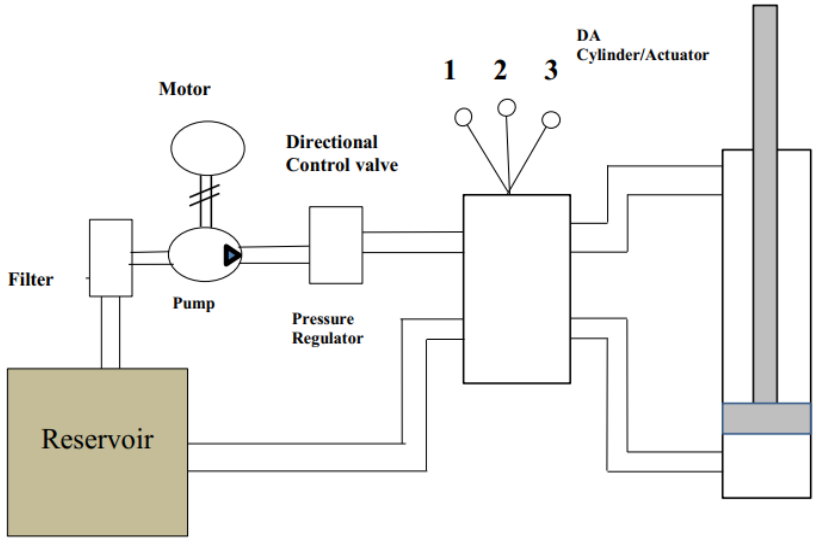
Important Instructions to examiners:

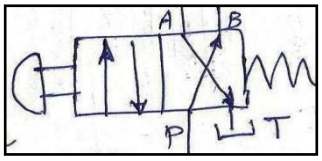
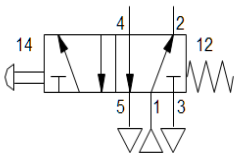
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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 a)	**Attempt any THREE of the following** **Draw and explain Hydraulic system with general layout**  **Hydraulic system with general layout** The working fluid, which is the hydraulic oil, is stored in a reservoir. When the electric motor is switched ON, it runs a positive displacement pump that draws hydraulic oil through a filter and delivers at high pressure. The pressurized oil passes through the pressure regulating valve and does work on actuator. Oil from the other end of the actuator goes back to the tank via return line. To and fro motion of the cylinder is controlled using directional control valve.	Sketch with label 2, Working 2

b) **4/2 DCV for Hydraulic system and 5/2 DCV for pneumatic system.**

3 marks for expiation 1 mark for sketch

4/2 DCV in hydraulic system and 5/2 DCV in pneumatic system because of following difference

4/2 DCV in hydraulic system	5/2 DCV in pneumatic system
In hydraulic system, in four-way 4/2 DCVs, two flows of the fluids are controlled at the same time. 	1) Most 5/2-way valves have a movable spool with seals along the length in a cylinder. By moving the spool through the cylinder, the valve ports are connected or blocked. Also the valve can be direct operated or pilot operated. With direct operation, the actuator is directly connected to the spool. 2) They are quick to operate because of small switching movement. 3) In pneumatic system, the **4-way spool valve** can be controlled by using two operators, one on each end or by a spring return and a single operator(5/2). The flow path when actuated at the 14 end of the valve is from port 1 to port 4 and from port 2 to port 3. Port 5 is blocked. When the valve is actuated from the 1 2 end, the flow path is from port 1 to port 2 and from port 4 to port 5. Port 3 is blocked. Each cylinder port has a separate exhaust port. 

c) **Four criteria for selection of Hydraulic pump**

1. Maximum operating pressure. This is determined by the power requirement of the circuit, the particular application, availability of components, type of fluid and to some extent the environment and level of labor both using and maintaining the equipment

2.Maximum delivery. The pump system selected must be capable of delivering the maximum flow rate demanded by the circuit. If the circuit demand is constant, a fixed displacement pump is chosen.

