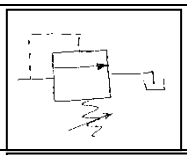
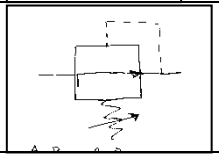
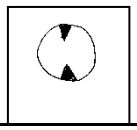
WINTER – 19 EXAMINATION

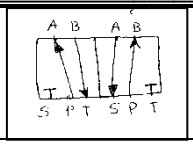
Subject Name: Industrial Fluid Power **Model Answer** Subject Code: 17608

Important Instructions to examiners:

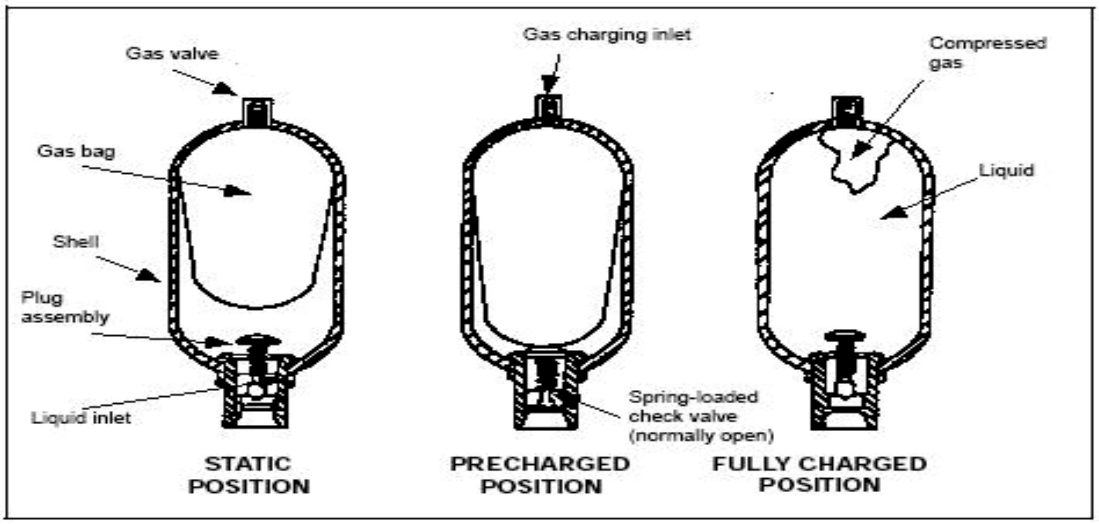
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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 judgement 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.

Q. No.	Sub Q. N.	Answer	Marking Scheme
1. a)	(i)	**Attempt any THREE of the following:** **Essential Properties oil used in Hydraulics:** 1. **Demulsibility**: The ability of a fluid that is insoluble in water to separate from water with which it may be mixed in the form of emulsion. Or it is the oil ability to release water. 2. **Lubricity:** it is the measure of the reduction in friction of a lubricant. 3. **High flash point**: Flash point is a temperature at which liquid catches fire automatically. The flash point of good hydraulic oil must be as high as possible so that fire possibility nullified. 4. **Minimum Toxicity**: Good hydraulic oil must be minimum toxic to human being working with them. Some fire resistance hydraulic oils are highly toxic which can cause occupational diseases. 5. **Low Foaming Tendency**: When oil returns to receiver, it comes in contact with air above the liquid surface. The oil has tendency to absorb air or gas which results in foam formation. Good hydraulic oil must release the air/gas very quickly so that it does not form foam. 6. **Fire resistance**: Good hydraulic oil must be fire resistant to avoid accidents.	4 Marks
	(ii)	**Draw symbol of**	4 Marks

S. N.	Pressure control valves	Symbol
1	Pressure relief valves	
2	Pressure-Reducing Valve	
3	Bi-directional hydraulic motor	

		4 5/3 D. C. Valve 	
	(iii)	**Merits of Hydraulic System** 1) We can generate very high pressures in hydraulic system. Due to this nature of hydraulic system we can use this power to lift, hold, press very heavy loads 2) Weight to power ratio of a hydraulic system is comparatively less than that of an Electro-Mechanical System. Electric motor weigh appropriately 8.5 Kg/kW whereas, same power hydraulic motor weighs 0.85 kg/kW only. 3) The speed control of linear as well as rotary actuators can be achieved with ease. By merely adjusting small flow control valve, wide range of speed and feed can be obtained. 4) The system provides instant and smooth reversible motion **Demerits of Hydraulic System** 1) Elements of hydraulic system have to be machined to high degree of precision which increases manufacturing cost of system. 2) The hydraulic system, due to oil leakages is 'dirty' and we cannot use this system in food and pharmaceutical industry. 3) Petroleum based hydraulic oils can create fire hazards if the temperature of the system goes beyond its 'flash point'	2 Marks 2 Marks
	(iv)	**Use of Accumulator:** A hydraulic accumulator is a device that stores the potential energy of an incompressible fluid held under pressure by an external source. **Functions:** 1. **Store fluid energy:** The stored potential energy in the accumulator is a quick secondary source of fluid power. 2. **To meet peak demand of power:** Energy stored by accumulator can be used for peak or more demand of power from the system. 3. **To smooth out pressure shocks/Surges:** Accumulator helps to reduce pressure shocks and fluctuations caused due to uneven flow and pressures. 4. **Emergency power source:** It will give energy backup during pump failure or whenever required.	Use 1 Marks Figure 2 Marks

Working of bag type accumulator:



Working
1 Marks

This accumulator consists of a seamless high-pressure shell, cylindrical in shape, with domed ends and a synthetic rubber bag that separates the liquid and gas (usually nitrogen) within the accumulator. The bag is fully enclosed in the upper end of a shell. The gas system contains a high-pressure gas valve. The bottom end of the shell is sealed with a special plug assembly containing a liquid port and a safety feature that makes it impossible to disassemble the accumulator with pressure in the system. The bag is larger at the top and tapers to a smaller diameter at the bottom. As the pump forces liquid into the accumulator shell, the liquid presses against the bag, reduces its volume, and increases the pressure, which is then available to do work.

