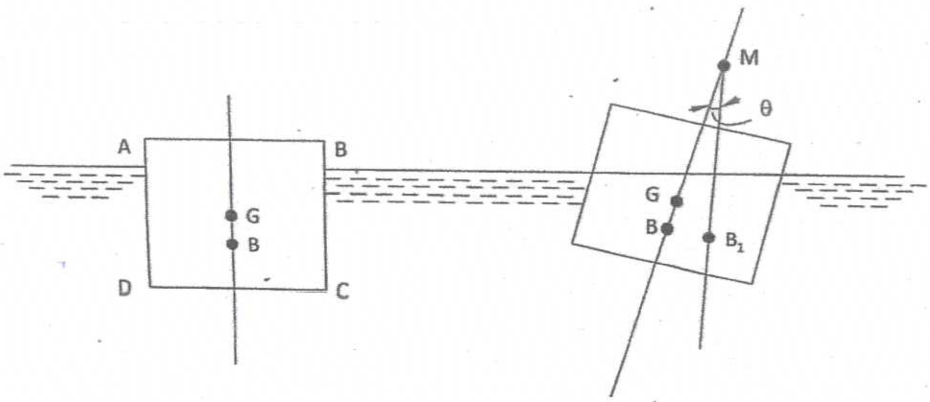
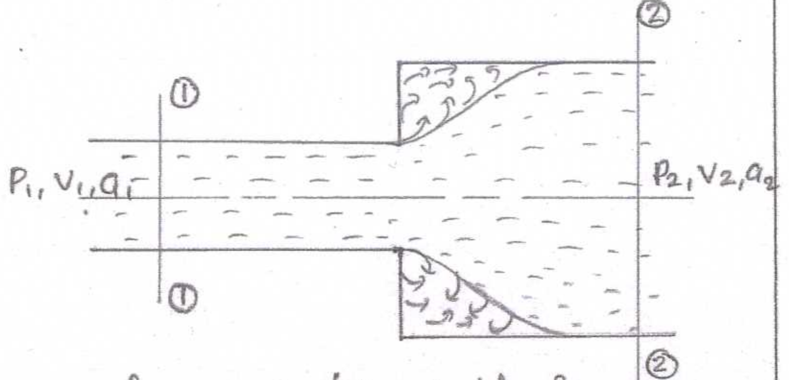
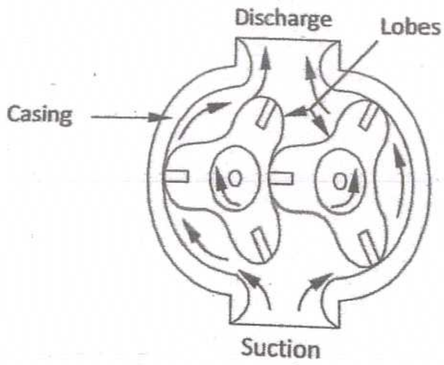
SCHEME OF VALUATION

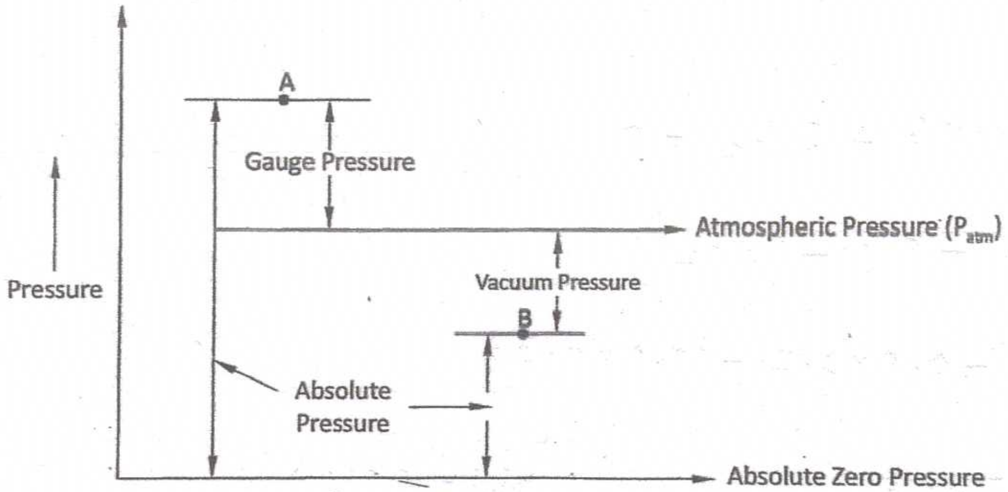
(Scoring Indicators)