3. Type of control. Various types of pump controls are available such as *manual servo control*, *pressure compensated control*, *constant power control* and *constant flow control*. The choice of control is dependent upon the circuit requirement such as complexity, accuracy of control, cost, type of machining operation, etc. The designer has to choose carefully the type of control after a detailed study of system characteristics.

4. **Pump drive speed.** The fluid delivery rate is proportional to the speed of rotation. Each design has a minimum and maximum operating speed: the faster the pump runs, the shorter its life

5. **Type of fluid.**Pumps are designed to operate within a particular range of fluid viscosity. Mineral oils of the correct viscosity work satisfactory with most pumps provided the oil is clean

6. **Pump noise**. The actual efficiency depends on design, operating pressure, speed and fluid viscosity

7. **Cost.** The initial cost of a pump is usually of secondary importance to running and maintenance costs. Gear pumps are cheaper, vane and piston pumps are expensive.

4 Marks

d) **Pressure control valves with applications.**

S. N.	Pressure control valves	Applications
1	**Pressure relief valves**	Relief valve opens and bypasses fluid when pressure exceeds its setting. These are used mostly in all circuits.
2	**Pressure-Reducing Valve**	This type of valve (which is normally open) is used to maintain reduced pressures in specified locations of hydraulic systems.
3	**Unloading Valves**	high-low pump circuits where two pumps move an actuator at a high speed and low pressure, punching press,
4	**Counter balance valves**	They are used to prevent a load from accelerating uncontrollably. This situation can occur in vertical cylinders in which the load is a weight. This can damage the load or even the cylinder itself when the load is stopped quickly at the end of the travel.

01 mark for each

1 B **Attempt any ONE of the following**

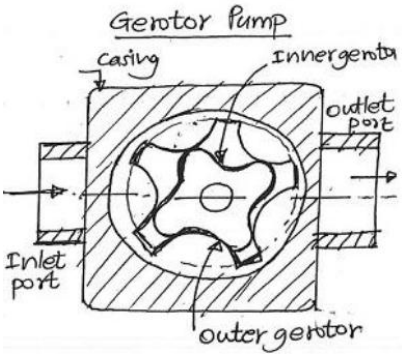
a) **Principle and working of Geroter pump**

Gerotor pumps operate in the same manner as internal gear pumps. The inner gear rotor is called a Geroter element. The gerotor element is driven by a prime mover and during the operation drives outer gear rotor around as they mesh together. The gerotor has *one tooth less than* the outer internal idler gear. Each tooth of the gerotor is always in sliding contact with the surface of the outer element. The teeth of the two elements engage at just one place to seal the pumping chambers from each other. On the right-hand side of the pump, shown in Fig. pockets of increasing size are formed, while on the opposite side, pockets decrease in size. The pockets of increasing size are suction pockets and those of decreasing size are discharge pockets. Therefore, the intake side of the pump is on the right and discharge side on the left.

Pumping chambers are formed by the adjacent pair of teeth, which are constantly in contact with the outer element, except for clearance. Refer to Fig as the rotor is turned, its gear tips are accurately machined so that they precisely follow the inner surface of the outer element. The expanding chambers are created as the gear teeth withdraw. The chamber reaches its maximum size when the female tooth of the outer rotor reaches the top dead center. During the second half of the revolution, the spaces collapse, displacing the fluid to the outlet port formed at the side plate.

03 marks for explanation and 03 marks for sketch

b)



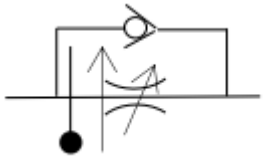
Pressure and temperature compensated flow control valve

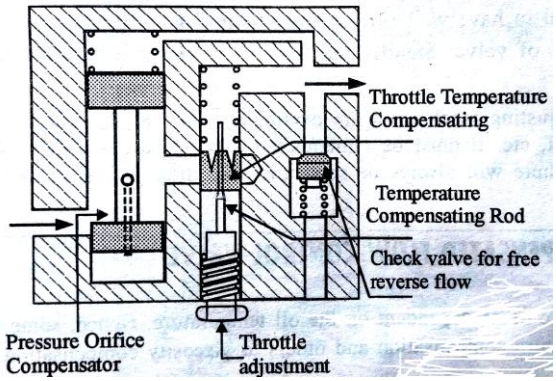
Schematic diagram of a pressure and temperature compensated flow-control valve is shown in Fig.