1 b) **Attempt any ONE of the following:**

(i) **Internal Gear Pump**

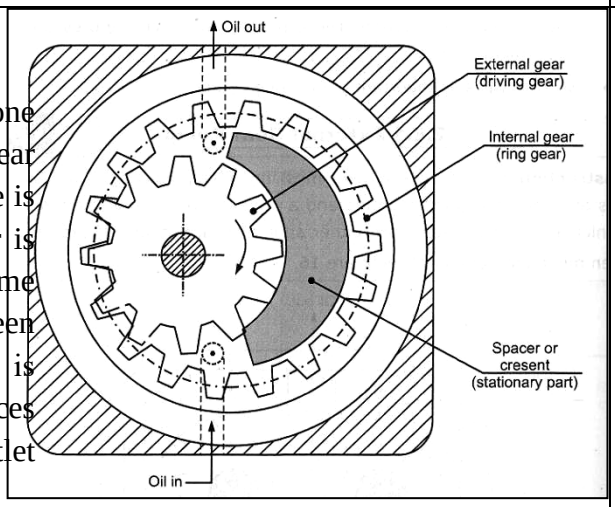


Figure
2 Marks

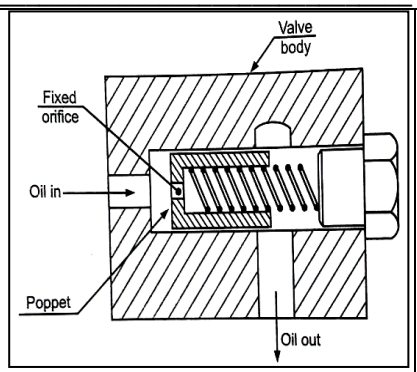
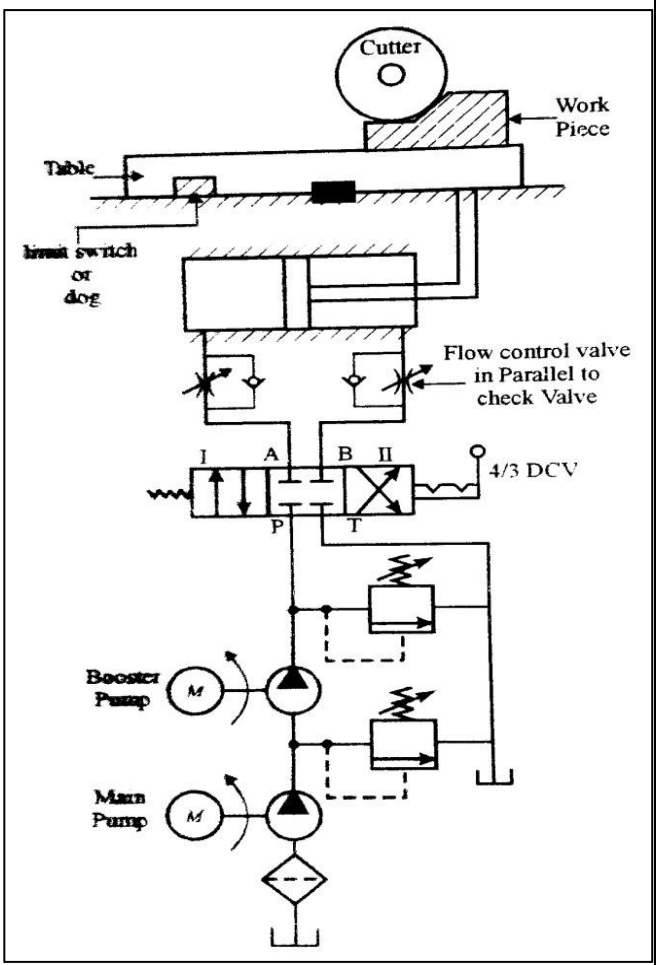
It consists of one external and one internal meshing gear pair. External gear is connected to electric motor and hence is driving gear. Internal gear or ring gear is driven gear which rotates in same direction as that of external gear. Between two gear a spacer called 'cresent' is located which is a stationary pieces connected to housing. Inlet and outlet ports are located in end plates.

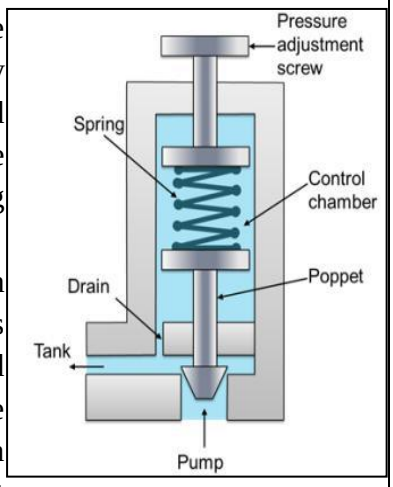
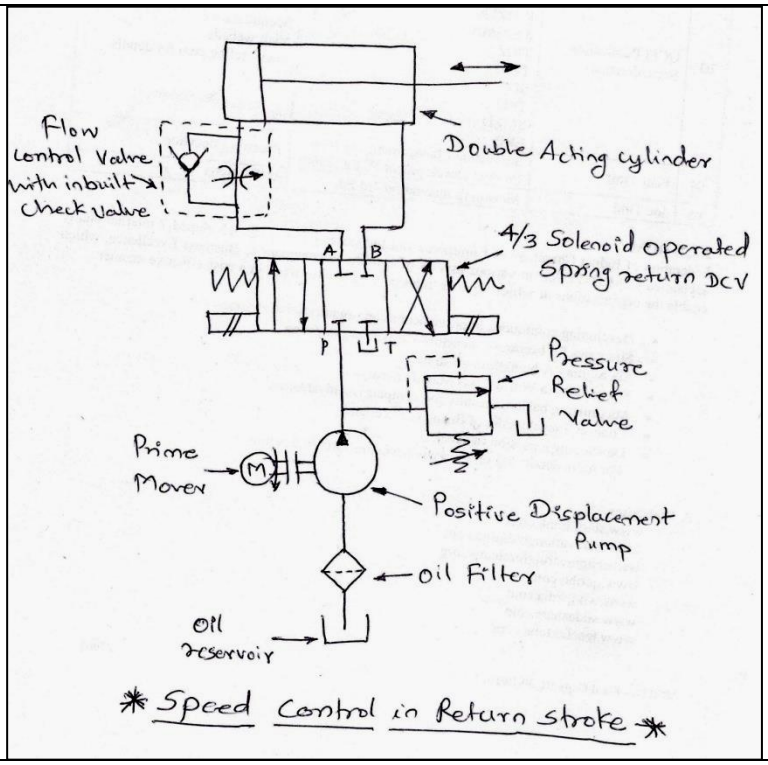
External gear (driving gear) drives the internal gear (Ring Gear). Portion where teeth start meshing, a tight seal is created near port the vacuum is created due to quick unmeshing and oil enters from oil tank through inlet port. Oil is trapped between the internal and external gear teeth on both sides of crescent (spacer) and is then carried from inlet to outlet port. Meshing of gear near outlet port reduces the volume or gap and oil gets pressurized. These pumps make very less noise.

