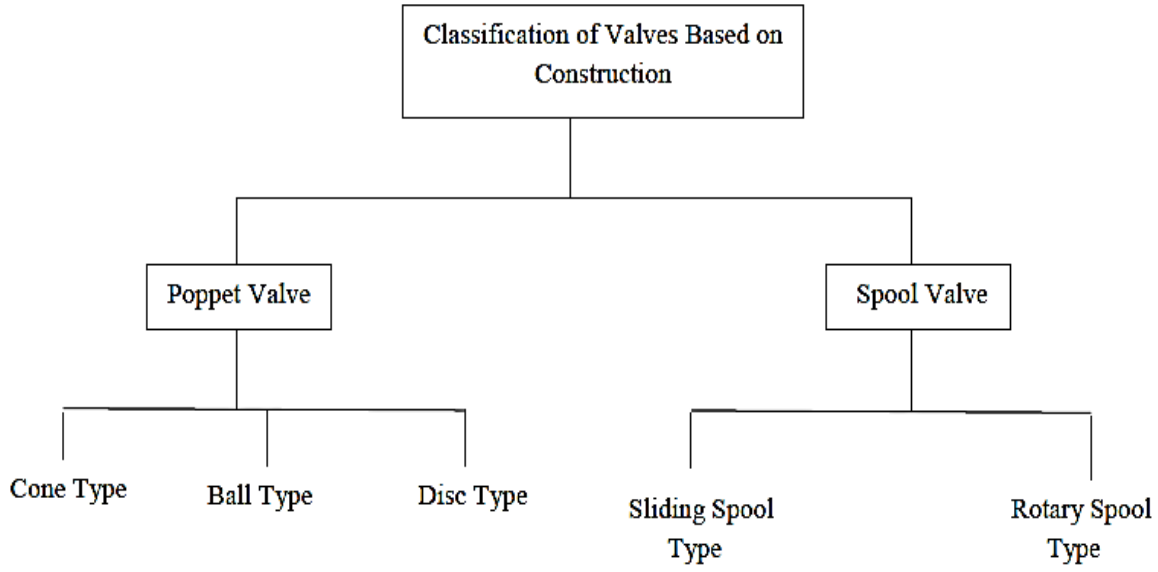
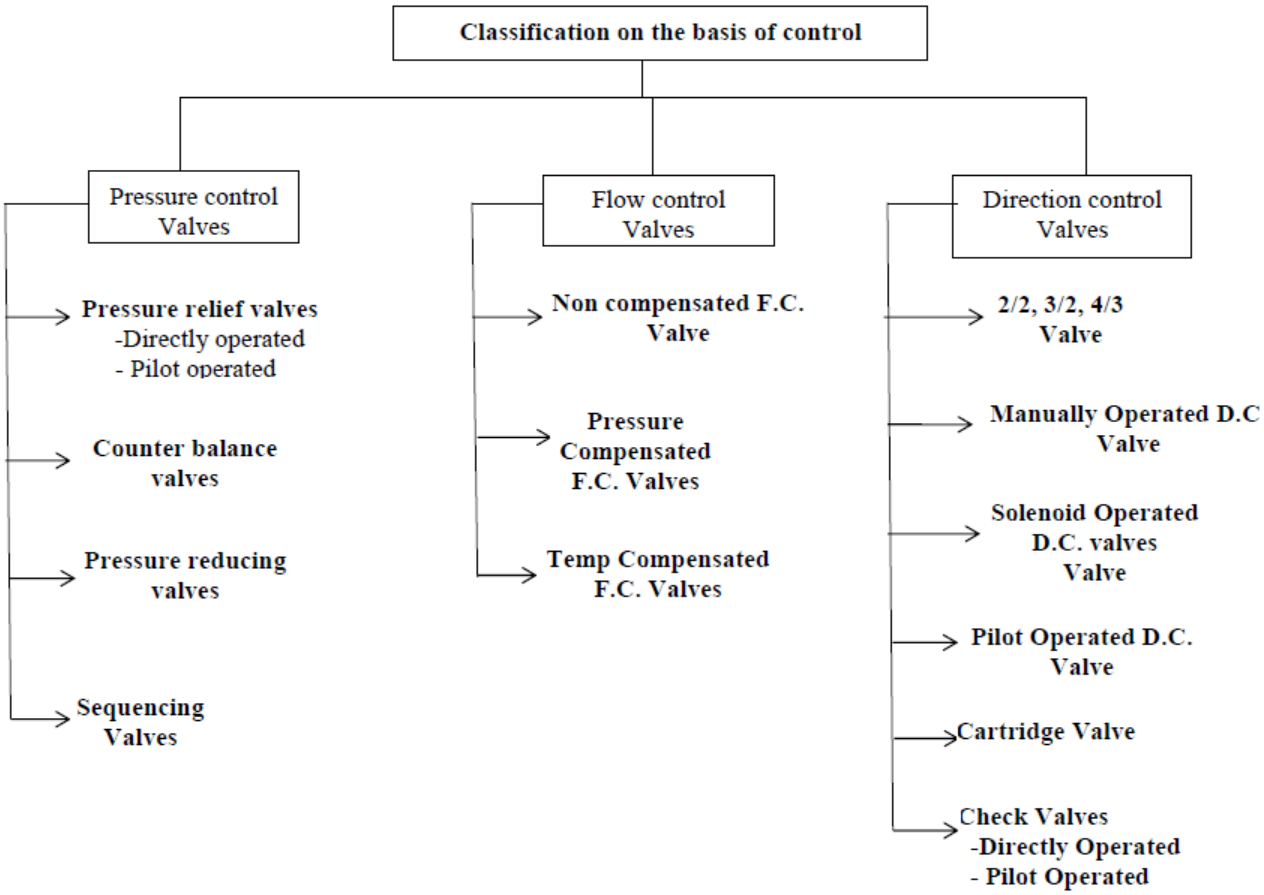
Important Instructions to examiners:
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language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