Revision : 2015	Course Code : 3022			
Course Title : FLUID MECHANICS AND PNEUMATICS				
Qst. No	**Scoring Indicator**	**Split up score**	**Sub Total**	**Total**
	PART – A			
I (1)	**Define density of a fluid.** **ANS:** It is the ratio of mass of fluid per unit volume of a liquid. $\rho = m/V$	2	2	2
I (2)	**Define kinematic viscosity.** **ANS:** it is the ratio between the dynamic viscosity and the density of the fluid. $\upsilon = \mu/\rho$	2	2	2
I (3)	**Explain rate of flow or discharge.** **ANS:** It is defined as the quantity of fluid flowing through a section of pipe or channel per second. $Q = AV$	2	2	2
I (4)	**Define hydraulic intensifier.** **ANS:** It is a device used to increase the intensity of pressure utilising the energy of a large quantity of liquid available at low pressure.	2	2	2
I (5)	**What is meant by an air cylinder?** **ANS:** Air cylinders are devices that convert compressed air into mechanical energy. This mechanical energy produces linear or rotary motion.	2	2	2

	PART – B			
II (1)	**Calculate the specific weight, density and specific gravity of one litre of liquid which weights 30N.**			
	Ans:- Given, $V = 1$ litre $= 10^{-3} m^3$ $W = 30N$ $w = ?, \rho = ?, S = ?$			
	i) $w = \frac{W}{V} = \frac{30}{10^{-3}} = 3\times10^4\ N/m^3$	2		
	(ii) $w = \rho g$ $\rho = \frac{w}{g} = \frac{3\times10^4}{9.81}$ $= 3058.1\ kg/m^3$	2		
	(iii) $S = \frac{\rho_l}{\rho_w}$ $= \frac{3058.1}{1000}$ $S = 3.058$	2	6	6
II (2)	**Describe metacentre and metacentric height.**			
	ANS: Metacentre is defined as a point about which floating body starts oscillating when it is given a small angular displacement.	1		
	 (a) Body in Equilibrium (b) Body in Small Angular Displacement	Fig-2		
	Consider a body floating in a liquid as shown in Fig. Let the body is in equilibrium and 'G' is the centre of gravity and 'B' is the centre of buoyancy. For equilibrium, both the points lie on the normal axis, which is vertical.			

	Let the body is given a slight angular displacement in clock wise direction as shown in fig. The centre of buoyancy is shifted to a new position B1 as shown in the fig. The line of action of the force of buoyancy in this new position, will intersect the normal axis of the body at some point say 'M'. This point 'M' is called Metacentre. The distance GM is called as **metacentric height**.	2 1	6	6
II (3)	**What are the limitations of Bernoulli's theorem?** **ANS:** 1) The assumption that, the velocity of liquid particle across any cross section of pipe is uniform is not practical. In actual practice, the velocity of liquid particle in the centre of a pipe is maximum and gradually decreases towards the walls of the pipe due to friction. Thus while using Bernoulli's equation the mean velocity of liquid is considered. 2) The assumption that, the external forces except the gravity acts on liquid are also not practical. There are always some external forces like pipe friction etc, acts on the liquid and affects its flow. 3) Another assumption is that there is no loss of energy of the liquid particle while flowing. But in turbulent flow, some kinetic energy is converted into heat energy and in viscous flow some energy is lost due to shear forces. 4) Bernoulli's theorem does not taken into account, the energy due to centrifugal forces for a liquid flowing in a curved path.	1.5 *4	6	6
II (4)	**Write short notes on head loss due to sudden enlargement with neat sketch.** Ans:-  Consider a pipe of cross section suddenly enlarges as shown in figure. Imagin a fluid flowing through a pipe at pressure 'P_1', velocity 'V_1' and area 'a_1' at section ①-①. The corresponding values at section ②-② are P_2, V_2, a_2 respectively.	3 2		

	Losses occur at sudden enlargement due to formation of eddies. The loss of head due to sudden enlargement is given by, $\boxed{h_e = \frac{(V_1 - V_2)^2}{2g}}$ m of liquid	1	6	6
II (5)	**State any six functions of control valves.** 1. To regulate pressure through a system. 2. To control and limit flow to the actuator. 3. To maintain constant ratio between output and input to actuator. 4. To start and shut off the flow. 5. To relieve the pressure. 6. To maintain the direction of flow. 7. To amplify the pressure. 8. To perform the predetermined operations.	Any 6x1	6	6
II (6)	**Explain the working of lobe pump with neat sketch.**  Lobe Pump Similar in operation to an external gear pump. It has two rotors called lobes. Here two lobes are used to rotate one against the other, creating two chambers between the lobes and the wall of the pump chamber. They are driven by electric motor. Fluid that enters the casing gets compressed between rotating lobes and the wall of the casing as it proceeds towards outlet. Volumetric capacity of fluid is more than that in gear pump. Used for pumping gas, air, liquid with low pressures and higher flow rate.	Fig-3 3	6	6
II (7)	**What are the practical applications of pneumatics?** 1. Operation of heavy doors in a linear or rotary movement. 2. Rotary mixers 3. Mining 4. Lifting and moving in slab moulding machines. 5. Bottling and filling machines. 6. Chemical industries.			