Working
4 Marks

(ii) **Pressure Compensated Flow Control Valve**

In any hydraulic circuit there are slight variations in presence of oil. When pressure changes the rate of flow changes but many circuits requires constant flow regardless of input or output pressure variations in the circuit then the pressure compensated FCV is used. It consists of hollow cylinder shaped poppet at the bottom

		of which there is a fixed orifice. There is a spring inside a poppet as shown in fig.  Pressurized oil entering through the inlet port will apply full force on the bottom of the poppet and will try to compress the spring by shifting the poppet to right the poppet will move to right and will close the outlet port. Then movement of the poppet toward right will stop. Now flow of oil through the orifice will start. Oil will occupy the bore of cylinder this flow of oil will equalize the pressure on both ends of the poppet. The poppet will then balance. During the process of poppet balancing, spring will expand and poppet will move toward left thereby uncovering the outlet port. A balance will automatically be established between quantity of oil through orifice and quantity of oil going out through the outlet port even if the pressure of incoming oil changes, the rebalancing will established automatically and constant flow of oil will come out.	Sketch 2 Marks Working 4 Marks
2		**Attempt any TWO of the following:**	
	a)	**Working of hydraulic circuit for milling machine.** Hydraulic circuit for milling machine is comparatively different from other circuits. Table movement of milling machine is required to be adjustable for different feeds for different type of work. Therefore for both strokes of the cylinder, on both ends of cylinder flow control valves are used. Another feature of this circuit is that there are two pumps 1. Main pump – low pressure high discharge 2. Booster pump - high pressure low discharge The function of booster pump is to boost the hydraulic pressure to a higher level than given by main pump. Reason behind using this type is to save power as well as use of high pressure high discharge pump is avoided.  4/3 DCV used manually operated stroke length of cylinder is adjustable through limit switch. In centre position of 4/3 DCV all the ports are close therefore, total hydraulic system is lock. In position (I) pump flow is given to cylinder blank end and extension starts and oil from rod end is discharge to tank.	Sketch 4 Marks Working 4 Marks

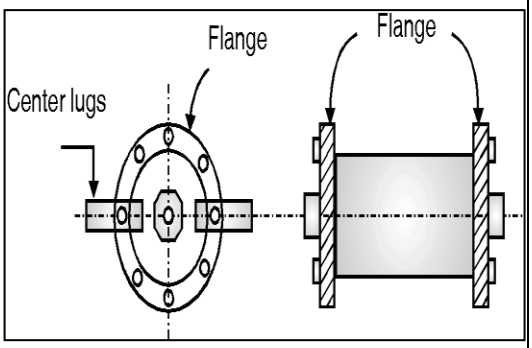
		In (II) position, pump flow diverted to rod end for retraction and blank end side flow pass to tank	
	b)	**Function of Pressure Relief for Pneumatic system** Pressure switch in Pneumatic is similar like pressure relief valve of hydraulic circuit. The main function of this pressure relief valve is to limit the system pressure within a specified range. **Working** The pressure relief valves are used to protect the system components from excessive pressure. Its primary function is to limit the system pressure within a specified range. It is normally a closed type and it opens when the pressure exceeds a specified maximum value by diverting pump flow back to the tank. The simplest type valve contains a poppet held in a seat against the spring force as shown in Figure. This type of valves has two ports; one of which is connected to the pump and another is connected to the tank. The fluid enters from the opposite side of the poppet. When the system pressure exceeds the preset value, the poppet lifts and the fluid is escaped through the orifice to the storage tank directly. It reduces the system pressure and as the pressure reduces to the set limit again the valve closes.  	Function 2 marks Sketch 3 Marks Working 3 Marks
	c)	**Speed control circuit for return stroke.**  	Circuit 4 Marks Label 4 Marks
3.		**Attempt any FOUR of the following:**	
	a)	**Mounting methods of cylinders:** Cylinder mountings methods are (a) Centre line mounting (b) Foot mounting	2 Mark

(c) Pivot mounting

(i) Clevis mounting (ii) Trunnion mounting

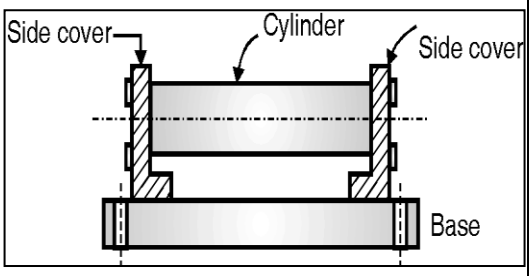
1) Centerline mounting

- Centerline mounts are used to take care of thrust that can occur linearly or along a centerline with the cylinder.
- Proper alignment is essential to prevent compound stresses that may cause excessive friction and bending, as piston extends. Additional holding strength may be essential with long stroke cylinders.



2) Foot mounting

- It consists of mounting the cylinder with the help of side end lungs or side covers.
- These mountings are used where cylinders are to be mounted on to surface parallel to the axis of cylinder.



methods

one Method – 2 marks

b) **Functions of Hydraulic seals:**

(a) Prevent both internal and external leakage of fluid.

(b) Prevent entry of dirt, dust and other contaminants in the system.

(c) Improve efficiency of the system.

(d) Maintain oil pressure by minimising pressure drop due to leakage.

(e) Prevent loss of fluid from the system.

(f) Enhance working life of hydraulic components and functional reliability over a longer period.

4 Functions – 2 marks

Failure reasons of seals:

(a) **Excessive clearance:** Excessive clearance between moving parts causes extrusion of the O-ring and other rings and reduces the performance of the seal.

(b) **Fluid temperature:** High working temperature of fluid may cause seal abrasion.

(c) **Damaged or worn out parts:** Causes improper fitting of seal.