Its operation is essentially same as the restrictor type, pressure compensated flow control valve in association with a throttle type temperature compensating device. In the compensatory spool, the pressure is sensed to the bottom of the spool through a passage drilled in its body, instead of having a separate sensing passage. In order to attain balance position, the compensatory spool moves and adjusts the area of metering orifice. This gives necessary pressure compensation.

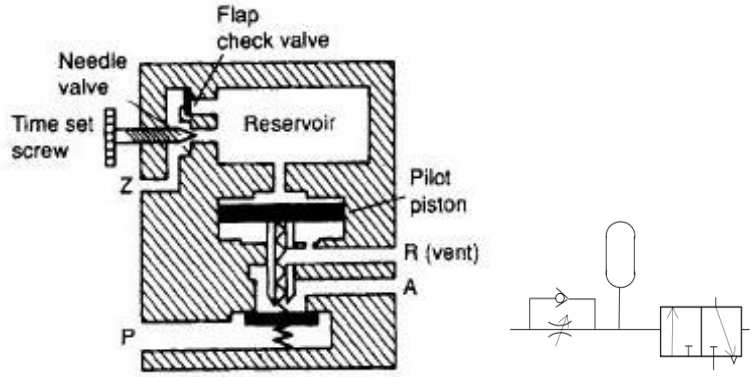
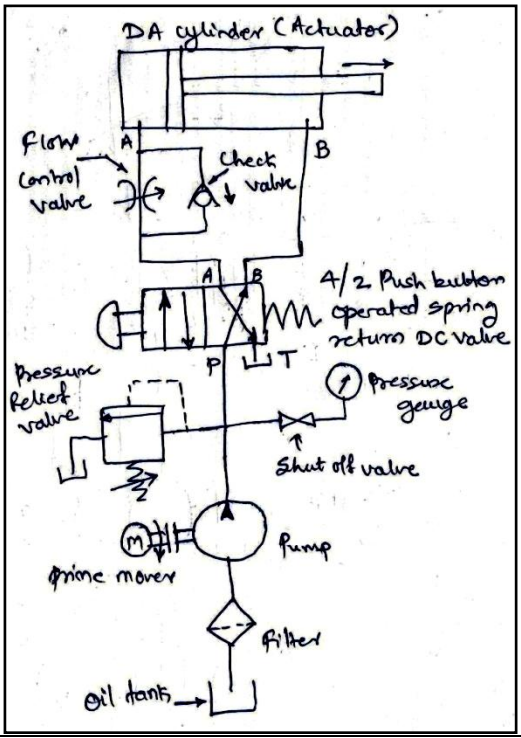
Also instead of using the usual throttling arrangement, a cup shaped device with "V" notches is used for better control on flow rate. This cup is held by a small spring against the shoulder of an aluminium alloy rod which extends through the cup into the oil flow. It is set for a particular flow rate. As temperature of oil rises, the oil becomes a little thinner and tend to flow faster through. However, the increased temperature also causes the Aluminium rod to expand and close the throttle opening to compensate for the change in oil viscosity. Thus even with the thinner oil, the flow rate stays essentially the same.