	7. Metal industries. 8. Agriculture 9. Air separation and vacuum lifting of thin sheets. 10. Component and material conveyor transfer. 11. Dental drills. 12. Plastic and rubber industries. 13. Spray painting. 14. Petroleum industry. 15. Air craft. 16. Refrigeration and air conditioning.	Any 6x1	6	6
III (a)	**PART – C** **Explain the relationship between absolute pressure, atmospheric pressure, gauge pressure and vacuum pressure with the help of a diagram.** **ANS:** **Atmospheric pressure:-** it is the pressure at any place due to the weight of air column above that place. **Gauge pressure:-** pressure measured above atmospheric pressure. **Vacuum pressure:-** pressure measured below atmospheric pressure. **Absolute pressure:-** pressure measured above absolute zero pressure line ia called as absolute pressure.  **Pabs = Patm + Pg** in case of positive pressure **Pabs = Patm – Pv** in case of negative pressure	2 Fig. 3 1	6	6

III (b) **A simple U-tube manometer containing mercury is connected to a pipe in which a fluid of specific gravity 0.8 and having vacuum pressure is flowing. The other end of the manometer is open to atmosphere. Find the vacuum pressure in the pipe, if the difference of mercury levels in the two limbs is 45cm and the height of the fluid in the left limb from the centre of the pipe is 20cm below.**

Ans:-

Given,

$S_1 = 0.8$

$h_1 = 20cm$

$= 0.2m$

$S_2 = 13.6$

$h_2 = 45cm$

$= 0.45m$

Given Data ⇒ 1

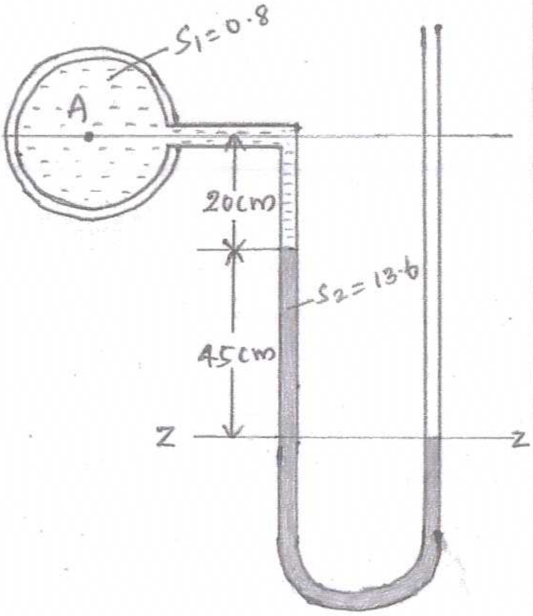


Fig. 3

Pressure ~~at~~ in the left limb = Pressure in the right limb (above Z-Z line)

1

$$\frac{P_A}{w} + S_1 h_1 + S_2 h_2 = 0$$

$$\frac{P_A}{w} = -S_1 h_1 - S_2 h_2$$

$$\frac{P_A}{w} = -0.8 \times 0.2 - 13.6 \times 0.45$$

$$\frac{P_A}{w} = -6.28$$

$w_w = 9810\ N/m^3$

$$P_A = -6.28 \times w$$

$$= -6.28 \times 9810$$

$$P_A = -61606.8\ N/m^2$$

$$P_A = -61.61\ kPa$$

4 | 9 | 9

IV (a) **A circular plate 3m diameter is submerged in water in such a way that its greater and least depth is 2m and 1m respectively. Find the total pressure on the surface of the plate.**

Ans:-

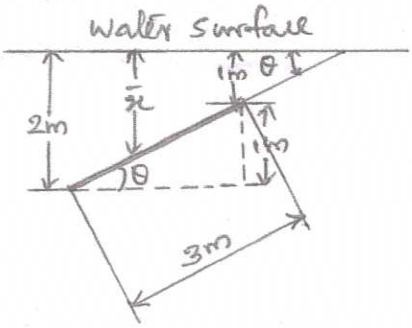


Fig. 1

Given, $d = 3m$

$F = ?$

Greater depth = 2m

Least depth = 1m

From the figure, $\sin\theta = \frac{1}{3}$

$\theta = \sin^{-1}(1/3)$

$= 19.47^{\circ}$ 1

$\bar{x} = 1 + 1.5\sin\theta$

$= 1 + 1.5\sin 19.47$

$= 1.499m$ 1

Area, $A = \frac{\pi}{4}d^2 = \frac{\pi}{4}(3)^2 = 7.068\ m^2$ 1

Total pressure, $F = w A\bar{x}$ $\quad w_w = 9810\ N/m^3$

$= 9810 \times 7.068 \times 1.499$

$= 103936.28\ N$ 2 6 6

$= 103.93\ kN$

IV (b) **A U-tube mercury manometer is connected to two pipes A & B. Pipe B is 50mm below pipe A. The specific gravity of liquid in pipe A & B is 1.2 & 0.80 respectively. Mercury level in the left limb is 75mm below the centre of pipe A. Find the pressure difference between two pipes in kN/m², if the level difference of mercury in the two limbs of manometer is 120mm.**

