

TED (15)-3022(A)

(Revision - 2015)

THIRD SEMESTER DIPLOMA EXAMINATION IN ENGINEERING

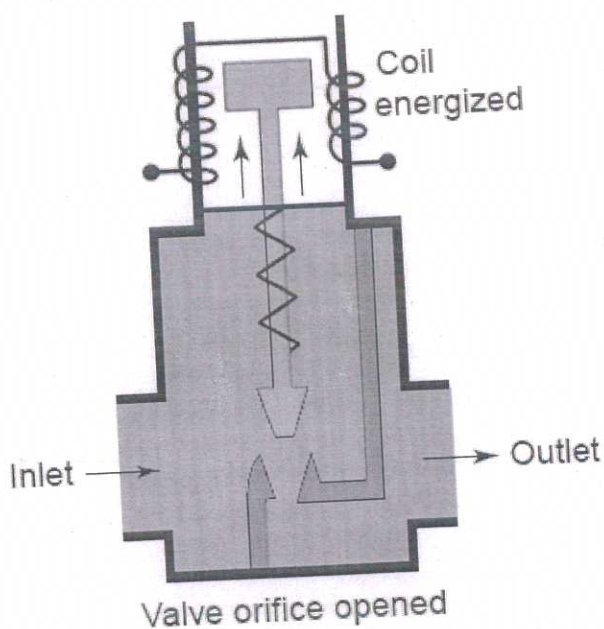
FLUID MECHANICS AND PNEUMATICS

SCHEME OF VALUATION

Qn No.	Scoring Indicator	Split up Score	Sub total	Total
<b>PART : A</b>				
1	Point of intersection of the line of action of buoyant force before and after the heel is called Metacenter.	2	1x2=2	10
2	It is used for measuring small pressure difference between two points.	2	1x2=2	
3	Examples of minor losses are a.due to sudden enlargement losses b.due to sudden contractionc. losses due to bend in pipe etc	2	1x2=2	
4	Flash point is the temperature at which a liquid gives off sufficient quantity to ignite momentarily or flash when flame is applied.	2	1x2=2	
5	To filter , regulate and lubricate	2	1x2=2	
<b>PART B</b>				6x5 =30
II ..1	<p>Newton's law of viscosity states that for a liquid shear stress is propotional to rate of shear strain.</p> <p>ie. <math>\tau \propto \frac{d\theta}{dt}</math></p> $\tau = \mu \frac{d\theta}{dt}$ <p>Where, <math>\tau</math> = shear stress at a point.</p> <p><math>\frac{d\theta}{dt}</math> = shear strain rate.</p> <p><math>\mu</math> = coefficient of viscosity.</p> <p>Kinematic viscosity is defined as the ratio of absolute viscosity to the density of fluid.</p>	4	1X6=6	2

II.2	<p>Initial Volume of baloon= <math>500\text{cm}^3 = 500 \times 10^{-6} \text{ m}^3</math></p> <p>Initial pressure of balloon= <math>1 \text{ atm} = 1.013 \times 10^5 \text{ N/m}^2</math> (absolute)</p> <p>Depth to which balloon is immersed, <math>H = 100\text{m}</math></p> <p>Final pressure of balloon= <math>\rho gH = 1000 \times 9.81 \times 100 + P_a = 981000 + 101300 \text{ N/m}^2</math></p> <p>Bulk modulus of elasticity, <math>K = -\frac{dP}{\frac{dV}{V}} = 3.75 \times 10^9 \text{ N/m}^2</math></p> <p>Change in pressure, <math>dp = 981000 + 101300 - 101300 = 981000 \text{ N/m}^2</math>.</p> $-\frac{dV}{V} = \frac{dP}{K} = \frac{981000}{3.75 \times 10^9}$ $-dV = V \frac{dP}{K} = \frac{981000}{3.75 \times 10^9} \times 500 \times 10^{-6} = 1.308 \times 10^{-7} \text{ m}^3 = 0.138 \text{ cm}^3$	6	1X6=6	
II.3	<p>Length of notch, <math>L = 2\text{m}</math></p> <p>Head over notch= <math>400 \text{ mm} = 0.4\text{m}</math></p> <p>Co-efficient of discharge <math>C_d = 0.6</math></p> <p>Discharge of rectangular notch, <math>Q = C_d \times \frac{2}{3} \times L \times \sqrt{2} \times g \times H^{\frac{3}{2}} \text{ m}^3/\text{s}</math></p> $Q = 0.6 \times \frac{2}{3} \times 2 \times \sqrt{2} \times 9.81 \times 0.4^{\frac{3}{2}} \text{ m}^3/\text{s}$ $Q = 0.896 \text{ m}^3/\text{s} = 896.45 \text{ l/s}$	6	1X6=6	30
II.4	<p>When flow along a conduit is closed suddenly, a sudden rise of pressure is observed in a conduit due to the momentum of water being destroyed. This causes a wave of high pressure to be transmitted along the pipe which creates noise known as knocking. This phenomenon of sudden rise in pressure in the pipe is known as water hammer or hammer blow. the magnitude of pressure rise depends upon</p> <ol style="list-style-type: none"> <li>The speed at which valve is closed</li> <li>The velocity of flow in the pipe.</li> <li>The length of pipe and</li> <li>The elastic properties of material of the pipe.</li> </ol>	6	1X6=6	