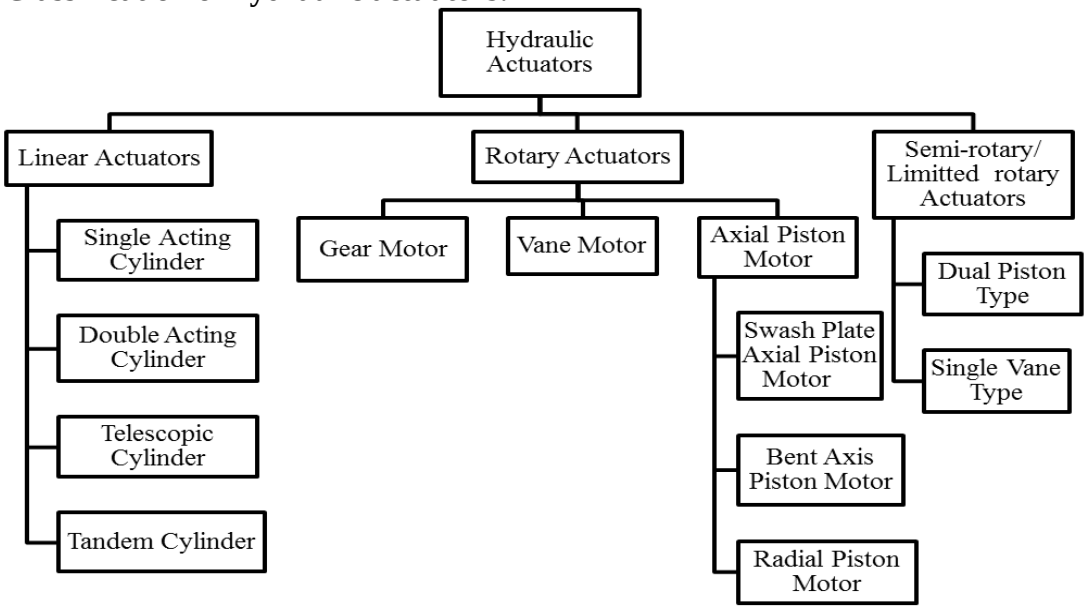
Marks

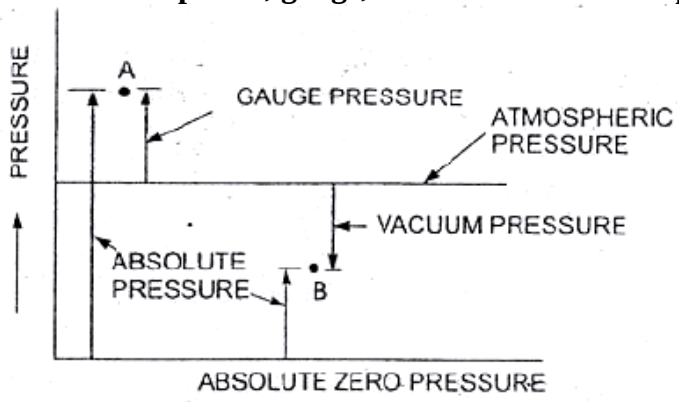
1. **A) Attempt any THREE of the following:**	12
(a) Define specific weight and specific gravity.	4
Answer: **Specific Weight:** It is the ratio of weight of fluid to its volume or weight per unit volume of a fluid is called specific weight. It is denoted by w. **Specific gravity:** It is defined as the ratio of the weight density (density) of a fluid to the weight density (density) of a standard fluid. It is denoted by S.	2 2
(b) Give the classification of valves.	4
Answer: Classification of valves: 	4

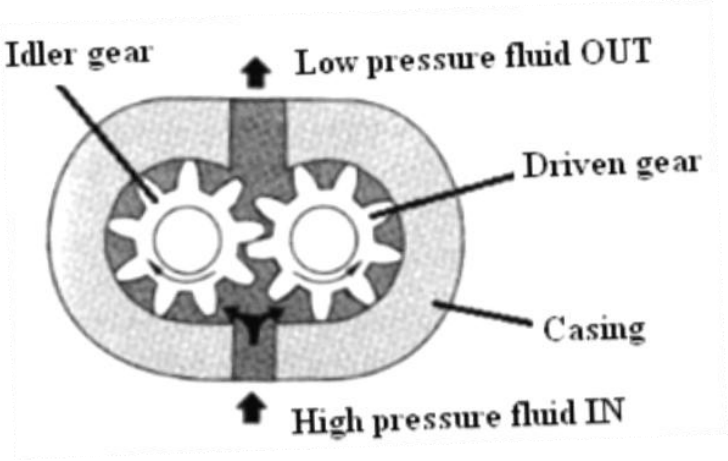
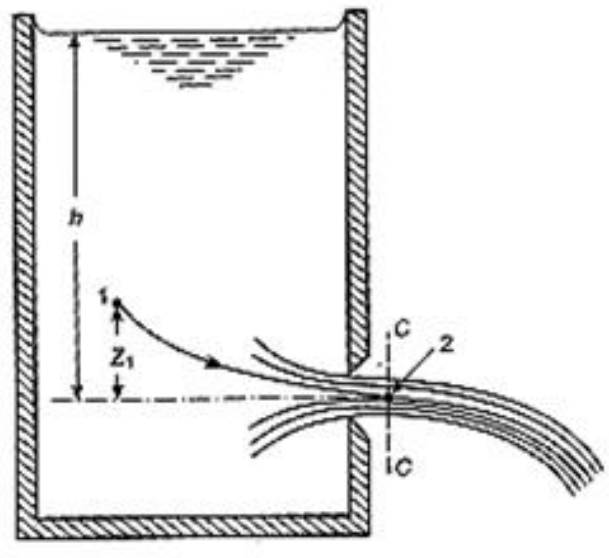


(c) Give classification of hydraulic actuators. Write application of each. 4

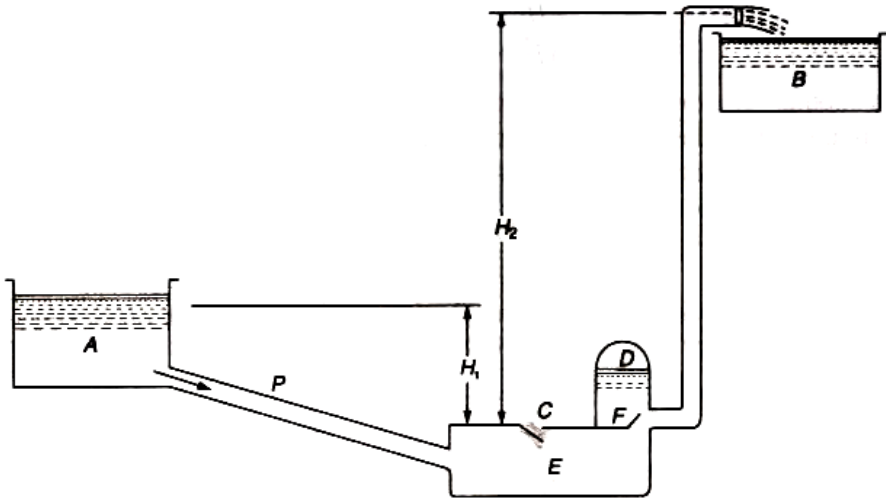
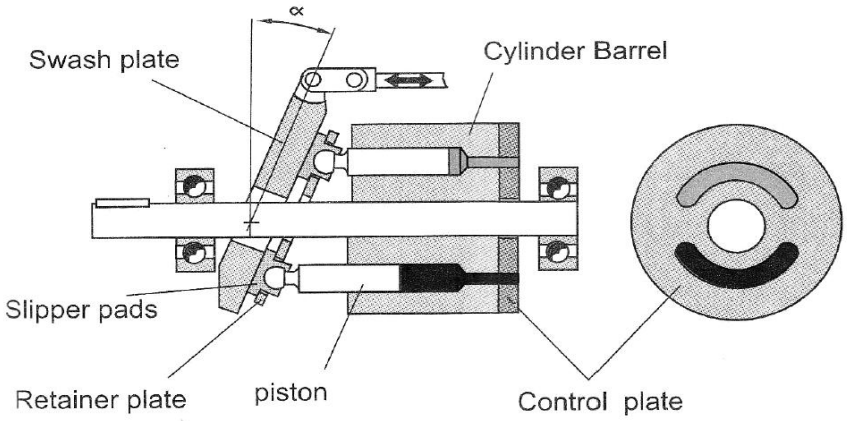
Answer: Classification of hydraulic actuators: 2