(d) **Incompatibility of the seal material and oil:** When oil is improperly selected with respect to type of oil.

(e) **Excessive side loads/overloading:** It causes wobbling of piston rod and dislocates the seals.

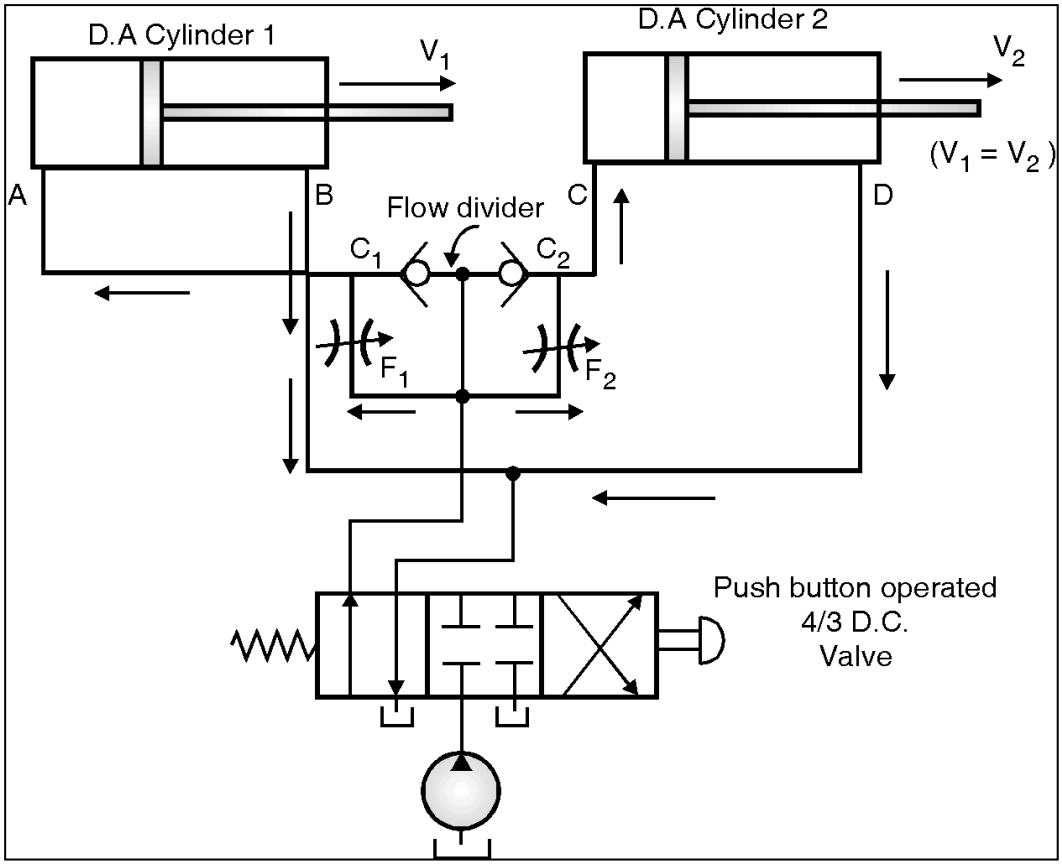
(f) **Vibrations :** Caused due to bent shaft, broken vane, misaligned or damaged bearing, defective coupling, etc.

4 reasons – 2 marks

c) **Motion synchronization circuit:**

- When two or more actuators are operated simultaneously and there action is synchronized (in a same manner) the circuit is called as motion

synchronization circuit.



2 Mark: suitable Circuit

Explanation of Circuit :

- The flow of oil from the pump is divided using flow equalizer (divider) with the help of flow control valve f_1 and f_2.
- The oil will enter in the D.A. cylinder 1 from inlet A and at the same time in the D.A. cylinder 2 from inlet C. Both the cylinders will move the piston in the forward direction at same speed.
- Check valves C_1 and C_2 prevents the flow in the backward direction.
- Both the cylinder will extend at the same speed regardless of load resistance differentials they may have to overcome.

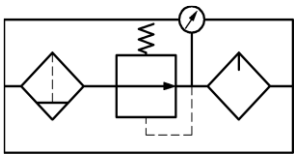
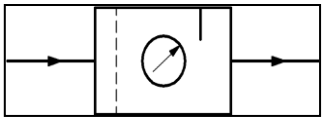
Explanation – 2 marks

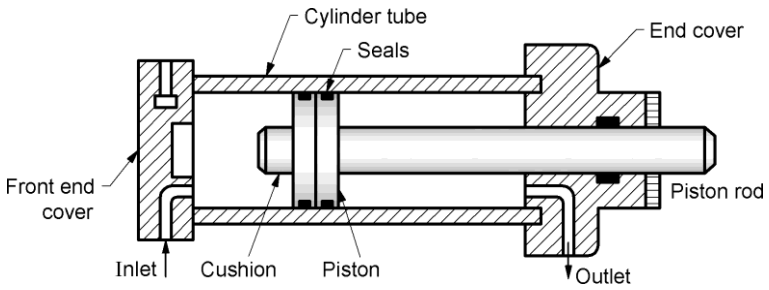
d) **Applications of hydraulic system:**

It is used in various fields which are listed below :

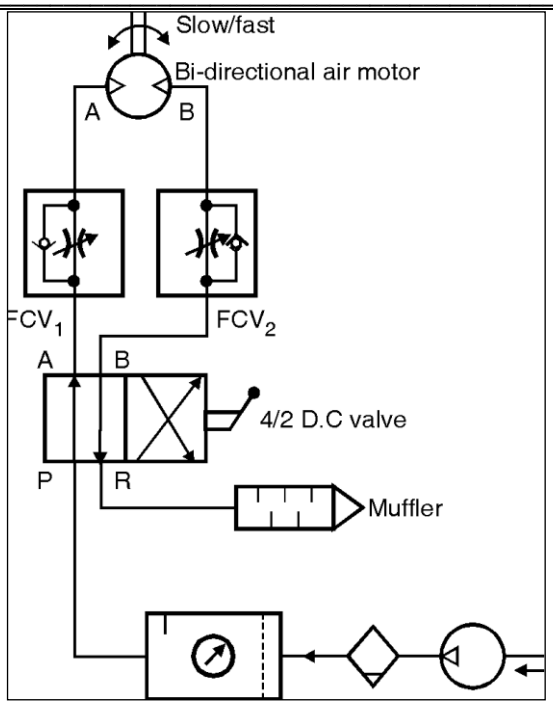
- **Agricultural equipments:** Modern farm equipments uses hydraulics extensively from hydraulic cylinders that raise and lowers implements to complex devices used on tractors, a variety of specialized planting, harvesting and processing equipments.
- **Transportation systems:** Modern transportation systems are designed to move people and products. These uses range from automobiles to complex, wide body air craft flights. Hydraulic brakes, power assisted steering system, hydrostatic transmission with unlimited speed/torque control, suspension systems, etc.
- **Manufacturing organizations (machine tools) :** Applications range from huge presses in automobile body fabrication plants, packaging equipments for small parts in electrical component manufacturing organizations. Hydraulic shapers, milling machines, Drives of CNC machines, etc.