<p>II.5</p>	<p>To accomplish primary functions of hydraulic fluid, it should possess</p> <ol style="list-style-type: none"> <li>Good lubricity</li> <li>Medium viscosity</li> <li>High chemical stability</li> <li>High degree of incompressibility</li> <li>Good heat transfer capacity</li> <li>Low volatility</li> <li>High oxidation stability</li> <li>Demulsibility</li> <li>Non-toxicity</li> </ol>	<p>6</p>	<p>1X6=6</p>
<p>II.6</p>	<p>A solenoid valve is basically an electro mechanically operated valve. It consists of copper coil provided with a freely movable plunger in it. Valve actuated by solenoids are called solenoid valves in a two way valve a solenoid is directly connected to the actuator and in others it is connected through the actuating mechanism these valves are preferred when large forces is to be exerted to control high pressure. In a normally closed solenoid valve the plunger is lifted when coil is energized.</p> <p>Figure shows 2 way solenoid valve which is normally closed when electric supply is given to the coil, the coil get magnetized and pulls up the plunger against the spring force. Now the ports gets open and Allows fluid flow.</p>	<p>6</p>	<p>1X6=6</p>



II.7	<p>Hydropneumatic system have advantages of both hydraulic and pneumatic systems. they are</p> <ol style="list-style-type: none"> <li>1. Constant speed can be maintained with variable or constant load</li> <li>2. Poses high speed than that of hydraulic system</li> <li>3. It does not require pump but a small reservoir is sufficient.</li> <li>4. Low operating cost compared to traditional system</li> <li>5. Control of cylinder stroke is easily attainable and precise</li> <li>6. Requires simple maintenance</li> <li>7. Overall cost is low to moderate.</li> </ol>	6	1X6=6
III (a)	<p>absolute pressure - The actual pressure at a given position is called the absolute pressure, and it is measured relative to absolute vacuum (i.e., absolute zero pressure).</p> <p>gauge pressure - Gauge pressure is the pressure relative to the atmospheric pressure. In other words, how much above or below is the pressure with respect to the atmospheric pressure.</p> <p>vacuum pressure - Pressures below atmospheric pressure are called vacuum pressures and are measured by vacuum gages that indicate the difference between the atmospheric pressure and the absolute pressure.</p> <p>atmospheric pressure - The atmospheric pressure is the pressure that an area experiences due to the force exerted by the atmosphere.</p> <p>So the relation between gauge pressure, absolute pressure, atmospheric pressure and vacuum pressure is :-</p> $P(\text{abs}) = P(\text{gauge}) + P(\text{atm})$ $P(\text{vac}) = P(\text{atm}) - P(\text{abs})$ <p>Or <math>P(\text{vac}) = -P(\text{gauge})</math></p>	8	1x8=8
III(b)		7	<p>1x7=7</p> <p>FIG-2 SOL-5</p>

