert the numbers.

$$\sqrt{\frac{2}{\rho}\left(\frac{1}{2}\rho v_1^2 + P_1 - P_2\right)} = v_2 = 14\ m/s$$ 2 marks

VII

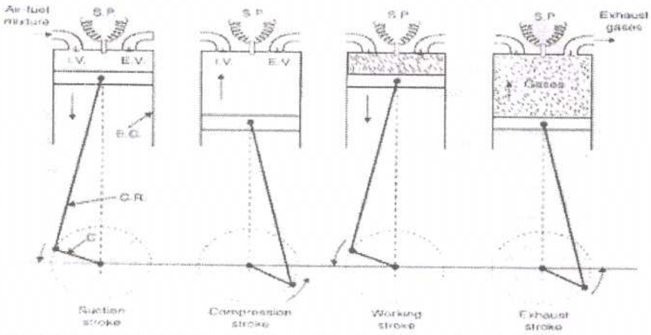
a

FOUR STROKE PETROL ENGINE refers to its use in petrol engines, gas engines, light, oil engine and heavy oil engines in which the mixture of air fuel are drawn in the engine cylinder. Since ignition in these engines is due to a spark, therefore they are also called spark ignition engines. In four stroke cycle engine, cycle is completed in two revolutions of crank shaft or four strokes of the piston.

Cycle consists of following four strokes

1) Suction Stroke
2) Compression Stroke
3) Expansion or Power Stroke
4) Exhaust Stroke

2 marks



4 marks

I.V = Inlet valve, E.V = Exhaust valve, E.C. = Engine cylinder, C.R. = Connecting rod
C = Crank, S.P = Spark plug

explanation - 2 marks

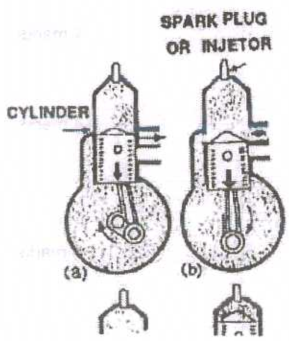
b

Water Tube Boiler is a type of boiler where feed water is introduced and circulated within metallic tubes known as Water Tubes. The increased surface area of the tubes allows for greater heat absorption, enabling these boilers to produce large amounts of steam. This heats the water tubes, and the heat is transferred to the water, raising its temperature. These boilers are capable of operating at pressures up to 250 Bars. Water tube boilers are commonly used in power plants, industrial facilities, and large-scale applications where high-pressure steam is required. 3 marks

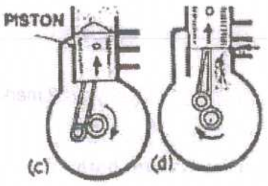
diagram 4 marks

VIII

a



4 marks



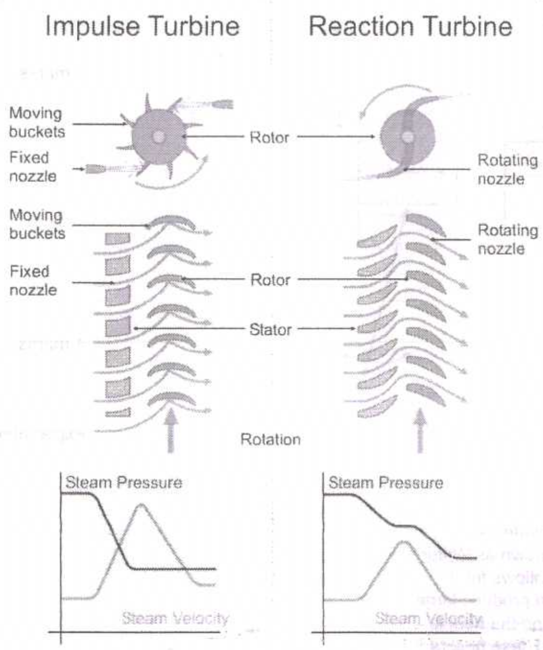
explanation 4 marks

b In impulse stage the steam expands only in the fixed nozzles and kinetic energy is transferred to the rotating buckets as the steam impinges on the buckets while flowing through the passage between the buckets. The steam pressure is constant and the steam velocity relative to the bucket decreases in the bucket passages. — Impulse turbine

The steam expands in both the fixed nozzles and the rotating buckets. The kinetic energy is transferred to the rotating buckets by the expansion of the steam in the passages between the buckets. The steam pressure decreases as the steam velocity relative to the bucket increases in the bucket passages. — Reaction turbine