4 applications – 4 marks

		• **Construction equipments:** One of the best places to find applications of large hydraulic machines is at construction sites. It is useful for handling heavy objects as well as for transportation work • **Mining:** Mining companies uses hydraulic system in open pit and underground operations. Mine drilling, crushing and material handling equipments are based on principle of hydraulic systems e.g. coal mines uses huge shovels. • **Material handling equipments:** It includes cranes, jacks, lifts for movements of group of small or heavy objects from one location to the other e.g. forklift, trucks, jacks, cranes etc.	
	e)	**Function of FRL unit:** It is a combination of three components : **Filter (F) –** 1) To remove the micron and sub-micron particles present in the entering air of compressor 2) Used to separate out contaminants like dust, dirt p[articles from the compressed air **Regulator (R)–**In pneumatic system the pressure of compressed air may not stable due to possibility of line fluctuation. Hence there is a need to maintain and regulate the air pressure. This function is perform by regulator. **Lubricator (L) –** Sliding components like spool, a pneumatic cylinder has sliding motion between parts. It may cause friction and wear and tear at mating parts. To reduce friction, lubricating oil particles are added in the compressed air with the help of lubricator. **Symbol:** 1) Combined symbol of FRL unit 2) common symbol  	Function – 2 marks Symbol-2 marks
4.	a)	**Attempt any THREE of the following** **i) Advantages of pneumatic system:** **1. Freely available air :** The input medium is air which is freely available in unlimited large quantity naturally. **2. Clean system :** When compared to hydraulic system in which oil leakage may cause dirty work area, this problem is eliminated in pneumatic system hence it is clean system. **3. Fire proof :** As air is having fire proof characteristics, system has less fire hazards compared electrical and hydraulic system. **4. Simple and easy system :** The construction and operation of pneumatic system is simple and easy. **5. No need of return lines :** The air from the outlet of the actuator is exhausted directly to the atmosphere and no need to reuse it again hence no need of providing the return lines. It reduces cost of return lines **Disadvantages of pneumatic system:** **1. High cost of compression :**	Any 4 advantages– 2 marks

		High cost of compressing and conditioning air for use in pneumatic system. **2. Reduced accuracy :** As air is compressible, it causes errors due to charge in pressure and reduces accuracy of actuator movement. Hence system is not suitable for precise control of movements. **3. Noisy working :** Pneumatic system may produce noise when air is directly exhausted to the atmosphere from components; muffler or silencers are provided to reduce this problem. **4. High operating cost :** The cost of handling air for distribution, conditioning increases the operating cost. **5. Low pressure applications :** Pneumatic system is able to produce maximum 10 bar pressure hence suitable for low pressure applications like punching press. It can not able to handle heavy tasks.	Any 4 Dis advantages– 2 marks
		ii) Construction and working of Double acting pneumatic cylinder **Construction :**  • It consists of (i) Cylinder tube (ii) Piston with piston seals (iii) Cushioning assembly (iv) Piston red (v) End covers on both sides (vi) Inlet and outlet connections. • The construction is quite simple and varies according to the use and application of the cylinder. **Working :** • The compressed air will enter from inlet of the cylinder provided from the face side. It will exert the pressure on the face of piston and movement of piston occurs from left to right. It will complete forward movement of the cylinder. • Now the piston is at right end. The air will allowed to enter through inlet provided at the rod end side. The air pressure will act from rod end side on the piston and moves it from right to left to complete return stroke. • Hence it will produce reciprocating motion with the help of compressed air.	Construction- 2 marks Working- 2marks

iii) Speed control of bi-directional air motor:



Explanation of circuit :

1. **Slow speed :**

- Compressed air is passed through D.C. Valve from port P to port A. It will enter in the FCV1 where flow area of the FCV1 is reduced by partially closing the valve.
- Hence, small quantity of air will enter in the air motor through inlet A. It will rotate the motor at slow speed.

2. **Fast speed :**

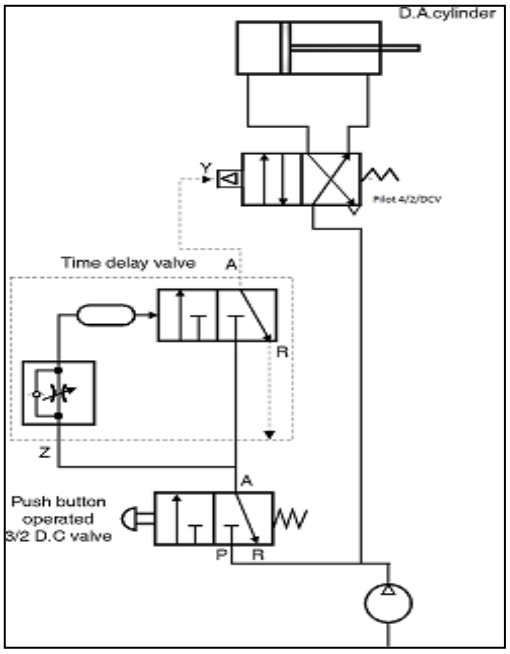
- Similarly, when flow area of the FCV1 is increased by fully opening the valve, it will supply full quantity of compressed air to the air motor through inlet A.
- As large quantity is supplied it will rotate the motor at high speed. We can control the speed in another direction using FCV2 and second position of D.C. Valve.