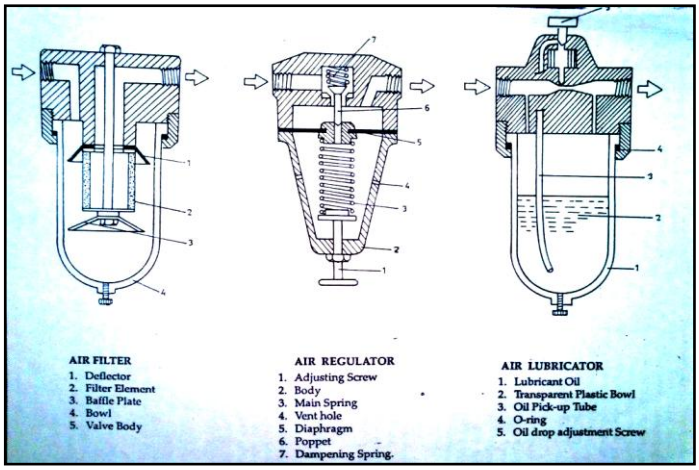
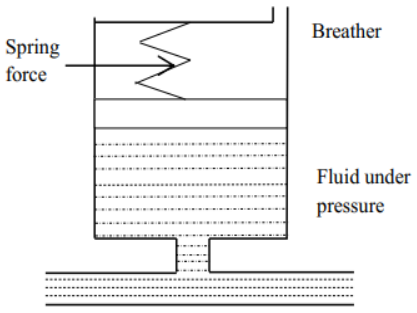
A check valve is frequently incorporated to allow relatively unrestricted reverse flow.





03 marks for explanation and 03 marks for sketch

2		**Attempt any TWO of the following**	
	a)	**Sketch Symbol and working of time delay valve.** Time delay valve is a combination valve used to set the operation time as per the requirement. The time delay can be increased or decreased by adjusting the flow through the non-return flow control valve. The change invariably increases or decreases the time taken to fill and pilot actuates the direction control valve. Time delay valve is a combination of a pneumatically actuated 3/2direction control valve, an air reservoir and a throttle relief valve. The time delay function is obtained by controlling the air flow rate to or from the reservoir by using the throttle valve. Adjustment of throttle valve permits fine control of time delay between minimum and maximum times. In pneumatic time delay valves, typical time delays in the range 5-30 seconds are possible. The time delay can be extended with the addition of external reservoir. **Time delay valve, NC type**. The constructions of an on-delay timer (NC) type in the normal and actuated are shown in Figure It can be seen that 3/2 DCV operates in the on delay mode permanently. But, in some designs, the valve can be operated in the off-delay mode by connecting the check valve in reverse direction. 	04 marks for sketch and 03 for explanation and 01 mark for symbol, 01 mark
	b)	**Sketch and explain of meter in hydraulic circuit to control the speed of extension of DAC (double acting cylinder).** Figure1 shows a meter-in circuit with control of extend stroke. The inlet flow into the cylinder is controlled using a flow-control valve. In the return stroke, however, the fluid can bypass the needle valve and flow through the check valve and hence the return speed is not controlled. This implies that the extending speed of the cylinder is controlled whereas the retracing speed is not. **Meter in circuit not for overrunning loads.** The expanding air/ oil speeds up cylinder movement, causing it to lunge forward. This increased speed moves the piston faster than the incoming air / oil can fill the space behind it, so pressure drops to less than it takes to keep it moving and the cylinder stops. 	04 marks for sketch and 03 for explanation and 01 mark for symbol, 01mark for reason