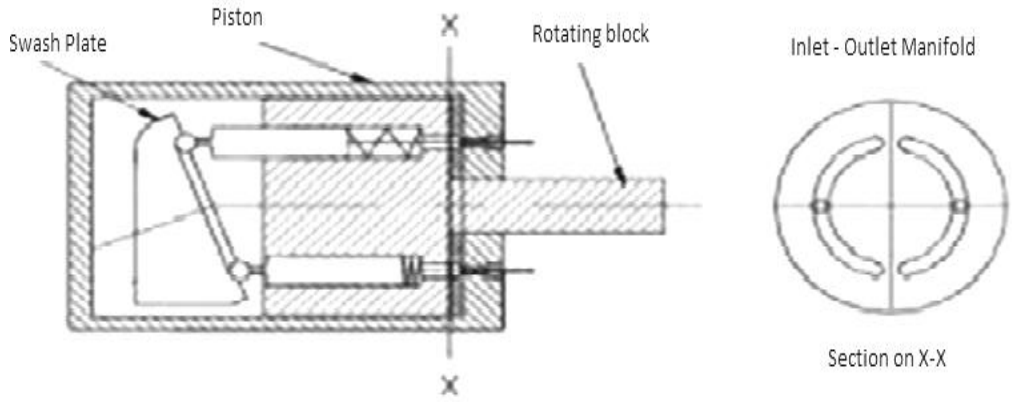


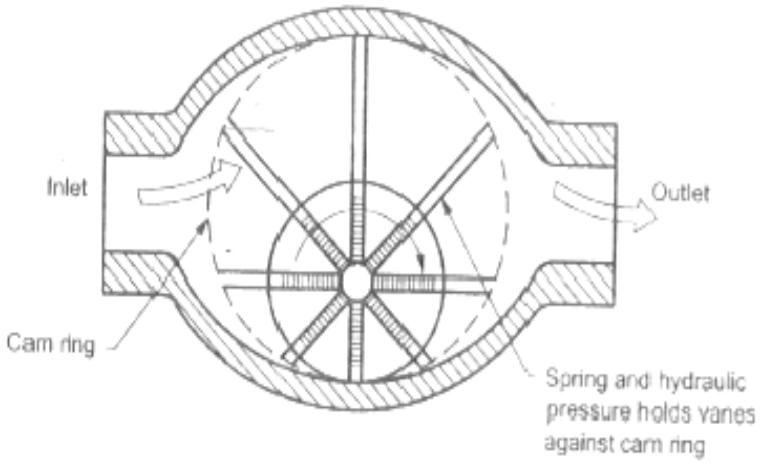
Applications: *(Any one application of each)* **1) Linear Actuators:** Machnine tools, Industrial machinery, Earth moving equipments, construction equipments, Space applications etc. **2) Rotary Actuators:** Hydraulic morors, Engineering vehicles, Manufacturing machinery, Automotive transmission, LPG cylinder filling, Aviation service etc.	2
(d) State the types of seals and gaskets and write application of seals.	4
Answer: **Types of seals:** Static, dynamic, positive, non-positive, O-ring, V-ring, U-packing, T-ring, Cup seal. **Types of gaskets:** Rubber gasket, non-asbestos gasket, cork gasket; Flanged gasket, Spiral wound gasket; Man-way gasket, Transformer gasket **Application of Seals:** *(Any four)* Gear pump, motors, Hydraulic and Pneumatic actuators, Gear box casings, Centrifugal pump, Automotive braking system, food processing machine, CFC based automotive refrigeration system, car engine etc.	1 1 2
B) Attempt any ONE of the following:	6
(a) Represent schematically atmospheric, gauge, vacuum and absolute pressure. State the relations between them.	6
Answer: Relationship between atmospheric, gauge, vacuum and absolute pressure:  Figure: Relationship between atmospheric, gauge, vacuum and absolute pressure. 1. **Atmospheric Pressure**: At the earth surface, the pressure due to the weight of air above the earth surface is called as atmospheric pressure. 2. **Gauge Pressure:** If the pressure is measured above the atmospheric pressure, it is called as gauge pressure. 3. **Vacuum Pressure:** If the pressure is measured below the atmospheric pressure, it is called as Vacuum pressure. 4. **Absolute pressure =** Atmospheric Pressure + Gauge Pressure **Absolute pressure =** Atmospheric Pressure – Vacuum Pressure	2 4

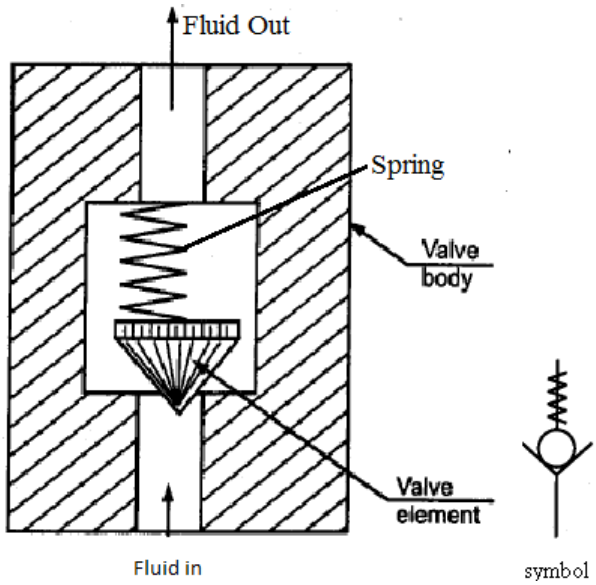
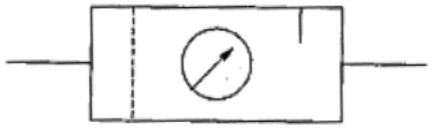
(b) Explain with the sketch working of gear type hydraulic motor.	6
Answer: Working of gear type hydraulic motor: Gear type motor is a rotary actuator used to rotate the shaft. It consists of two gears in mesh with each other. One gear is connected to output shaft and other is idler. Both the gears are mounted in closed casing. Pressurized fluid enters from the bottom, and pressurizes the chamber. This pressure exerts a force on teethes These forces results in rotation of both gears. This rotary motion is further used in rotation of output shaft. Gear motors suffer from leakage, which is quiet high at low speeds. Hence gear motors are used where medium speed and low torque are required.  Fig. Gear type hydraulic motor	3 3
2. Attempt any FOUR of the following	16
(a) Explain the term vena contracta as applied to flow of water through a sharped edge orifice.	4
Answer : Vena Contracta:  Fig. Resrvior with sharp edge orifice *(Note: Equivalent credit shall be given to any other diagram and suitable explaination)* Figure shows a sharp edged orifice in one side of reservoir containing water. The water will emerge from the orifice as a free jet, that is, a jet discharged in the atmosphere and will therefore be under the influence of gravity only.	2 2