Circuit- 2 marks

Explanation- 2 marks

iv) Time delay circuit:

Explanation:



- A push button operated 3/2 D.C. Valve will start the cycle. The normally closed time delay valve actuates the main impulse valve (pilot operated 4/2 D.C. Valve) at its pilot port Y.
- The time delay valve can be set for delay for actuation of impulse valve. The time taken by time delay valve to transmit the signal is the time delay for the forward motion of the cylinder.
- When pilot operated 4/2 D.C. Valve in an actuated position it, advances the cylinder and complete its forward stroke.

Any correct circuit - 2 marks

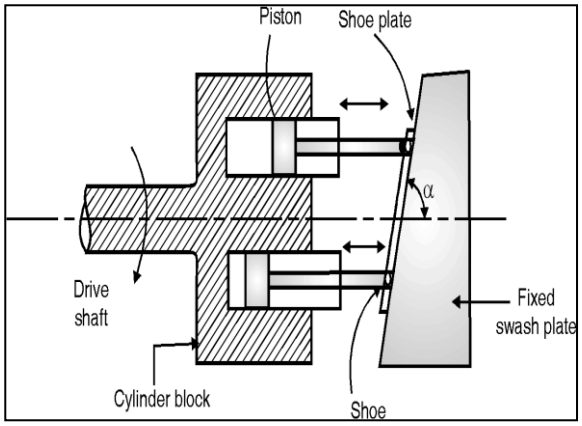
Explanation – 2 marks

b) **Attempt any ONE of the following**

i) Axial piston pump:

Construction:

It consists of following main plates :



Sketch- 2marks

a) Drive shaft with cylinder block: It is rotating element of the pump in which cylinder block is mounted with shaft.

b) Pistons: Pistons are mounted in the cylinder block with piston rods.

Construction- 2 marks

c) Shoe and shoe plate: The piston rod ends are covered with shoe and fitted on the shoe plate as shown in Fig.

d) Swash plate: The cam plate or swash plate being kept fixed and positioned at an angle α with the axis of the cylinder block. The shoe plate is attached to the angular surface of the swash plate.

Working :

- As the drive shaft rotates, it will cause rotary movement of cylinder barrel. The piston shoes follow the surface of the swash plate.
- Swash plate is an angular surface plate used in swash plate axial piston pump. It is provided to obtain to and fro motion of the pistons in the bore of cylinders.
- Since the swash plate has angular surface, the pistons reciprocates within the cylinder bore and thus oil is sucked during one half of the circle of rotation and during other half of rotation, the oil is forced to the outlet port.

Working – 2 marks

ii) Types of Rotary actuators:
(Hydraulic or Pneumatic is to be considered)

Rotary actuators are classified as;

(a) As per direction of rotation :

(i) **Uni-directional motors:** When oil enters and rotates the motor in either direction (only one either clockwise or counter clockwise) it is known as uni-directional motor.

(ii) **Bi-directional motor:** When oil is feed alternately from inlets of motor to produce clockwise and counter clockwise motion, it is known as bi-directional motor.

Types: 2 marks

(b) As per construction :

(i) **Gear motors**: When gear pair is used, it is known as gear motor.

(ii) **Vane motors**: When sliding vanes are used, it is known as vane motor.

(iii) **Piston motor**: When piston and cylinder are used, it is known as piston

Any one type- 2 marks

motor. It has two types :

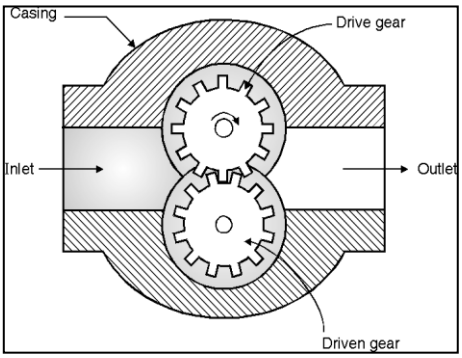
(A) Axial piston

(B) Radial piston

Gear Motors

Principle :

- It works on the principle of imbalance of oil pressure to act on the gear tooth and push the tooth for development of torque.



sketch and 2 marks explanation

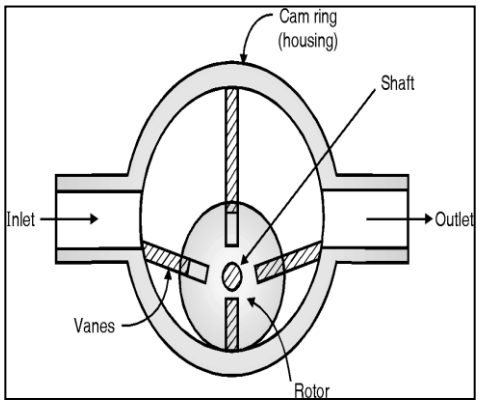
Working :

- When pressurized oil enters through the inlet port it exerts oil pressure on the gear teeth's.
- As the casing inside surface and gear pair are closely fitted, the oil pressure acts on the one side of one tooth on the gear located near the inlet port.
- This will cause hydraulic imbalance and it push the gear tooth to develop torque. The larger the gear tooth or higher the pressure, more is the torque developed

Vane Motors :

Principle :

- It works on the principle of hydraulic imbalance is caused by the difference in vane area subjected to hydraulic energy of oil due to eccentric mounting of rotor to the housing.



Working :

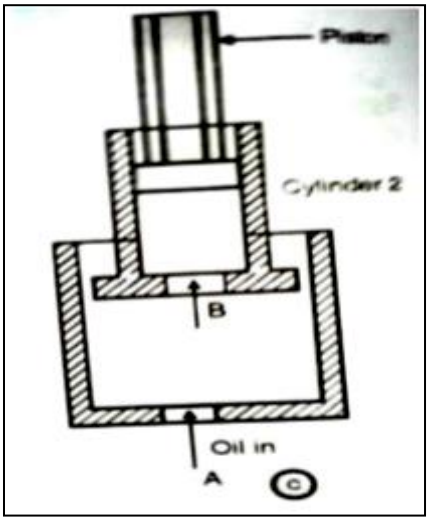
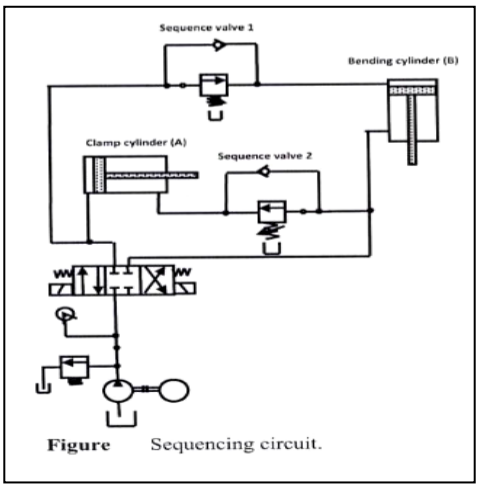
- When pressurized oil enters in the vane motor, it will enter in the cam ring and rotor surface. It strikes on the vanes.
- Due to eccentric mounting of rotor, the unequal area of vanes occurs. The oil passing through unequal area pushes the vanes in the forward direction. It results in development of torque in the motor shaft.
- The oil strikes the vanes successively and develops rotary motion. Higher the oil pressures, more is the torque developed.