Ans:-

Given, $S_1 = 1.2$

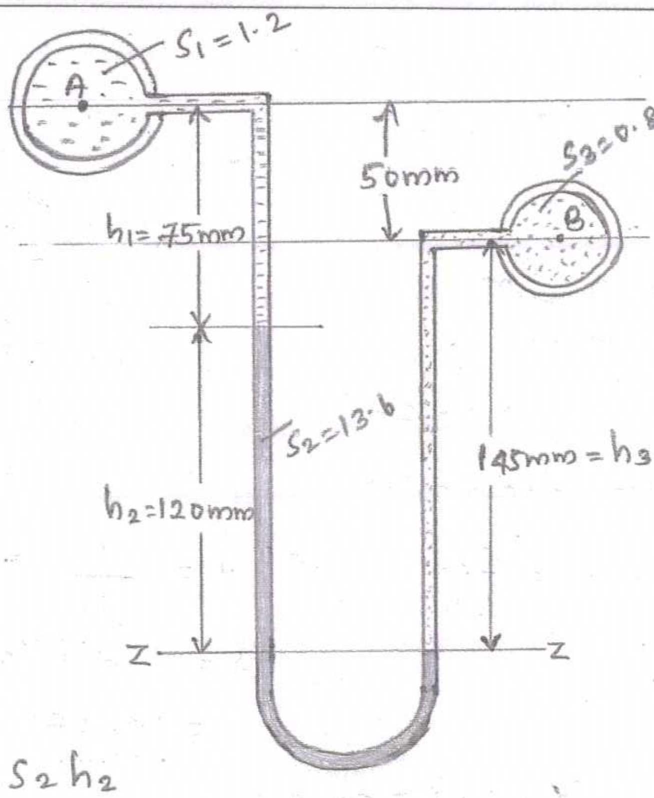
$S_2 = 13.6$

$S_3 = 0.8$

$h_1 = 75mm = 0.075m$ 1

$h_2 = 120mm = 0.12m$

$h_3 = 145mm = 0.145m$



4

$$\frac{P_A-P_B}{w} = S_3h_3 - S_1h_1 - S_2h_2$$

$$= 0.8\times0.145 - 1.2\times0.075 - 13.6\times0.12$$

$$\frac{P_A-P_B}{w} = \underline{\underline{-1.606}}$$

$$w_w = \underline{\underline{9810\ N/m^3}}$$

$$P_A-P_B = -1.606\times w$$

$$= -1.606\times9810$$

$$= -15754.86\ N/m^2$$

$$P_A-P_B = \underline{\underline{-15.75\ kN/m^2}}$$

4 | 9 | 9

V (a) **Name and define hydraulic coefficients. State the relationship between them.**

ANS: Most commonly used hydraulic coefficients are

1. Coefficient of contraction, Cc
2. Coefficient of velocity, Cv
3. Coefficient of discharge, Cd

	1) Coefficient of contraction, Cc Defined as the area of the jet at vena-contracta to the area of the orifice. Cc = Area of jet at vena-contracta / Area of orifice Value of Cc varies from 0.61 to 0.69	2		
	2) Coefficient of velocity, Cv Defined as the ratio of tha actual velocity of a jet of liquid at vana-contracta to the theoretical velocity of jet. Cv = Actual velocity of jet of liquid at vena-contracta / Theoretical velocity of jet $Cv = v / \sqrt{2gH}$ Value of Cv varies from 0.95 to 0.99	2		
	3) Coefficient of discharge, Cd Defined as the ratio of actual discharge from an orifice to the theoretical discharge from an orifice. Cd = Actual discharge / Theoretical discharge Cd = Qact / Qth Value of Cd varies from 0.61-0.65	2		
	Relation between Cc, Cv and Cd Cd = Qact / Qth Cd = (Actual velocity x Actual area) / (Theoretical velocity x Theoretical area) **Cd = Cv x Cc**	1	7	7
V (b)	**A venturimeter with inlet diameter 150mm and throat diameter 80mm is laid its axis horizontal and is used to measure the flow of water. The mercury manometer shows a gauge. difference measured as 150mm. Assume the coefficient of meter as 0.95. Calculate the discharge.** Ans:- Given, $d_1 = 150mm = 0.15m$ $d_2 = 80mm = 0.08m$ $x = 150mm$ of Hg $= 0.15m$ of Hg $C_d = 0.95$ $S_m = 13.6$ $S_w = 1$	1		