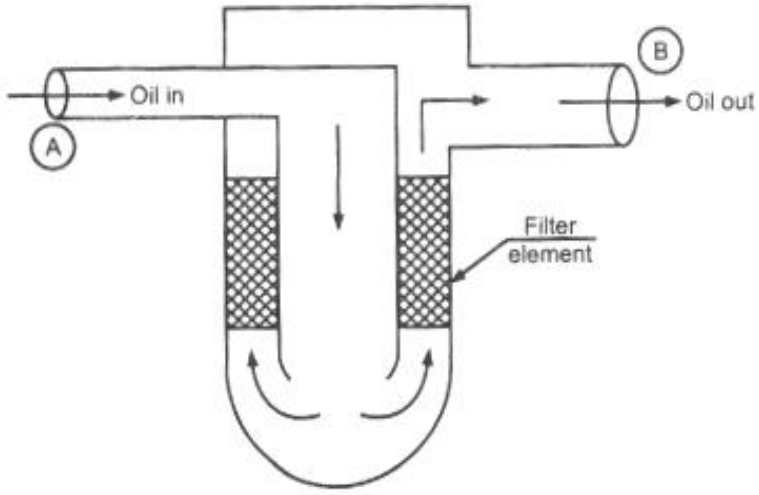
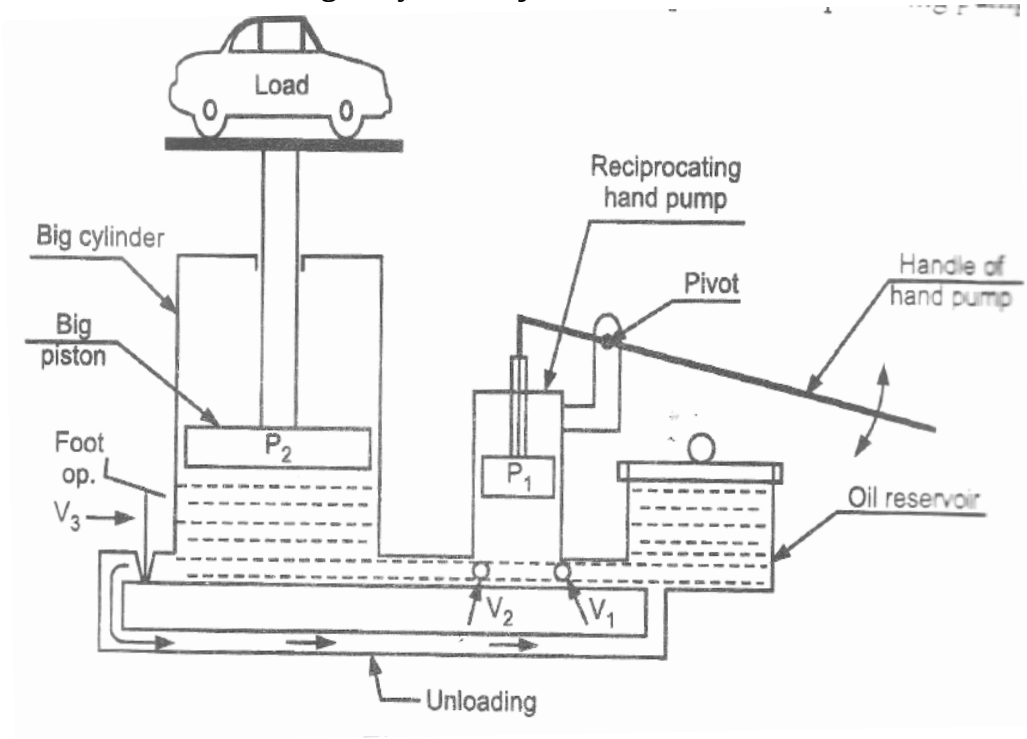
The section C-C of the jet, at which the streamlines are straight and parallel to each other and perpendicular to the plane of the orifice, and the jet has the minimum cross sectional area, is known as vena contracta. The pressure at section C-C is uniform and it is equal to the pressure of surrounding the jet. The velocity of flow of water at this section will be maximum by the principle of continuity. Beyond the section C-C the jet may, however, diverge again and it undergoes a downward deflection due to gravity. The area of jet a_2 i.e. at vena contracta may be related to the area of orifice a_0 by following expression $a_2 = c_c . a_0$ C_c = Coefficient of contraction	
(b) What is priming of a centrifugal pump? Why is it necessary?	4
Answer: **Priming of Centrifugal pump:** It is the operation in which the suction pipe, casing of the pump and the portion of delivery pipe up to delivery valve is completely filled with the liquid which is to be raised by pump. This operation is carried out only once before starting the pump thus air within these parts is removed. **Necessity:** The pressure developed by the impeller of the centrifugal pump is proportional to the density of fluid in the impeller. It is thus obvious that if the impeller is running in air, it will produce only negligible pressure which may not suck liquid from its source through the suction pipe. To avoid this priming is necessary. Priming reduces the risk of pump damage during start-up as it prevents the dry run. Pump runs smooth and delivers continuous discharge of flow. Priming reduces noise, vibrations in pump.	2 2
(c) What is cavitation and what are its causes?	4
Answer: **Cavitation**: It means formation of vapour bubbles of a flowing liquid in a region where the pressure of the liquid falls below its vapour pressure and sudden collapsing of these vapour bubbles in a region of higher pressure. When the vapour bubbles collapse, a very high pressure is created. The metallic surfaces, above which these vapour bubbles collapse is subjected to high pressure which causes pitting action on surfaces. Thus cavities are formed on metallic surface, known as cavitation. Also considerable noise and vibrations are produced. **Causes of cavitation:** *(Any two)* Cavitation in pumps is usually due to insufficient NPSH (Net Positive Suction Head) energy on the suction side of the pump. This can be caused by: 1. Having the pump at too high of a distance above the fluid source 2. Having too small of a diameter of suction pipe 3. Having too long of a distance of suction pipe 4. Having too many fittings on the suction pipe 5. Handling a liquid with a low vapour pressure 6. Running the pump too fast	2 2

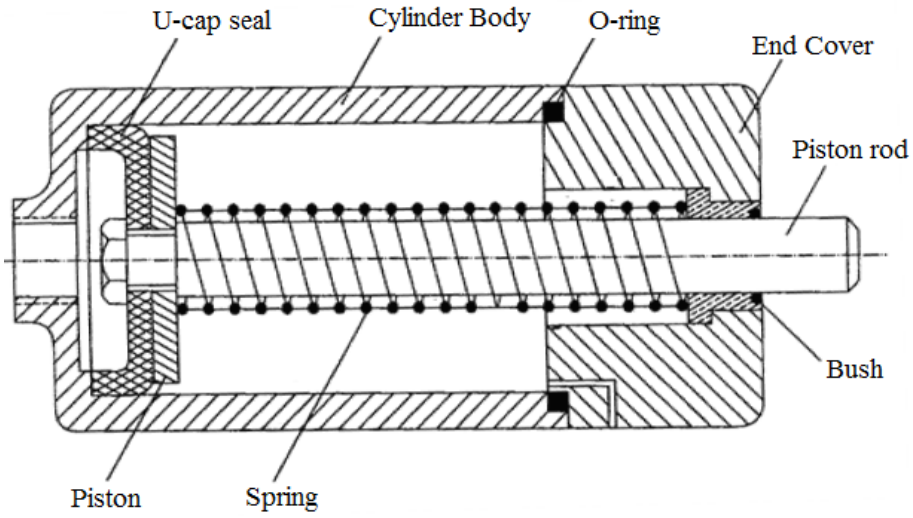
(d)Explain construction and working of Hydraulic Ram with neat sketch.	4
Answer: Hydraulic Ram:*(Construction and working-2marks, Sketch-2marks)*  Figure: Hydraulic Ram **Construction:** It is a type of pump which can lift a small quantity of water to a greater height when large quantity of water is available at smaller height. It consists of large reservoir A at smaller height, chamber E consists of waste valve C and delivery valve F. **Working:** The working of hydraulic ram is based on the principle of water hammer or inertia pressure developed in a supply pipe. When water starts flowing from tank A to chamber E through supply pipe P, it starts flowing through waste valve C as it is open. As the speed of water increases, the pressure on the valve lid increases thereby closing the waste valve. This sudden closing of waste valve brings the water in supply pipe to rest, causing further increase of pressure in valve chamber due to development of inertia pressure. Due to this increase of pressure in the valve chamber the delivery valve is forced to open. The water starts flowing in air vessel and delivery pipe which supply to delivery tank. When the momentum of water in the chamber is destroyed, the waste valve is opened again causing flow of water from tank A to recommence.	2 1 1
(e) Draw a neat labeled sketch of Swash plate type pump.	4
Answer: Swash plate type pump:  **OR**	4