	c)	**FRL unit** A FRL unit is combined box set made up of a filter, regulator and lubricator with the associated fittings and wall mounting bracket used in Pneumatic system. **Function of FRL with ketch** i) **Filter (F): -**It is used to separate out contaminants of air like dust, dirt particles (micron and sub-micron) from the compressed air. ii) **Regulator (R):-** A pressure regulator maintains a constant output pressure regardless of variations in the input pressure and downstream flow requirements. iii) **Lubricator (L):-**To reduce friction of pneumatic components lubricating oil particles are added in the compressed air with the help of lubricator.  AIR FILTER 1. Deflector 2. Filter Element 3. Baffle Plate 4. Bowl 5. Valve Body AIR REGULATOR 1. Adjusting Screw 2. Body 3. Main Spring 4. Vent hole 5. Diaphragm 6. Poppet 7. Dampening Spring. AIR LUBRICATOR 1. Lubricant Oil 2. Transparent Plastic Bowl 3. Oil Pick-up Tube 4. O-ring 5. Oil drop adjustment Screw	(2+04+2)
3		**Attempt any FOUR of the following**	
	a)	**Four reasons for failure of hydraulic seals** 1. **Wear L**ubrication is not proper or excessive lateral load, wear on the face of a seal can cause damage of seal. 2. **Improper installation** As mentioned before, improper installation can create problems with hydraulic seals. It may result in uncleanliness, unsafe handling, contamination, and incorrect sizing of the chosen seal. Deciding the seal prior to build is important to make certain that the design is done correctly to ensure proper sealing. 3. **Chemical Erosion** Seal material will break down when it encounters a corrosive fluid. This will occur when the improper seal material is chosen for an application. The use of non-compatible materials leads to chemical attack by oil additives, hydrolysis, and/or oxidation reduction of seal elements. 4. **Hardening** : At high speed seals can harden due to heat generation. Hardening causes cracks in seal and lead to seal failure. 5. **Fracturing:** Fracturing causes cutting of seals, cracks on the side of the seal. This may happen because of excessive high loads or in proper materials of the seal.	01 mark each
	b)	**Use of accumulator in hydraulic circuits.** i. A hydraulic accumulator is a device that stores the potential energy of an incompressible fluid held under pressure by an external source. **ii.** The stored potential energy in the accumulator is a quick secondary source of fluid power **Spring loaded hydraulic accumulator with sketch.**  Spring force Breather Fluid under pressure	1+02+1

A spring-loaded accumulator stores energy in the form of a compressed spring. A hydraulic fluid is pumped into the accumulator, causing the piston to move up and compress the spring as shown in Fig. **.** The compressed spring then applies a force on the piston that exerts a pressure on the hydraulic fluid.

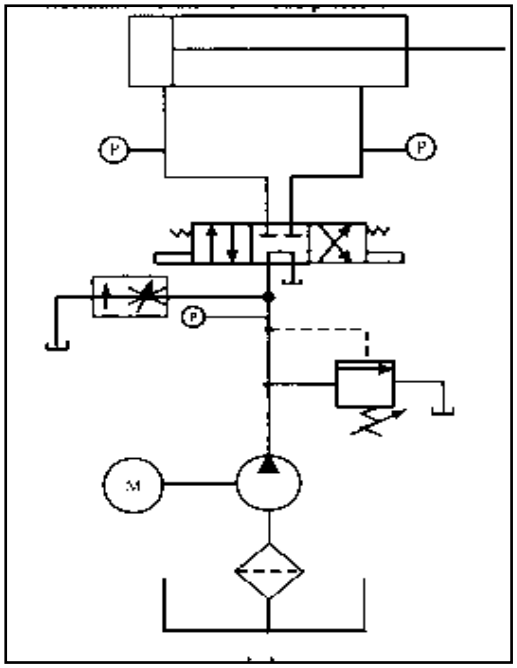
c) **Bleed off circuit with sketch**

Fig shows typical bleed off circuit. Here, the flow control valve is arranged to bypass a part of the pump output directly to the tank. When the flow control valve is completely closed, the full flow from the pump would go into the cylinder. However, the moment the flow control valve is opened, some portion of the pump outlet will be bled off and the cylinder starts to slow down. Adjusting the size of the opening will bleed off any amount necessary to control the speed of piston.

Unlike the meter-in and meter-out circuit there is no excess flow going over the relief valve. The excess oil bleed-off circuits are more efficient in energy saving and work in a cooler environment.

However, bleed off circuit provides less accuracy is speed control, because they don't compensate for any change in fluid losses due to pressure change. Here the measured flow goes to the tank rather than the cylinder. This makes the cylinder speed subject to change with the pump delivery and hydraulic system leakage which occur as work load pressure changes. To minimize these effects, it is recommended to bleed-off no more than half the pump delivery and avoid using a bleed-off circuit completely where there is a wide fluctuation is the load pressure.