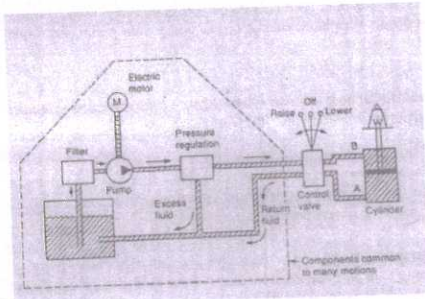
	<p>Density of fluid in pipe A, <math>\rho_A = \text{specific gravity} \times \text{density of water} = 1600 \text{ Kg/m}^3</math>  Density of fluid in pipe B, <math>\rho_B = \text{specific gravity} \times \text{density of water} = 800 \text{ Kg/m}^3</math>  Pressure at A, <math>P_A = 120 \text{ KN} = 120 \times 10^3 \text{ N}</math>  Pressure at B, <math>P_B = 200 \text{ KN} = 200 \times 10^3 \text{ N}</math>  Equating pressure at 0-0,  <math>P_A + \rho_A \times g \times 2.5 + \rho_m \times g \times h_m = P_B + \rho_B \times g \times 1.5 + \rho_B \times g \times h_m</math>  solving, level difference, <math>h_m = 0.231 \text{ m} = 23.1 \text{ cm}</math></p>			
IV(a)	<p>1. Density or Mass Density:  The mass density or Density of a fluid is defined as the ratio of a mass of fluid to its a volume of the fluid.  Density is called a Mass per unit volume of a fluid. This is denoted by symbol <math>\rho</math> (rho) and the unit of mass density is <math>(\text{kg/m}^3)</math>.  The density of liquid may be constant but the density of gases changes with the variation of temperature and pressure.</p> <p>2. Weight Density or Specific Weight:  Weight density or specific density of a fluid is defined as the ratio of the weight of fluid to its volume of the fluid.  Weight density is called Weight per unit volume of a fluid. This is denoted by symbol 'w' and the unit of mass density is <math>(\text{N/m}^3)</math>.  <math>w = (\text{Weight of Fluid}) / (\text{Volume of fluid})</math>  <math>w = \rho * g</math></p> <p>3. Specific Volume:  The specific volume of a fluid is defined as the ratio of the volume of fluid to the mass of fluid.  The unit of Specific volume is <math>\text{m}^3/\text{kg}</math> and This is commonly applied to Gases.</p> <p style="text-align: center;"><b>Specific Volume = (Volume of fluid) / (Mass of fluid)</b>  <b>Specific volume is the reciprocal of Mass Density</b></p> <p>4. Specific Gravity:  This is defined as the ratio of the Density or weight density of a fluid to density or weight density of a standard fluid.  We know the Standard fluid is water so for liquid the water is standard fluid and For gases, the Standard fluid is taken as Air.  The specific gravity is called Relative Density. This is denoted by the symbol <math>S'</math> and this is dimensionless because the upper unit and lower units get canceled.</p> <p style="text-align: center;"><b><math>S (\text{liquid}) = (\text{Weight Density of liquid}) / (\text{Weight Density of water})</math></b>  <b><math>S (\text{Gases}) = (\text{Weight Density of Gases}) / (\text{Weight Density of Air})</math></b></p> <p>Here liquid cannot be the same as water it can be some oil and other.</p> <p><b>Density of liquid = <math>S * \text{Density of water} = S * 1000 \text{ kg/m}^3</math></b></p>	8	1X8=8	15

<p>IV(b)</p>	<p> <math>A = \frac{1}{2} \times 3 \times 2 = 3 \text{ m}^2</math>        Water surface  <math>y_p</math>  <math>y_c</math>        2 m        1 m        3 m        O Apex        C        P        Depth of centre of plate from the free water surface,  <math>y_c = 1 + \left(\frac{1}{3} \times 3\right) = 2 \text{ m}</math>        Pressure force on the plate, <math>F = w A y_c</math>  <math>= 9810 \times 3 \times 2</math>  <math>= 58860 \text{ N}</math> </p>	<p>7</p>	<p>1x7=7</p>
<p>V(a)</p>	<p>Bernoulli's theorem states that "in a steady, continuous flow of frictionless incompressible fluid, the sum of potential head, pressure head and kinetic head is the same at all points".</p> <p><math>p/\rho g + v^2/2g + z = \text{constant}</math></p> <p>the limitations of the Bernoulli's principle</p> <ol style="list-style-type: none"> <li>1. The above equation has been derived by assuming that the velocity of every element of the liquid across any cross-section of the pipe is uniform. Practically, it is not true. The elements of the liquid in the innermost layer have the maximum velocity. The velocity of the liquid decreases towards the walls of the pipe. Therefore, we should take into account the mean velocity of the liquid.</li> <li>2. While deriving Bernoulli's equation, the viscous drag of the liquid has not been taken into consideration. The viscous drag comes into play, when a liquid is in motion.</li> <li>3. Bernoulli's equation has been derived on the assumption that there appears no loss of energy, when a liquid is in motion. In fact, some kinetic energy is converted into heat energy and a part of it is lost due to shear force.</li> <li>4. If the liquid is flowing along a curved path, the energy due to centrifugal force should also be taken into consideration.</li> </ol>	<p>8</p> <p>THE-3</p> <p>LIM-5</p>	<p>1X8=8</p> <p>15</p>