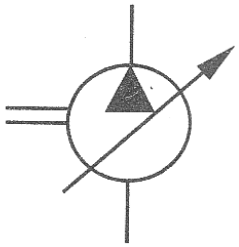
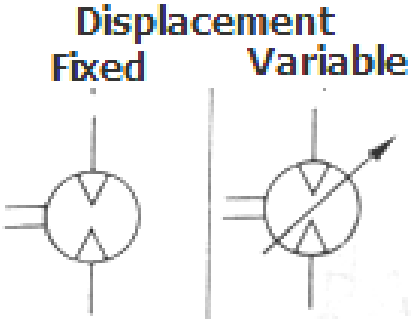


3. Attempt any FOUR of the following:	16
(a) Explain with neat sketch working of vane type pump.	4
Answer: Working of vane type pump: Vane pump consists of a rotor in which vanes are held in a series of slots around the rotor. As the rotor rotates in clockwise direction, the area between vanes is sealed as the vane uncover suction port this creates partial vacuum in suction chamber. Further, the fluid confined between two vanes is carried away to the outlet chamber, forcing the fluid into the delivery port.	2
 Fig. Vane type pump	2
(b) Write two advantages and two applications of air motor.	4
Answer: **Advantages of air motor:** *(Any two)* 1. Air motor develops more power per weight and per cubic meter of displacement than standard electric motor. 2. Shock and explosion proof. 3. Air motors are not affected by hot, wet or corrosive atmosphere. 4. Air motors are not damaged by overloading, rapid reversals, or continuous stalling. 5. Speed can be varied over a wide range without complicated control arrangement in air mass. 6. Air motors accelerate and decelerate quickly. 7. Simple in design and construction is relatively inexpensive.	2

Applications of air motor: *(Any two)* 1. Pneumatic drill 2. Pneumatic screw driver 3. Pneumatic wood borer 4. Pneumatic wrenches and nut runners 5. Pneumatic grinder	2
(c) Explain with neat sketch operation of non-return valve.	4
Answer: Operation of non-return valve: This valve consists of valve body with inlet and outlet ports having valve element like cone, ball or spherical poppet. The valve element is incorporate with specially designed spring. When pressurized oil comes in through port A it will lift up the cone by overcoming spring force and flow will start from port A to port B .When flow from A stops spring will expand and cone will block the flow hence only one direction of flow is possible.  Figure: Non-Return Valve	2 2
(d) State the function of FRL unit in a pneumatic system. Draw symbol for FRL unit.	4
Answer: Function of FRL Unit:- **1. Filter**: i) To prevent entrance of solid contaminants to the system. ii)To condensate and remove the water vapour that is present in the air. iii) To arrest submicron particles that may pose a problem in the system components. **2. Regulator**: To regulate the incoming pressure to the system so that the desired air pressure is capable of flowing at a steady condition. **3. Lubricator:** To provide lubrication for mating components of valves, cylinders etc.by forming a mist of oil and air. **Symbol for FRL unit:** 	3 1

(e) Explain construction and working of full flow type filter with neat sketch.	4
Answer: Full flow type filter: As shown in figure, in full flow filter oil comes in through port A, passes through filter element and goes out through port B. In this filter all flow passes through filter, hence it is called as a full flow filter. This is very efficient filter but only drawback of this filter is that there is large pressure drop. It increases due to clogging of filtering element.  Figure: Full flow filter	2 2
4. A)Attempt any THREE of the following:	12
(a) Explain construction and working of hydraulic jack with neat sketch.	4
Answer: Construction and working of hydraulic jack:  Figure: Hydraulic Jack	2

Construction: It consists of pair of big cylinder –piston and hand lever operated reciprocating pump. There is oil reservoir fitted to hand pump. There are three valves V_1 V_2 and V_3 as shown in fig. Valve V_3 can be open by pressing foot lever. **Working:** The hydraulic jack works on Pascal's principle. Reciprocating pump is operated by moving handle up and down. During upward movement of piston (P1) oil from reservoir will be sucked in via valve (V_1) due to vacuum created in cylinder During downward stroke of piston (P_1) valve (V_1) will close and valve (V_2) will open and pressurized oil will enter into big cylinder via valve (V_2).The pressurized oil will lift the piston (P_2) upward and load will be lifted up.	1 1
(b) Explain working of single acting air cylinder with sketch.	4
Answer: Working of single acting air cylinder: It consist of cylinder body, two end covers, piston, piston rod, U-cap seal, O- ring, bush or bearing to guide the piston rod, built in spring. In a single acting cylinder, the compressed air is fed only in one side. Hence, this cylinder can produce work in only one direction. The compressed air has to first overcome the pressure of spring and hence some power is lost before actual stroke of the piston starts. Compressed air advances the piston. The return movement of the piston is effected by a built in spring or application of external force.  Figure: Single Acting Air Cylinder	2 2
(c) State types of hoses and gives its two applications.	4
Answer: Types of hoses : 1) Hydraulic hoses: Rubber reinforced with fiber or steel wire braiding flexible hoses are classified as- a. Medium pressure (SAE- 100 R1,R3, R4) b. Medium high pressure (SAE- 100 R2,R5, R6) c. Super high and heavy duty type including Teflon and metallic hoses(SAE- 100 R9,R12) 2) Pneumatic hoses a. Straight Reinforced Polyurethane Hose b. Coiled Reinforced Polyurethane Hose c. Coiled Polyurethane Hose d. Coiled Nylon Hose	1 1

Applications of Hydraulic hoses: *(Any two)* 1) Earthmoving equipments 2) Machine tools 3) Robotics 4) Material handling equipments 5) CNC/VMC machines 6) Hydraulic automobile brakes SAE 100 R series hoses should be used with petroleum- and water-based hydraulic fluids, within a temperature range from -40° to 100° C. **Applications of Pneumatic hoses:** *(Any two)* 1) Construction equipments like breaker, drill, air compressor 2) Mining 3)Printing presses 4) Air motor 5) Pneumatic automobile brakes 6) Pneumatic crane	1 1
(d) Draw a symbol for : (i) Variable speed unidirectional pump (ii) Air motor with two directional flow.	4
Answer: Symbol for	
(i)Variable speed unidirectional pump 	2
(ii) Air motor with two directional flow 	2
(B)Attempt any ONE of the following:	6
(a) Explain with neat sketch meter – in hydraulic circuit.	6
Answer: **Working of Meter-in circuit:** Figure shows a meter in circuit in which the flow control valve is placed in the primary line, directly after load. In meter in circuit speed control is achieved by changing the flow adjustment of flow control valve which controls the oil going to the blind end of the cylinder. When spool valve is operated pump is connected to blind end of cylinder thus piston moves forward causing work done. During return stroke the fluid returns back through non return valve. Meter in circuit are generally used when load characteristics are constant and positive, in grinding and milling machine.	3