$$a_1 = \frac{\pi}{4} d_1^2 = \frac{\pi}{4}(0.15)^2 = 0.0176\ m^2$$ 1

$$a_2 = \frac{\pi}{4} d_2^2 = \frac{\pi}{4}(0.08)^2 = 5.026\times10^{-3}\ m^2$$ 1

$$h = x\left(\frac{S_m}{S_w} - 1\right)$$

$$= 0.15\left(\frac{13.6}{1} - 1\right)$$ 1

$$= 0.15 \times 12.6$$

$$h = 1.89\ m \text{ of water}$$ 1

$$\text{Actual discharge, } Q = C_d \times \frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$$

$$Q = \frac{0.95 \times 0.0176 \times 5.026\times10^{-3} \times \sqrt{2\times9.81\times1.89}}{\sqrt{(0.0176)^2 - (5.026\times10^{-3})^2}}$$

$$= \frac{5.117\times10^{-4}}{0.01686}$$ 3 | 8 | 8

$$Q = 0.03\ m^3/s$$

VI (a) **What is a notch? Explain the difference between orifice and notch.**

ANS: A notch may be defined as an opening provided in the side of a tank or a small channel in such a way that the liquid surface in the tank or channel is below the top edge of the opening. 1

Sl. No	ORIFICE	NOTCH
1	There is a small opening in the side of a tank, through which the fluid flows.	There is a large opening, in the side of a tank or dam over which the fluid flows.
2	The upper edge of the orifice is below the free surface of the water in the tank.	The upsteam water level is below the upper edge of the notch.
3	The stream of water flowing through an orifice is termed as jet.	The sheet of water flowing over a notch is termed as nappe or vein.
4	Head of water compared to the orifice dimension is large.	Head of water over the sill of the notch is small compared to the notch dimensions.
5	Pressure on the upstream side of the orifice is more than the downstream side pressure which is atmospheric.	Pressure on the upstream as well as downstream side of the notch is atmospheric.

5 | 6 | 6

VI (b) **Water is flowing through a pipe of 250mm in diameter and 100mm long with a velocity 3m/s. Find the head loss due to friction using Darcy's formula and Chezy's formula. Assume f=0.005 and C=55.**

Ans:- Given, $d = 250\,mm = 0.25\,m$

$l = 100\,mm = 0.1\,m$

$V = 3\,m/s$ — 1

$f = 0.005$

$C = 55$

(i) Darcy's formula, $h_f = \frac{4flv^2}{2gd}$ — 1

$$= \frac{4 \times 0.005 \times 0.1 \times (3)^2}{2 \times 9.81 \times 0.25}$$

$$h_f = \underline{\underline{3.67 \times 10^{-3}}}\ m \text{ of water}$$ — 2

b) Chezy's formula, $V = C\sqrt{mi}$ —(1) — 1

Hydraulic mean depth, $m = \frac{d}{4}$

$$= \frac{0.25}{4}$$

$$m = \underline{\underline{0.0625}}\,m$$ — 1

$$i = \frac{h_f}{l}$$

Squaring the eqn (1),

$$V^2 = C^2 \times m \times i$$

$$V^2 = C^2 \times m \times \frac{h_f}{l}$$

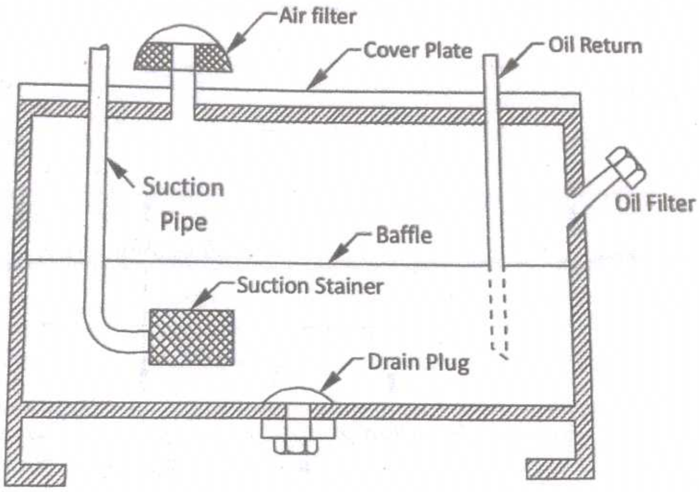
$$h_f = \frac{lV^2}{C^2 m}$$

$$= \frac{0.1 \times (3)^2}{55^2 \times 0.0625}$$ — 2 — 8 — 8

$$h_f = \underline{\underline{4.76 \times 10^{-3}}}\ m \text{ of water}$$

VII (a) **Explain the basic elements of fluid reservoir and their functions with neat sketch.**

ANS:



Elements of an Oil Reservoir

Fig. 4

Following are the basic components of a hydraulic reservoir

1). FILTER

It is provided at the inlet of the reservoir. It prevents dirt and other foreign matter from entering the tank of reservoir. Filter removes particles as small as 2 to 10 microns.