V(b)	<p>inlet diameter, <math>d_1 = 300\text{mm} = 0.3\text{ m}</math>  throat diameter, <math>d_2 = 150\text{mm} = 0.15\text{m}</math>  Reading of differential manometer, <math>x = 200\text{mm} = 0.2\text{m}</math>  Coefficient of venturimeter, <math>C_d = 0.95</math>  Area of inlet of venturimeter = <math>a_1 = \frac{\pi}{4}d_1^2 = 0.0769\text{m}^2</math>  Area of throat of venturimeter = <math>a_2 = \frac{\pi}{4}d_2^2 = 0.01767\text{m}^2</math>  Specific gravity of mercury, <math>s = 13.6</math>  Difference of pressure head, <math>h = x\left(\frac{S_f}{S_m} - 1\right)</math>  <math>= 2.52\text{m of water}</math>  Discharge through venturimeter, <math>Q = C_d \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \sqrt{2gh} = 0.1212\text{m}^3/\text{s} = 121.2</math>  l/s</p>	7	1x7=7
VI(a)	<p>Following are three hydraulic coefficients of orifice:</p> <p>Coefficient of Contraction (<math>C_c</math>)</p> <p>Coefficient of Velocity (<math>C_v</math>)</p> <p>Coefficient of discharge (<math>C_d</math>)</p> <p><b>Coefficient of contraction</b></p> <p>Coefficient of contraction is defined as the ratio of the area of jet at Vena contracta to the area of orifice (theoretical area). It is denoted by <math>C_c</math>.</p> <p>Mathematically, <math>C_c = \text{Area of jet at Vena contracta} / \text{area of orifice}</math>  <math>C_c = A_c / A</math>  <math>A_c = \text{area of jet at vena-contracta}</math>  <math>A = \text{area of orifice}</math></p> <p>The value of <math>C_c</math> varies with the available head of liquid and shape, size of orifice. In general for an orifice <math>C_c = 0.61</math> to <math>.69</math></p> <p><b>Coefficient of Velocity</b></p> <p>It is defined as the ratio of actual velocity of jet of fluid at vena-contracta to the theoretical velocity of jet. The coefficient of velocity is denoted by <math>C_v</math>  The mathematical expression for <math>C_v</math> is given below  <math>C_v = \text{Actual velocity of jet at Vena contracta} / \text{theoretical velocity of jet}</math>  <math>C_v = V_a / \sqrt{2gH}</math>  Here <math>V_a</math> is actual velocity and <math>\sqrt{2gH}</math> is theoretical velocity  <math>g = \text{Acceleration due to gravity}</math>  <math>H = \text{Head of liquid}</math>  The variation in fluid velocity is due to friction of orifice. For orifice <math>C_v = 0.95</math> to <math>0.99</math></p>	8	1x8=8

	<p><b>Coefficient of discharge</b></p> <p>Coefficient of discharge is defined as the ratio of actual discharge of fluid to the theoretical discharge. It is denoted by Cd.</p> <p>Let Qa = Actual discharge Qth = Theoretical discharge</p> <p>Then Cd = Qa/ Qth</p> <p>For an orifice Cd = 0.61 to 0.65</p>			
VI(b)	<p>Given,</p> <p>Diameter of the pipe, d = 250mm = 0.250m</p> <p>Length of the pipe, l = 150m</p> <p>Velocity of flow, V = 3m/s</p> <p>Co-efficient of friction, f = 0.05</p> <p>Chezy's constant, C = 55</p> <p>Using darcy's formulae,</p> <p>Head loss due to friction, <math>hf = \frac{4f l V^2}{2gd} = \frac{4 \times 0.005 \times 150 \times 3^2}{2 \times 9.81 \times 0.250} = 5.504</math> m of water.</p> <p>Hydraulic mean depth, m = d/4 = 0.25/4 = 0.0625m</p> <p>Loss of head per unit length, i = hf/l = hf/150</p> <p>Using Chezy's formulae for velocity of flow,</p> <p><math>V = C\sqrt{mi} = 55 \sqrt{0.0625 \times \frac{hf}{150}} = 3</math> m/s</p> <p><math>hf = (3/55)^2 \times 150 / 0.0625 = 7.14</math> m of water.</p>	7	1x7=7	

VII(a)



Hydraulic System Components

The major components that make up a hydraulic system are the reservoir, pump, valve(s) and actuator(s) (motor, cylinder, etc.).