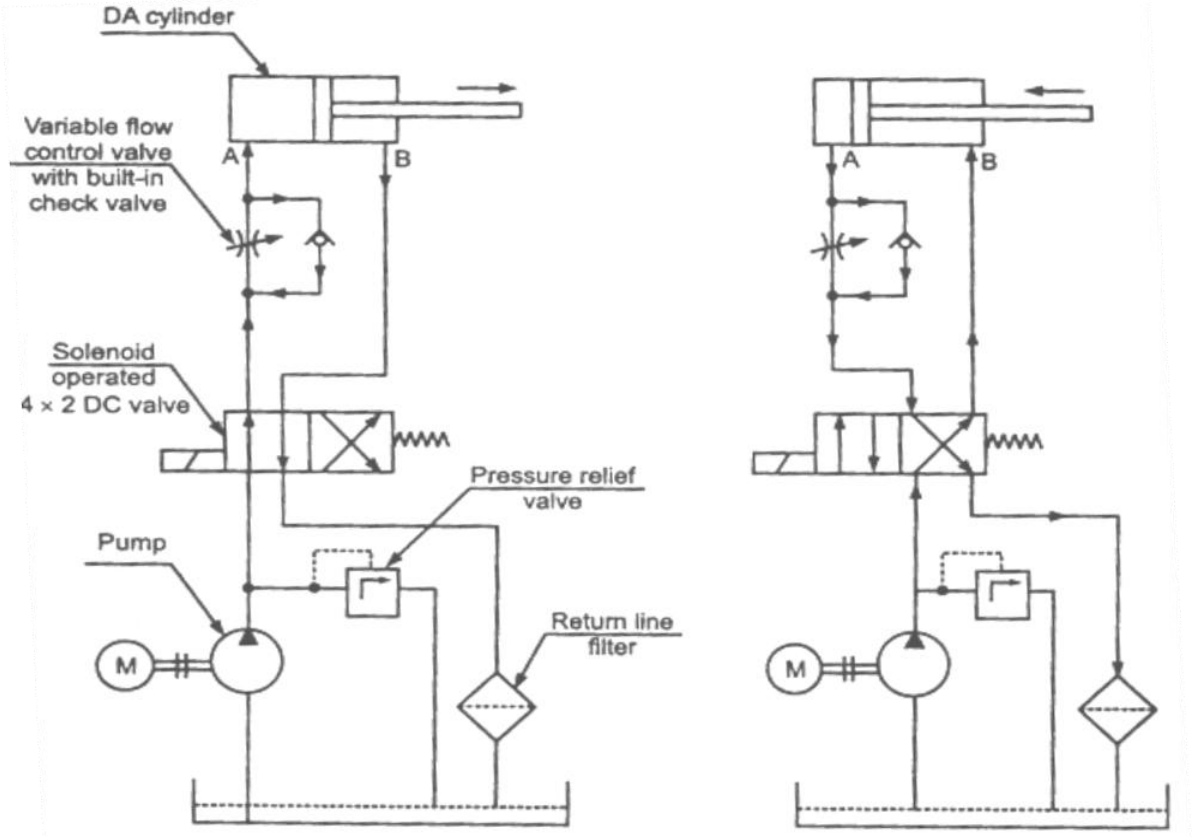


Fig. Meter in Circuit

3

(b) Give six points of comparison between hydraulic and pneumatic circuits. 6

Answer: Comparison between hydraulic and pneumatic circuits *(Any six)* 6

SR	Hydraulic circuit	Pneumatic circuit
1	Used for circuits up to 700 bar pressure	Operative below 10 bar pressure.
2	Uses hydraulic oil as a medium	Uses air as a medium
3	Pump is used to pressurize the oil	Compressor is used to pressurize the air.
4	Since hydraulic oil is reused in the circuit hydraulic oil tank is a must and there are return lines	Air is taken from atmosphere and is vented to atmosphere after use. Hence no return lines. Air reservoir is used to store pressurized air.
5	The rigidity of the system using hydraulic circuit is good.	The rigidity of the system using hydraulic circuit is poor.
6	Moderate operating cost.	Operating cost is low.
7	Maintenance is critical.	Maintenance is simple.
8	Very suitable for accurate speed/feed movement of cutting tool mechanism.	No accuracy in movement.
9	The system using hydraulic circuit is not clean due to oil leakages.	Pneumatic circuits are very clean.
10	Weight to pressure ratio is small.	Weight to pressure ratio is high.
11	Problem of cavitation is serious in hydraulic circuit.	No problem of cavitation.
12	Oil is changed as per schedule.	No need of change of air as per schedule.

13	Hydraulic circuits are used in tackling heavy loads, hence used in earthmoving equipments, CNC-VMC machines.	Pneumatic circuits are used when loads are much lighter. Hence used in transferring the light weight components, vacuum handling in printing press, food industry.	

5. Attempt any TWO of the following: 16

(a) (i) State law of continuity and write its applications. 8
(ii) State Bernoulli's theorem and write its applications.

Answer: i) Law of continuity:

For a fluid flowing through the pipe at all cross section, the quantity of fluid per second is constant. 2

OR

It states that if an incompressible liquid is continuously flowing through a pipe or a channel whose cross sectional area may or may not be constant then quantity of liquid passing through it per second is same at all sections.

Applications *(Any two)* **:**

i) Flow through branching of pipe. ii) Steady and unsteady flow 2
iii) Uniform and non-uniform flow iv) Compressible and incompressible flow

ii) Bernoulli's theorem:

It states that, in a steady flow of real fluid, the total head (total energy per N of flowing fluid) at any section is equal to that at any subsequent section, plus the loss of head occurring between the two sections. 2

OR

It states that whenever there is a continuous flow of liquid, the total energy at every section remains the same provided that there is no loss or addition of the energy.

Applications of Bernoulli's Theorem *(Any two)* **:**

1) Venturimeter 2) Orifice meter 3) Pitot tube 2
4) Rota meter 5) Nozzle meter or Flow nozzle 6) Elbow meter or Pipe bend meter.

(b) Compare centrifugal pump with reciprocating pump. 8

Answer: Comparison of centrifugal pump with reciprocating pump *(Any eight)* 8

Sr	Centrifugal Pump	Reciprocating Pump
1	The discharge is continuous and smooth	The discharge is fluctuating and pulsating
2	It can handle large quantity of liquid.	It can handle small quantity of liquid only.
3	It is used for large discharge through smaller head	It is used for small discharge and high heads
4	It is coupled directly through flanged coupling to an electric motor	Since it can be operated at low speeds only, these pumps are mostly belt driven
5	It needs smaller floor area and installation cost is low	It needs large floor area and installation cost is high
6	Maintenance cost is low	Maintenance cost is more
7	Runs at high speed	Runs at Low speed
8	Operation is smooth and without much noise.	Operation is complicated and with much noise.
9	Efficiency is high	Efficiency is low.

10	It can be used for lifting highly viscous liquids such as oils, muddy and sewage water, paper pulp, sugar molasses, chemicals etc.	It can be used for lifting pure water or less viscous liquids free from impurities, lifting oil from very deep oil wells.	