In general, bleed-off speed control is best employed when the majority of the pump outlet is utilized by the cylinder and only a small percentage is bypassed. Also it is employed in systems where the pressure is reasonably constant and precise speed control is not the criteria.



02+02

d) **Causes and remedies of following**

Sr. no.	Particulars	Causes	Remedies
i.	**Pump not delivering oil**	**Cavitation**	**Any or all of the following:** Replace dirty filters. Wash strainers. Clean the clogged inlet line.,/reservoir breather vent. Change the system fluid.

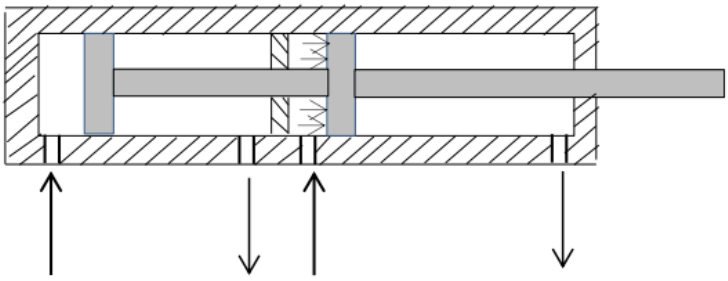
			Change to proper pump drive motor speed. Overhaul or replace the pump. Check fluid temperature.	01 mark each, minimum 4
		Air in fluid	Any or all of the following: Tighten leaky inlet connections. Fill the reservoir to proper level. Bleed air from the system. Replace the pump shaft seal.	
ii.	**Excessive noise**	Coupling misaligned	Align unit. Check the condition of seals, bearings and couplings	
		Pump worn or damaged	Overhaul or replace defective parts	
iii.	**System excessively hot**	**Pump heated**		
		Air in fluid	Any or all of the following: Tighten leaky inlet connections. Fill the reservoir to proper level. Bleed air from the system. Replace the pump shaft seal.	
		Excessive load	All of the following: Align unit. Check the condition of seals, bearings and couplings. Locate and correct mechanical binding. Check for workload in excess of circuit design.	
		Motor heated		
		Relief or unloading valve set	Install and adjust pressure gauge	
		Excessive loading	All of the following: Align unit. Locate and correct mechanical binding. seals, bearings and couplings. Check for workload in excess of circuit design.	

	e)	iv.	**Low pressure in system**	Pressure relief path exists	Any or all of the following: Replace dirty filters. Clean the clogged inlet line. Clean the reservoir breather vent. Change the system fluid. Overhaul or replace the pump.
				Pressure-reducing valve set too low/	Adjust part
				Pressure-reducing valve damaged	Overhaul or replace part

Sketch and explain working of Tandem cylinder — 02+02

Tandem cylinders are two separate double acting air cylinders arranged in line to one cylinder body so that the power generated by the two is added together. Thereby approximately doubling the piston output.

A tandem cylinder is used in applications where a large amount of force is required from a small-diameter cylinder. Basically, a tandem cylinder is simply two or more separate cylinders stacked end to end in a unit and with all the pistons mounted on a common piton rod. Pressure is applied to both pistons, resulting in increased force because of the larger area**.**