#### Reservoir

The purpose of the hydraulic reservoir is to hold a volume of fluid, transfer heat from the system, allow solid contaminants to settle and facilitate the release of air and moisture from the fluid.

#### Pump

The hydraulic pump transmits mechanical energy into hydraulic energy. This is done by the movement of fluid which is the transmission medium. There are several types of hydraulic pumps including gear, vane and piston. All of these pumps have different subtypes intended for specific applications such as a bent-axis piston pump or a variable displacement vane pump. All hydraulic pumps work on the same principle, which is to displace fluid volume against a resistant load or pressure.

#### Valves

Hydraulic valves are used in a system to start, stop and direct fluid flow. Hydraulic valves are made up of poppets or spools and can be actuated by means of pneumatic, hydraulic, electrical, manual or mechanical means.

#### Actuators

Hydraulic actuators are the end result of Pascal's law. This is where the hydraulic energy is converted back to mechanical energy. This can be done through use of a hydraulic cylinder which converts hydraulic energy into linear motion and work, or a hydraulic motor which converts hydraulic energy into rotary motion and work. As with hydraulic pumps, hydraulic cylinders and hydraulic motors have several different subtypes, each intended for specific design applications

8

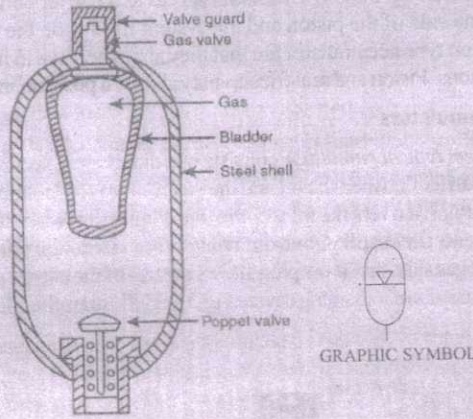
1x8=8

FIG-  
3  
EXP-  
5

VII(b)

**Bladder type accumulator**

A *bladder type accumulator* contains an elastic barrier (bladder) between the oil and gas, as shown in the Figure . The bladder is fitted in the accumulator by means of a vulcanized gas element and can be installed or removed through the shell opening at the poppet valve. The poppet valve closes the inlet when the accumulator bladder is fully expanded. This prevents the bladder from being pressed into the opening. The greatest advantage of this type of accumulator is the positive sealing between the gas and oil chambers. The light weight bladder provides quick response for pressure regulating, pump pulsation, and shock-dampening applications.

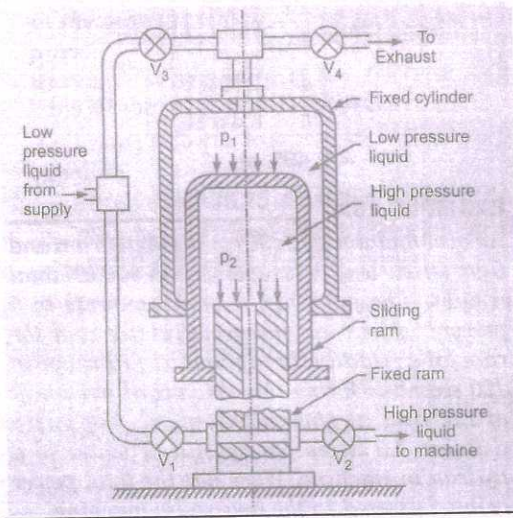


**Bladder type accumulator.**

The hydraulic pump provides oil into the accumulator and deforms the bladder. As the pressure increases, the volume of gas decreases, thus storing energy. In the reverse case, where additional oil is required in the circuit, it comes from the accumulator as pressure drops in the system by a corresponding amount.