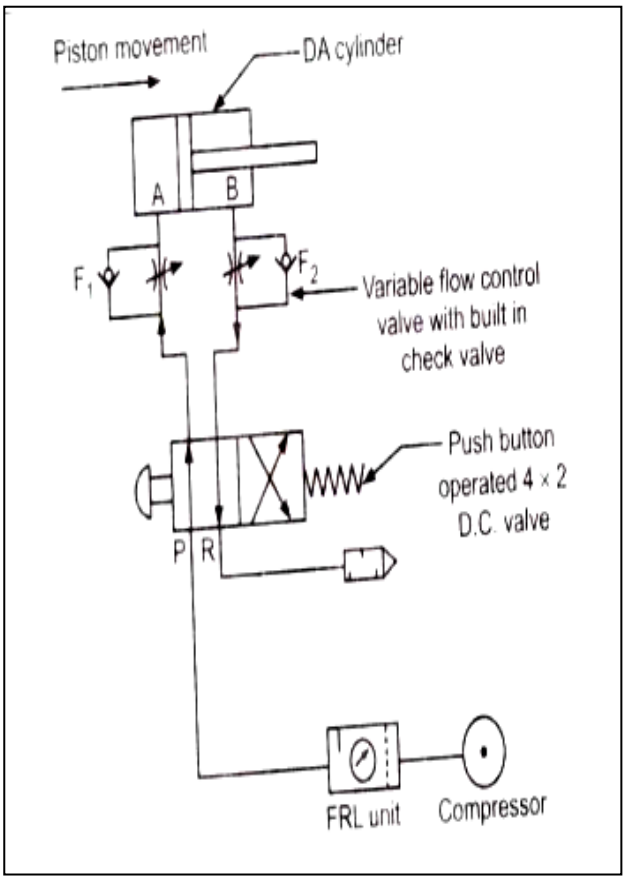
5. **Attempt any TWO of the following**

a) **Classify pneumatic actuators on the basis of (i) Motion (ii) Mode of action (iii) Displacement** — 1 Mark

(i) Based on Motion (application) for which air cylinders are used - 1) Light duty air cylinders 2) Medium duty air cylinders and 3) Heavy duty air cylinders

(ii) Based on the Mode of (cylinder) action - 1) Single acting cylinder 2) Double acting cylinder 3) Single rod type double acting cylinder 4) Double rod type double acting cylinder — 1 Mark

		(iii)Based on Displacement (cylinder's movement) - 1) Linear Actuator or Pneumatic cylinders 2) Rotary Actuator or Air motors 3) Limited angle Actuators **(iv) Describe telescopic cylinder with neat sketch.**  When numbers of cylinders are arranged in a compact envelope similar to telescope lenses, it is known as **telescopic cylinder.** It consists of number of cylinders, with decreasing in size. The main cylinder accommodates the number of cylinders arranged one inside the other. The inlet is provided for main cylinder to enter the pressurized oil. The corresponding inlets are also provided to each cylinder. The cylinders are arranged in a short envelope hence space required is less. **Working:** When pressurized oil enters in the main cylinder 1 it will push the cylinder 1 in the upward direction when sufficient oil pressure is generated. Now the cylinder 2 is completely lifted and oil will enter into the inlet of cylinder 2. The oil will flow in the cylinder 2 and push the piston in upward direction. It will raise the piston for stroke length of cylinder 2. In this manner the total length of stroke through which the load is lifted (L1 + L2)	2 Mark Explanation 2 Marks Diagram 2 Marks
b)	**Develop pneumatic circuit for operation of two D. A. cylinders that operates sequentially.**  **Figure** Sequencing circuit. Hydraulic cylinders can be operated sequentially using a sequence valve. Figure shows that two sequence valves are used to sequence the operation of two double-acting cylinders. When the DCV is actuated to its right envelope mode, the bending cylinder (B) retracts fully and then the clamp cylinder (A) retracts. This sequence of cylinder operation is controlled by sequence valves. This hydraulic circuit can be used in a production operation such as drilling. Cylinder A is used as a clamp cylinder and cylinder B as a drill cylinder. Cylinder A extends and clamps a work piece. Then cylinder B extends to drive a spindle to drill a hole. Cylinder B retracts the drill spindle and then cylinder A retracts to release the work piece for removal.	Explanation 4 Marks Diagram 4 Marks

	c)	**Draw pneumatic circuit for speed control of D.A. cylinder in forward direction. Write its applications.** Speed control circuit is adopted to control speed of actuators. This control is achieved by adopting flow control valve in circuit. In this circuit use 4x 2 DC valve and variable flow control valves. The two flow control valves are placed in two supply lines of DA cylinder. As position shown in the circuit, pressure port P is connected to inlet port A of DA cylinder. Now we can control the flow of air admitting in DA cylinder, through port A, by using variable flow control valve F1. If more flow will be allowed then more air will enter in cylinder and piston will move towards right with more linear speed, If less air is allowed to flow the linear speed of piston will be low. When push button is pressed then pressure port p will be connected to port b of DA cylinder and exhaust port R will be connected to port A of DA cylinder .The flow control valve F2 can control the speed of piston .During this stroke the air from earlier stroke in the other side of piston will exhausted through flow control valve F1 via DC valve. During this return the air flow to DC valve through throttled chamber of flow control valve. Air will not flow through check valve because it is unidirectional valve.  **Applications-** 1. This circuit is used where very stable movements of actuators are needed. 2. Clamping, Drilling, boring, reaming and tapping operations.	Explanation 3 Marks Diagram 4 Marks Application 1 Mark
6.	a)	**Attempt any THREE of the following** **Give selection criteria of air compressor for pneumatic system.** 1. Average air consumption of the system – should be selected of capacity 2 to 3 times the average air consumption of the system. 2. Free air delivery – volume of air drawn by the compressor per unit time. 3. Air receiver capacity – tank should be greater than the volume of compressed air developed by the compressor in 1 minute. 4. Power supply – 5. Configuration – Tank mounted or base mounted, Simplex or Duplex type, Reciprocating or Rotary 6. Components and accessories – Pressure switch, relays, thermostats, pressure gauge, drain plug etc.	1Mark for each criteria (1x4= 4Marks)