2). AIRVENT

It is used to permit air to enter or leave the tank. In dusty environments where the filter would rapidly become blocked, it is desirable to supply filtered air into the tank from some low pressure blower. As the fluid volume increases in the tank, air escapes through the vent.

3). STAINER

It is attached to the suction pipe of the pump. Oil sucked by pump and delivered to the system should be free from dirt and foreign matter. It filters off such dirt and foreign matter from entering the suction pipe.

4). BAFFLES

It keeps the oil from foaming and causes the sediment to drop to the bottom.

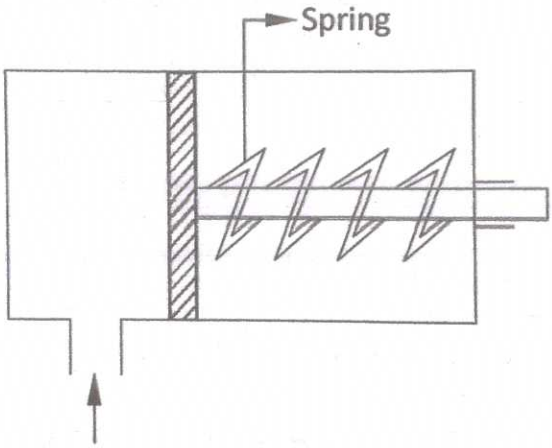
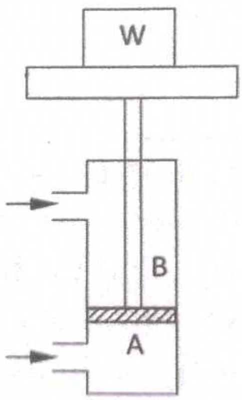
3 | 7 | 7

5). COVER PLATE

It is mounted on the top of reservoir to provide a seat for pump and motor. It provides a hole for the return line from the relief valve.

6). DRAIN PLUG

It is located at the bottom of the tank. For a periodical check-up and cleaning, oil is drained off through this plug.

<table>
<tr><td>VII
(b)</td><td>Describe the working principle of single and double acting cylinders with neat sketches.
ANS:
SINGLE ACTING CYLINDERS

</td><td>2</td><td></td><td></td></tr>
<tr><td></td><td>It may be placed horizontal or vertical. Pressurised fluid enters the cylinder on piston side. It pushes the piston right wards against the spring pressure. Piston rod makes a linear motion to do desired work.</td><td>2</td><td></td><td></td></tr>
<tr><td></td><td>DOUBLE ACTING CYLINDERS
It is also called differential cylinder. Fluid entering chamber ‘A’ exerts more pressure on piston and lifts it up along with any load ‘W’ placed on the collar attached to rod end. When desired lift is achieved piston would have reached on the top of its stroke, then the fluid is allowed to enter chamber ‘B”. Pressure on piston on rod end is comparatively less because the surface area is less and helps piston slide down with load released at the end of upward stroke.</td><td>2</td><td></td><td></td></tr>
<tr><td></td><td>

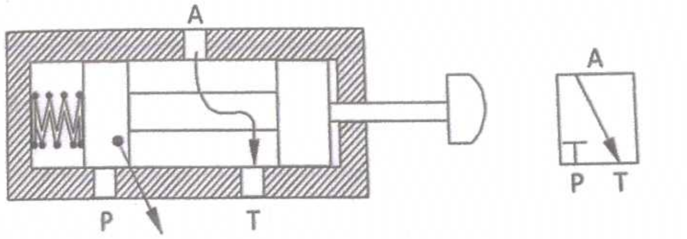
Double Acting Cylinder</td><td>2</td><td>8</td><td>8</td></tr>
</table>

VIII (a)

With the help of a neat sketch explain the working of 3-way DC valve.