7  
1x7=7  
FIG-3  
EXP-4

VIII(a)



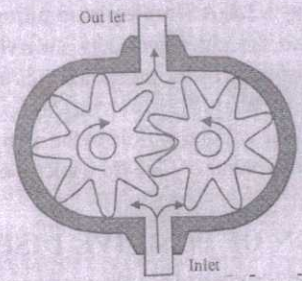
Intensifier is a device used to increase intensity of pressure of liquid by means of utilising the energy available from large amount of liquid at low pressure. figure shows the constructional features of hydraulic intensifier. it consists of a fixed Ram surrounded by a sliding cylinder which contains high pressure liquid which is supplied to the machine through the fixed Ram. the sliding cylinder is encased by a fixed cylinder which contains low pressure liquid from the main supply. the low

8  
1X8=8  
FIG-4  
EXP-4

pressure liquid from the supply enters the fixed cylinder the water in the sliding cylinder gets compressed due to downward movement of the sliding cylinder and its pressure is increased this high pressure water is forced out of the cylinder through the fixed Ram to the machine.

VIII (b)

The simplest and most robust positive displacement pump, having just two moving parts, is the gear pump. The most common type of gear pumps internal construction is shown in the Figure 6. It consists of just two close meshing gear wheels which rotates as shown. One of the gears is driven and the other runs free. As the teeth come out of mesh at the centre, a partial vacuum is created by the unmeshing of the rotating gears, draws fluid into the pump. This fluid is then transferred to the other side of the pump between the rotating gear teeth and the fixed casing. As the rotating gears mesh together, they generate an increase in pressure that forces the fluid into the outlet line. A gear pump can discharge fluid in either direction, depending on the direction of the gear rotation. This is called as external gear pump.

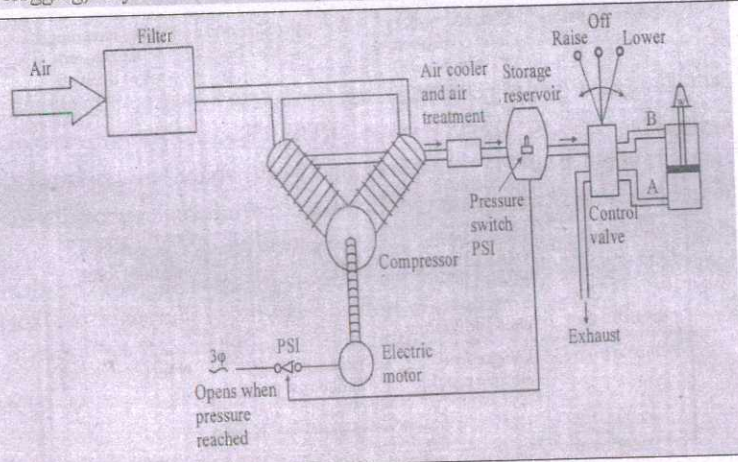


The pump displacement is determined by the volume of fluid between each pair of teeth, number of teeth and speed of rotation. The gear pump is suitable for low and medium heads. Thick and viscous liquids can be handled easily by this pump due to absence of valves. The gear pump gives higher efficiency and its cost is low. It is generally used in drills and saws. Gear pumps can pump liquids containing vapours or gases. Since they depend on the liquid pumped to lubricate the internal moving parts, they are not suitable for pumping gases. They deliver a constant output with negligible pulsations for a given rotor speed. Since gear pumps are subject to clogging, they are not suitable for pumping liquids containing solid particles.

7  
FIG-3  
EXP-4

1X7=7

IX(a)



8  
FIG-3  
EXP-5

1x8=8

15

**Compressor** : A device which converts mechanical energy in to pneumatic energy is called compressor. Air compressors are either diesel or electrically operated. Air is taken in at atmospheric pressure is compressed and delivered at a higher pressure to the pneumatic system. Based on the requirement of compressed air suitable capacity compressors may be used.

**Electric Motor** : It transforms electrical energy in to mechanical energy. It is used to drive the compressor.

**Air Receiver of Reservoir** : The compressed air from the compressor is stored in the air receiver.

**Pressure Switch** : It is used to maintain the required pressure in the air receiver. It adjust the high pressure limit to low pressure limit in the 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.

**Check Valve** : The check valve allows the flow in one direction and blocks flow in a 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.

**Safety Valve** : The function of safety valve is to release the extra pressure, if the pressure inside the receiver exceeds the safe pressure limit.