b) **Classify flow control valve with their applications.**

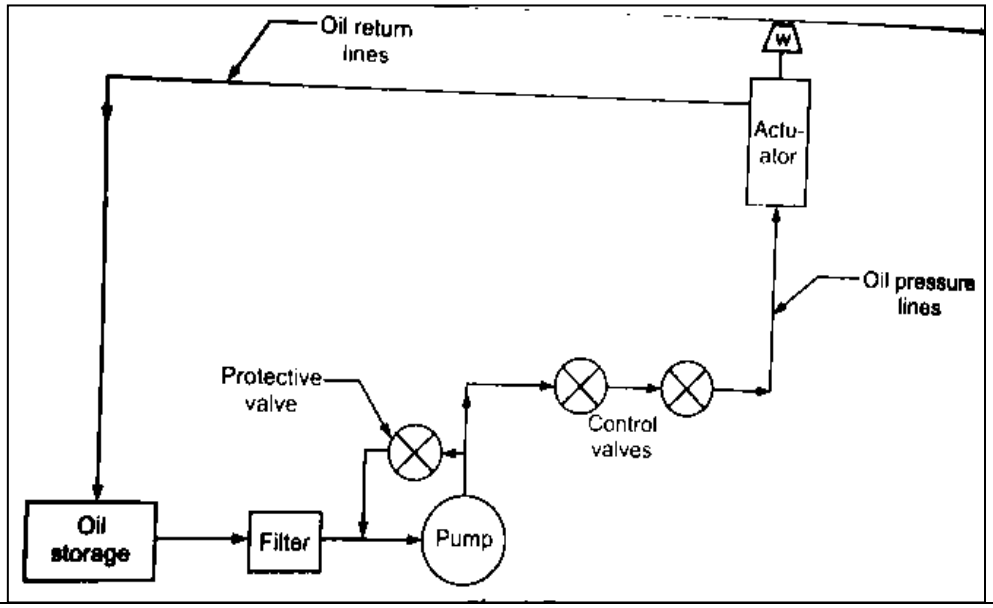
Flow Control Valve	Application
1. Needle valve	Used as stop valve or shut-off valve for flow
2. Pressure compensated flow control valve	Used in material handling system in industry eg. Lowering the speed of pallets where there are pressure variations. Also for constant pressure application.
3. Non-compensated flow control valve	Used where accuracy in movement and speed of actuator is not important.
4. Check valves	Used for unidirectional flow requirement

½ Marks for type and

½ Marks for application (each)

c) **Draw a general layout of hydraulic system.**

(Do consider the general circuit diagram of Hydraulic system with all components)



2 Marks for neat sketch and

2 Marks for naming

d) **What is hose? Enlist factors affecting on selection of hose in hydraulic system.**

Hoses are flexible connecting tubes or pipes to connect actuators, control valves. These are flexible vessels that are constructed of multiple layers of different materials.

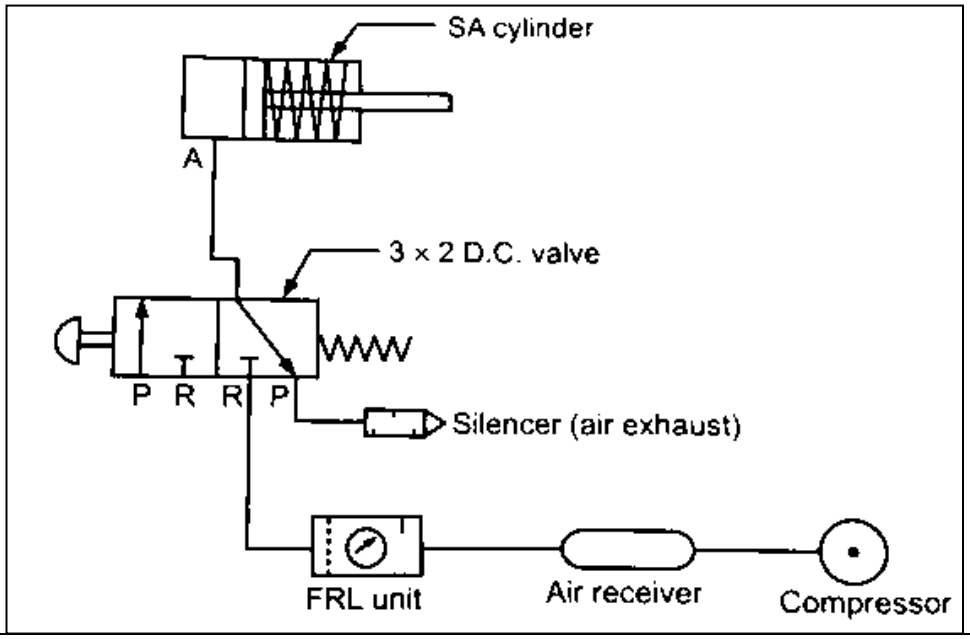
1) Inner tube 2) Reinforcement and 3) Outer protective cover

Factors affecting on selection :-

1. **Oil Pressure of hydraulic system** – Low duty, Medium duty or High duty
2. **Temperature** – Also the ambient temperature where the hydraulic system placed as well as the temperature of Hydraulic oil and its heat dissipating ability.

2 Marks for define

2 Marks for factors

		3. **Size** – The compactness or the space occupied by hydraulic system i.e. length of hose pipe. **4. Environment -** Protection from attack of chemical, salt water, steam, UV radiation etc.	
	e)	**Draw a simple pneumatic circuit to control speed of single acting cylinder.** 	2 Marks for neat sketch and 2 Marks for naming