(c) Draw hydraulic circuit for hydraulic press and explain its working. — 8

Answer: Hydraulic circuit for hydraulic press:

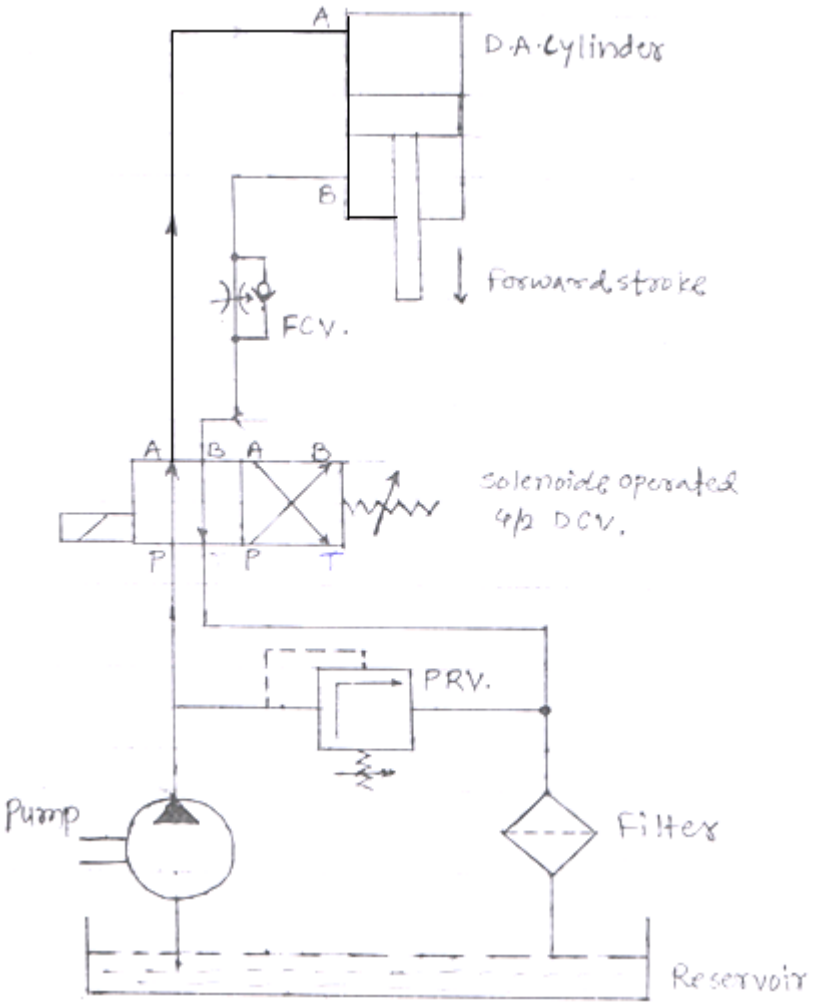


Figure: Hydraulic Circuit for Hydraulic Press — 4

Working: In this circuit, double acting cylinder is used.

The flow control valve is connected in secondary line directly after load. In this operation, retraction stroke should be rapid one, but for achieving forward stroke it should be controlled. So that flow is metered after coming out from cylinder. For forward stroke port 'P' is connected to 'A' and after completion of stroke 'B' is connected to 'R', but in return line flow control valve with check valve is placed in parallel with throttle valve. — 4

So the flow is metered before going to reservoir. In this forward stroke is controlled stroke. for return stroke 'P' is connected to 'B' and flow is taken into cylinder directly opening spool of check valve without restriction of flow control valve ; hence return stroke is uncontrolled stroke.

6. Attempt any TWO of the following :	16
(a) A horizontal venturimeter with inlet and throat diameters 300 mm and 150 mm respectively is used to measure the flow of water. The reading of differential manometer connected the inlet and throat is 200 mm of mercury. Determine the rate of flow. Take $C_d = 0.98$	8

Answer: Given:

Diameter of inlet = $d_1 = 300mm.$ i.e. $0.3\,\text{m}$

Diameter of throat = $d_2 = 15mm.$ i.e. 0.15m

Difference of pressure head $= x = 200mm.$ i.e. 0.2m of mercury

$C_d = 0.98$

Area of inlet $= a_1 = \frac{\Pi}{4} d_1^2 = \frac{\Pi}{4} \times (0.3)^2 = 0.0706m^2$ — 1

Area of throat $= a_2 = \frac{\Pi}{4} d_2^2 = \frac{\Pi}{4} \times (0.15)^2 = 0.0176m^2$ — 1

Difference of pressure head is given by ;

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

Where ;

S_m = Specific gravity of mercury =13.6

S_w =Specific gravity of water = 1

Putting all values in above expression:

$$h = 0.2\left(\frac{13.6}{1} - 1\right)$$

$$= 0.2(12.6)$$

$h = 2.52\,\text{m of water}$ — 1

Discharge through Venturimeter is given by

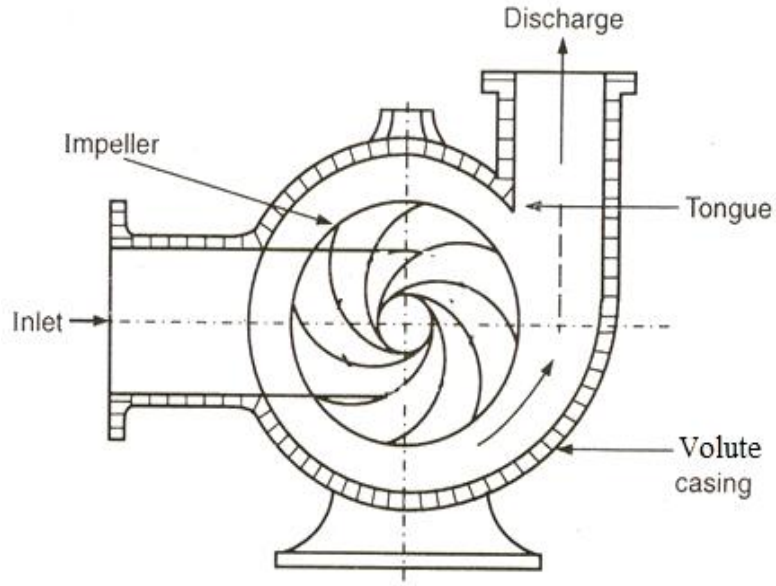
$$Q = C_d \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \times \sqrt{2gh}$$ — 1

$$Q = 0.98 \frac{0.0706 \times 0.0176}{\sqrt{(0.0706)^2 - (0.0176)^2}} \times \sqrt{2 \times 9.81 \times 2.52}$$

$$Q = \frac{8.5622 \times 10^{-3}}{0.068}$$

$Q = 0.125\, m^3/s$ — 3

Rate of flow of water is $0.125\, m^3/s$

(b) Explain construction and working of centrifugal pump with neat sketch.	8
Answer: Construction of centrifugal pump: Main parts of centrifugal pumps are: 1. Impeller. 2. Casing. 3. Suction pipe with foot valve and strainer. 4. Priming cup and delivery pipe with delivery valve. 5. Prime mover (Electric motor or engine) to drive the pump.	2
Working of centrifugal pump: The first step in the operation of a centrifugal pump is priming so that no air pocket is left. After pump is primed, the electric motor is started to rotate the impeller. The rotation of impeller forces the water in radially outward direction in delivery pipe with high velocity. This high velocity water gets converted into high pressure when it passes through spiral casing. At the eye of the impeller due to centrifugal action partial vacuum is created. This causes liquid from the sump to rush through suction pipe to the eye as sump is at atmospheric pressure. This high pressure of liquid leaving the impeller is utilized in lifting the liquid to the required height through the delivery pipe.	3
 Figure: Centrifugal Pump	3
(c) Explain with neat sketch sequencing pneumatic circuit. Write application of this circuit.	8
Answer: Sequencing pneumatic circuit: *(Any one type- 6 marks, application- 2 marks)* **1. Pressure dependent sequencing circuit:** The circuit is used for drilling a hole in work piece. The sequence of operation is - a) Clamping of work piece, b) Drilling, c) Decamping and drill taken out from hole. The DC valve takes centre position (no 3.) no compressed air supplied to either of cylinder C1 or C_2. Now undrilled work piece is kept on fixture seat. The compressed air from compressor is going to vent via DC valve so no movement of cylinder C1 or C_2. At position 1, compressed air starts supplying directly to C2 and through sequence valve to C_1. When compressed air enters through port A_2 of cylinder C_2, piston will advance and immediately clamps the	3

work piece. At the same time compressed air flow towards port A_1 of cylinder C_1 but through the sequence valve. Some higher pressure is set at pressure relief valve of sequence valve. When the pressure of flowing air reaches this set value the sequence valve opens and air enters through port A_1 into cylinder C_1. Due to this piston advances and comes down, so that drilling starts.