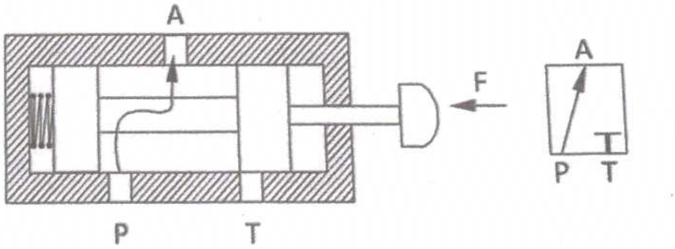
ANS:

3-WAY DC VALVE



4

(a) Ports 'A' and 'T' connected when force is not applied



(b) Ports A and P are Connectre when Force is Applied

It has three ports P, A and T, ie, pump port P, actuator passage A and tank port T. In one extreme position of spool, the pressurised oil flows from P to A to move the actuator. The tank port T remains closed. In other extreme position of spool, the oil from port P gets closed port A and the oil from the actuator is allowed to pass through A to T and then to the tank. Therefore the valve alternately connects or disconnects oil supply to the cylinder by the sliding spool As the valve has 3 openings and the valve takes two different positions, the valve is called 3 way/ 2 position DC valve and is represented by 3/2 DC valve. 3 7 7

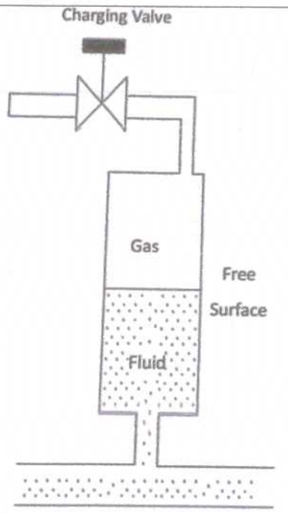
VIII (b)

With the help of neat sketches explain the working of separator and non-separator type accumulator.

ANS:

NON-SEPARATOR TYPE

It consists of a cylinder, a charging valve and ports. A portion of the cylinder is kept with oil before use. Air or nitrogen gas is then forced into the cylinder and the accumulator is precharged to the minimum pressure. As the oil level is increased, the air or gas above the oil is compressed. This energy in the compressed air is released as per the requirements of the system. If air or gas is absorbed by the oil, the accumulator will not function properly. 2

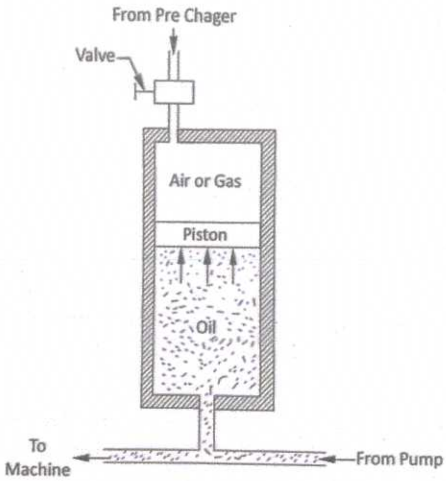


Non-Separator Type Accumulator

2

SEPARATOR TYPE

In this a free or floating piston acting as a barrier between air or gas and the oil. On the top side of piston high pressure gas or air is charged and other side hydraulic oil is charged. Oil pressure acts on the bottom of the piston and moves it up. As piston moves up, air or gas above it is compressed and stored energy. When the oil is drawn out by the machine connected to the accumulator, the piston moves downward and air or gas above it expands and release energy. 2