4 marks for explanation

3 marks for diagrams



IX

a

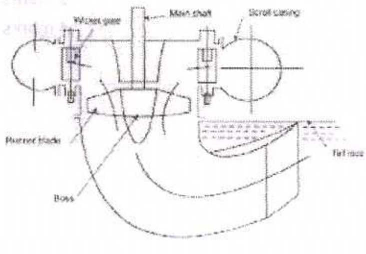


Figure: Kaplan turbine

Diagram 4 marks

Explanation 4 marks

b

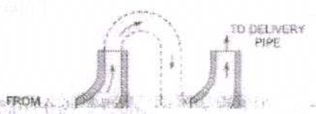
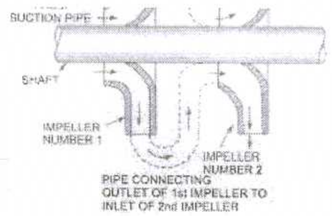
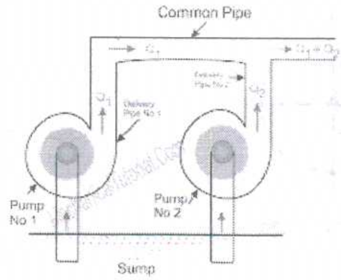


Diagram 4 marks

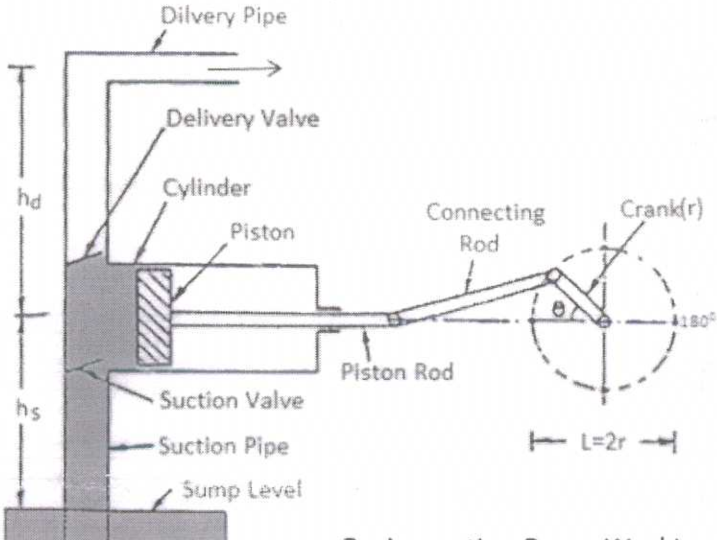




Multistage Centrifugal Pump For High Discharge

		Explanation	3 marks
X	Reciprocating and rotodynamic pumps		
a	<u>centrifugal pump</u>		
	Employs centrifugal effects for increasing fluid pressure.		
	It is converse of the Francis turbine, i.e., flow is radially outward.		
	Has certain inherent advantages such as compactness, smooth and uniform flow, low initial cost and high efficiency even at low heads.		
	A centrifugal pump consists essentially of a rotating impeller followed by a diffuser.	Diagram	
	major components being:		
	Suction pipe with foot valve and strainer		
	Eye	Explanation	4 marks
	Impeller		
	Volute casing (most common)		
	Delivery pipe and delivery valve.		
	Working:		
	As the impeller rotates, the fluid is drawn into the blade passage at the impeller eye, the centre of the impeller. The inlet pipe is axial and therefore fluid enters the impeller with very little whirl or tangential component of velocity and flows outwards in the direction of the blades. The fluid receives energy from the impeller while flowing through it and is discharged with increased pressure and velocity into the casing. The kinetic energy of the fluid gets converted at the impeller outlet gradually into pressure energy.		2 marks
	Applications:		
	Lifting water		
	Public water supply system		
	Sewage and waste water treatment		
	Agricultural water supply		
			1 mark
	Diagram		2 marks
	Sketch		3 marks
	components		2 marks

working 3 marks



Reciprocating Pump Working

Any One pump explanation with diagram

Major parts

- Piston-cylinder
- Piston rod
- Connecting rod
- Crank
- Suction pipe and delivery pipe
- Suction valve ad delivery valve
- Air vessels

b

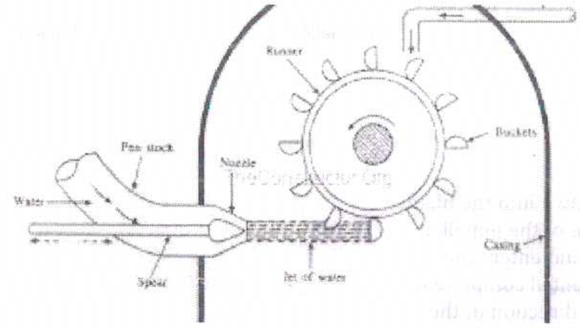


diagram - 4 marks

Explanation - 3 marks