When operator again operate foot lever of DC valve it takes position 2 and both piston retracts and work piece de-clamps and drill comes out of drilled hole.

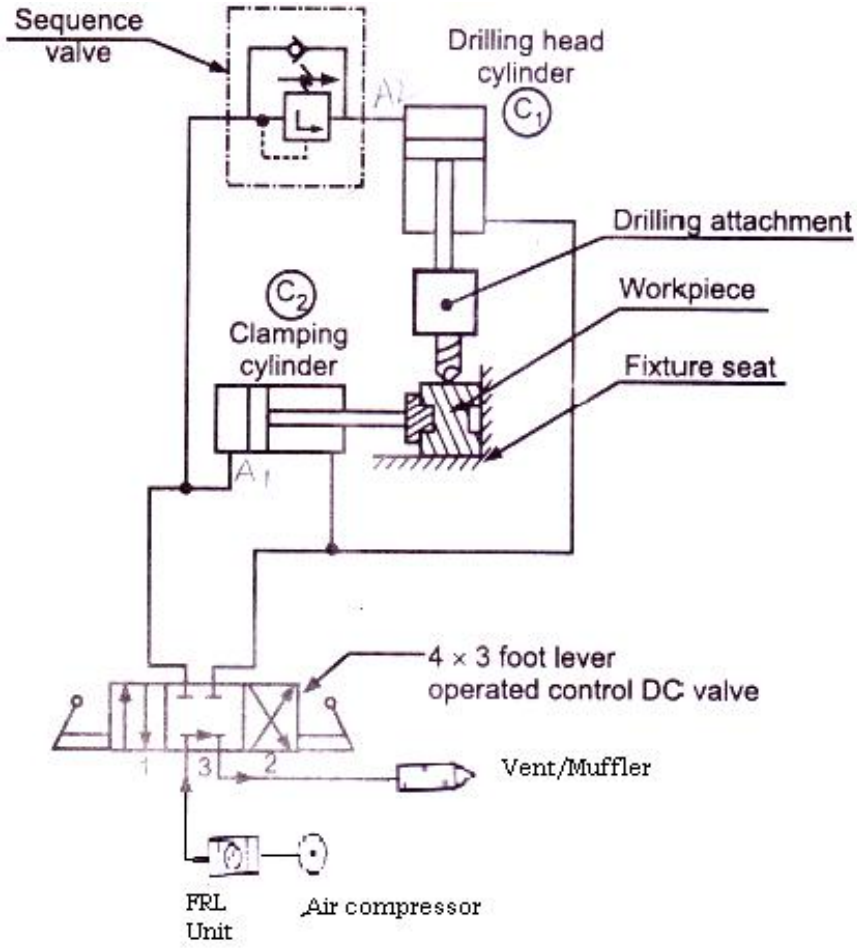


Figure: Pneumatic Circuit Using sequence valve

3

OR

Position based sequencing circuit:

When air is admitted at port B of DA-1 cylinder and port D of DA-2 cylinder. Both pistons move from right to left.

When push button of start valve (S_1) is operated (as shown in figure), the air signal (Impulse) will be supplied to DC valve (DC-1). The air will be admitted through port 'A' of DA-1 and piston will move towards right. The cam is attached to end of piston rod. This cam will push the push button of start valve (S_2). Due to this air signal (Impulse) will be supplied to direction control valve (DC-2) and it will operate. Now, air will be admitted through port 'C' of (DA-2) and the piston will move from left to right. The sequence is achieved by cam of (DA-1). Unless and until (S_2) will not be operated with the help of cam, the piston of (DA-2) cannot move from left to right.

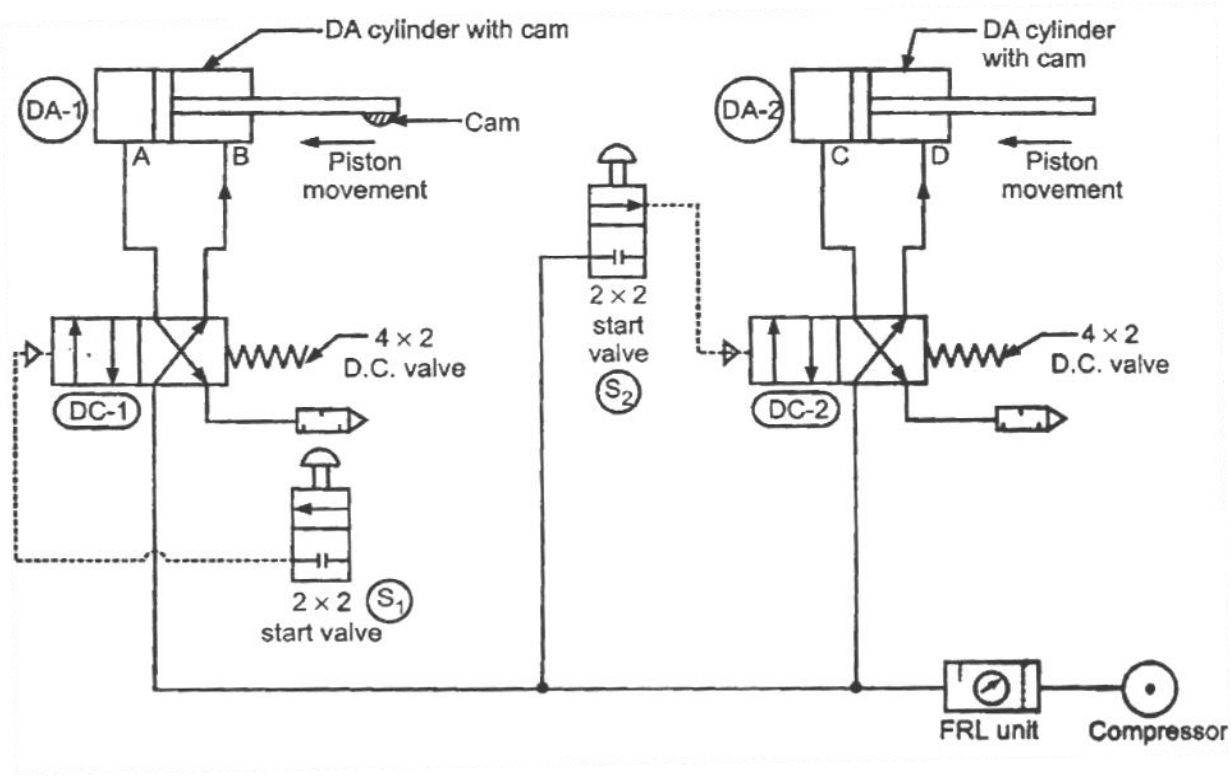


Figure: Position based sequencing circuit

Applications of sequencing circuit:

1. Food and beverage processing industry
2. Printing industry
3. Packaging industry
4. Press tools
5. Welding and fabrication machine
6. Wood working machine
7. Plastic industry
8. Material handling
9. Furnace operation
10. Textile and jute, chemical and pharmaceutical industry

2