**Auto Drain** : Auto drain, drains all the water condensing in the tank.

**Air Dryer** : The water vapor or moisture in the air is separated from the air by using dryer.

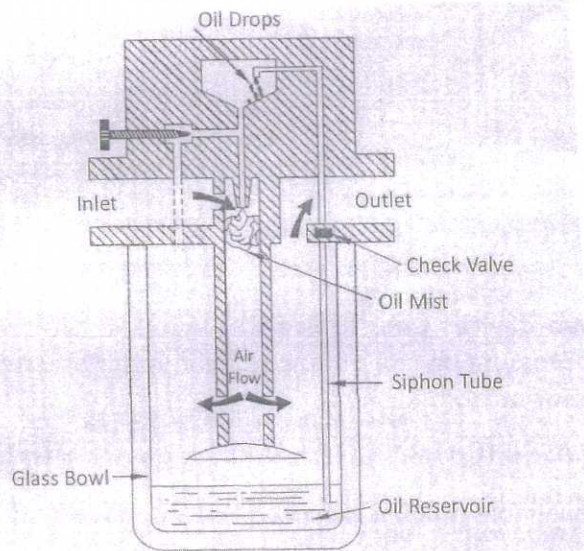
**Pressure Gauge** : Pressure gauge indicates the pressure inside the compressor receiver.

**Air Filter** : Air filter is used to filter out the dust and contaminants from the air.

**Control Valves** : Control valves are used to regulate, control and monitor for control of direction flow pressure etc.

**Air Actuator** : Air cylinder and motors are used to obtain the required movements of mechanical elements of pneumatic system.

IX (b)



The function of a lubricating is to add a controlled amount of with air to ensure proper lubrication of internal moving parts of pneumatic components.

7

1x7=7

FIG-3  
EXP-4

The compressed air from the dryer enters in the lubricator. this cause a pressure drop between oil reservoir and the upper part of the lubricator. due to the low pressure in the upper chamber the oil is push into the upper chamber from the the oil reservoir through a siphon tube with check valve. The main function of thevalve is to control the amount of oil passing through it. the oil drops inside the throttled zone where the velocity of air is much higher and this velocity of air brakes the oil drops into tiny particles and most of air air and oil is generated. thus the oil carried with the compressed air into the system helps lubricate the system components.

X(a)

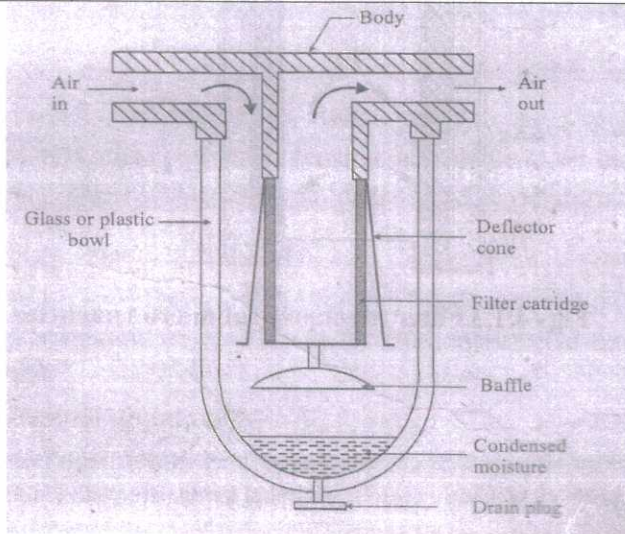
Sl. No.	Criterion	Hydraulic System	Pneumatic System
1.	Operating pressure	Varies from low to very high pressure (1400 bar)	Low (6 bar)
2.	Necessity of pump/compressor	Pump is necessary	Compressor and reservoir are necessary
3.	Weight to pressure ratio.	Small	Large
4.	System Rigidity	Good	Poor
5.	Speed	Limited	Very high
6.	Cavitation	Occurs	Nil
7.	Suitability	Resistant to fluctuating loads. Suitable for feed movement in machine tools.	Non-resistant to fluctuating loads. Un-suitable for feed movement in machine tools.
8.	Operating cost	Moderate	Very low
9.	Overall cost	Moderate	Low

8

1x8=8

15

X(b)



7

1x7=7

FIG-  
3  
EXP-  
4

Air filters are used to perform the following functions 1. To prevent entrance of solid contaminants to the system 2. to condense and remove the water vapour present in air 3. to arrest any submicron particle

Main component of the filter is sintered cartridge made up of sintered brass or bronze. Sintered cartridge helps to provide random zigzag passage for the air to flow which in turn arrests the solid particles.

Vapour gets condensed inside the filter and collects at the bottom of the filter bowl which is mostly made up of glass or transparent plastic material.