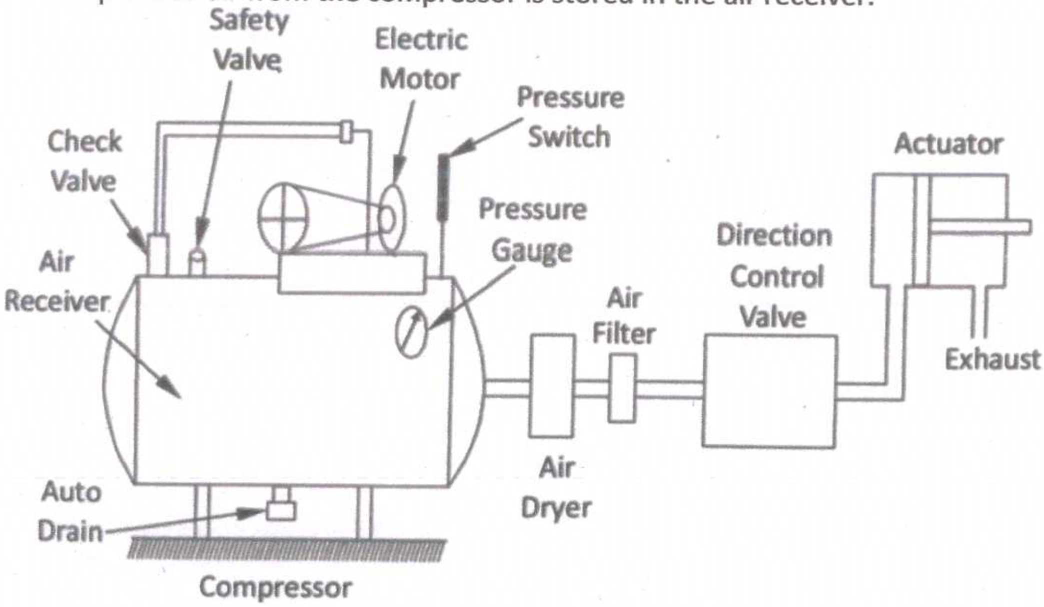
Piston Type Accumulator

2 8 8

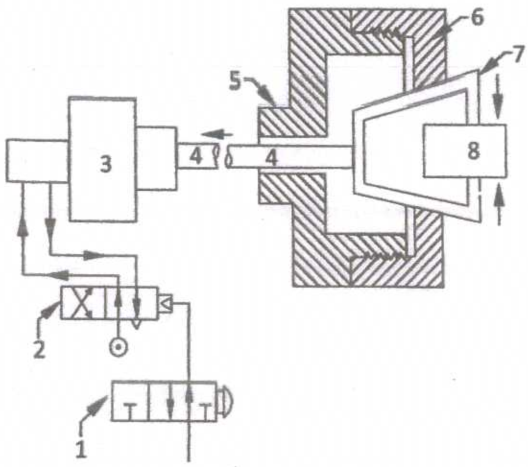
IX (a) Write any seven applications of air cylinders.

ANS:

1. Press work, eg:- squeezing, drawing etc
2. Plastic industry, eg:- injection moulding, press moulding etc.
3. Forge work, eg:-power hammers, bending etc.
4. Automotive industry, eg:- air brakes
5. Printing machinery
6. Power plant engineering

	7. Material handling 8. Textile industry 9. Leather and ceramic industry 10. Mining machinery 11. Railways 12. Agricultural machinery etc.	Any 7	7	7
IX (b)	**Explain the basic components of a pneumatic system with neat sketch.** **ANS:** The important basic components are, **1). Compressor** A device which converts mechanical energy into pneumatic energy is called compressor. Air is taken in at atmospheric pressure is compressed and delivered at a higher pressure to the pneumatic system. **2). Electric motor** It transforms electrical energy into mechanical energy. It is used to drive the compressor. **3). Air receiver or Reservoir** The compressed air from the compressor is stored in the air receiver.  Basic Pneumatic System **4). Pressure switch** It is used to maintain the required pressure in the air receiver. When the pressure is about to exceed the high pressure limit, the compressor is automatically turned off by the pressure switch. It is also automatically turned on when the pressure is about to fall below the low limit. **5). Check valve** It allows the flow in one direction and blocks flow in an opposite direction. Once compressed air enters the receiver tank via check valve, it is not allowed to go back even when the compressor is stopped. **6). Safety valve** Function is to release the extra pressure, if the pressure inside the receiver exceeds the safe pressure limit.	Fig-4		

	7). Auto drain It drains all the water condensing in the tank. **8). Air dryer** The water vapour or moisture in the air is separated from the air by using dryer. **9). Pressure gauge** It indicates the pressure inside the compressor receiver. **10). Air filter** It is used to filter out the dust and contaminants from the air. **11). Control valves** It is used to regulate, control and monitor for control of direction flow pressure etc. **12). Air actuator** Air cylinder and motors are used to obtain the required movements of mechanical elements of pneumatic system.	4	8	8
X (a)	**What are the advantages of hydro-pneumatic system?** **ANS:** 1. Quick response to the control signal 2. Smooth operation 3. Constant speed can be maintained for both variable loads and constant loads. 4. Greater flexibility. 5. Energy requirement is less to operate. 6. Due to better cushioning, vibration is less 7. Less power consumption 8. Low maintenance cost 9. Energy exhaust from cylinder 10. For explosive atmosphere hydro-pneumatic systems are more suitable.	7	7	7
X (b)	**Explain the working of a pneumatic Collet chuck with neat sketch.** **Ans:** **PNEUMATIC COLLET CHUCK** This type of chucks are used in large scale production on lathes to hole round work pieces such as shafts, tubes, spindles etc. The set up consists of a rotating cylinder which is connected to the rear end of the machine spindle and collet is mounted on the front end. The free end of the piston rod is connected to the collet when the piston rod moves left wards during inward stroke, the collet is pulled into the hood and offers a firm grip on the job. The cylinder is controlled by a direction control valve actuated by a lever or a push button. Pneumatic operated collet chucks increases production rate, cutting down loading and unloading time.	4		

	 1. Pilot Valve 2. Relay Valve 3. Rotating Air Cylinder 4. Piston Rod 5. Machine Spindle 6. Hood 7. Collet 8. Work Piece Pneumatic Collet Chuck	Fig-4	8	8