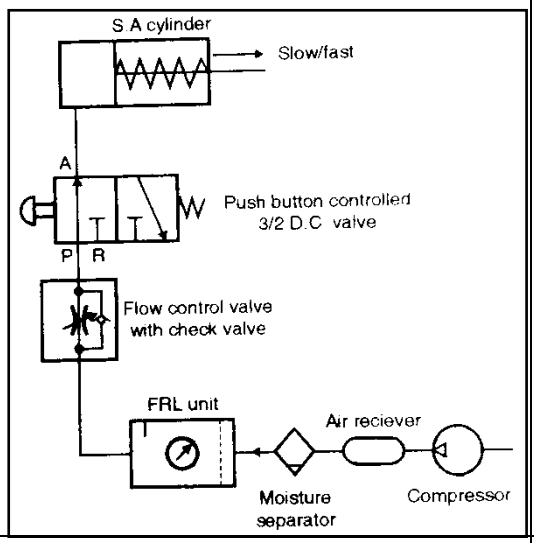


4	**(A)**	**Attempt any THREE:**	
	(a)	**Limitation of Pneumatic System.** 1) High cost of compression 2) Reduced accuracy 3) Noisy working 4) High operating cost 5) Low pressure application 6) Additional lubrication required.	4 marks
	(b)	**Factors considered for selecting the pipes.** 1) Pressure of compressed air in the line 2) Total flow rate per unit time through the line 3) Permissible pressure drop in the line 4) Type of tube material and type of line fittings 5) Length and diameter of tube or other pipelines 6) Working environment, etc.	4 marks

(c) **Two application of 3 x 2 DC pneumatic valve**

1) Pilot control of single acting cylinder
2) To start, stop and change the direction of motion of a Single acting cylinder.
3) To actuate Pilot control of 5/2 DCV.
4) To isolate certain branch of a circuit.

Circuit diagram



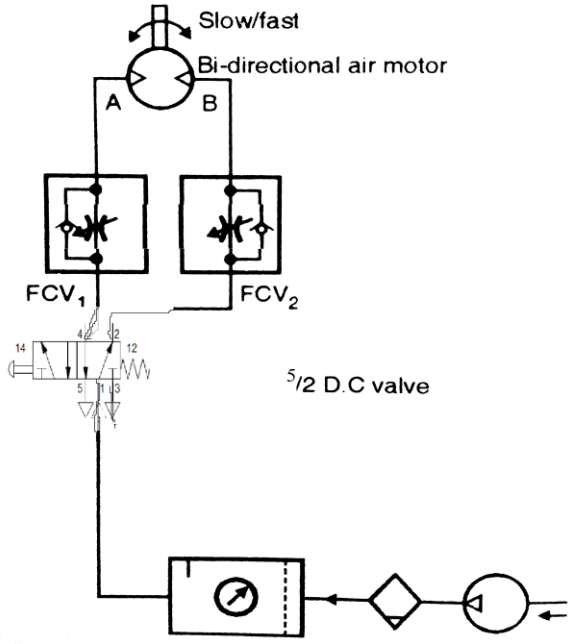
Application – 2 marks

Circuit- 2 Marks

(d) **Pneumatic circuit for speed control of bidirectional motor**

Compressed air is passed through DCV from port P to port A. it will enter in the FCV1 where flow area of 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.

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 DC valve. Hence by varying the flow quantity of air we can change the flow quantity of air we can change the speed of bi-directional motor.



Circuit – 2 marks

Explanation – 2 marks

(B)

(a)

Positive Displacement Pump	Non-positive displacement Pump
1. Delivers fluid in discrete volume per cycle	**1.** Delivery is continuous
2. After finishing on delivery stroke completely , only the next suction stroke can start	**2.** Suction & delivery can keep on going continuously & simultaneously.
3. Discharge is independent of the resisting pressure at delivery	**3.** As resistance increases the discharge reduces.
4. Discharge depends only on speed	**4.** Discharge depends on resisting pressure
5. Work done on the fluid is in the form of pressure energy	**5**. Work done is in the form of kinetic energy
6. There is no limit to the maximum pressure that can be built	**6.** The maximum pressure that can be developed is limited

Six points – 6 marks

(b)

Telescopic Cylinder

Construction: Figure shows three Rams assembled in each other like telescope. This arrangement provides relatively long stroke with good mechanical strength. There are two inlet ports through which pressurized hydraulic oil enters. Port (R) is raising the cylinder or extending the cylinders while port (L) is for cylinder lowering.

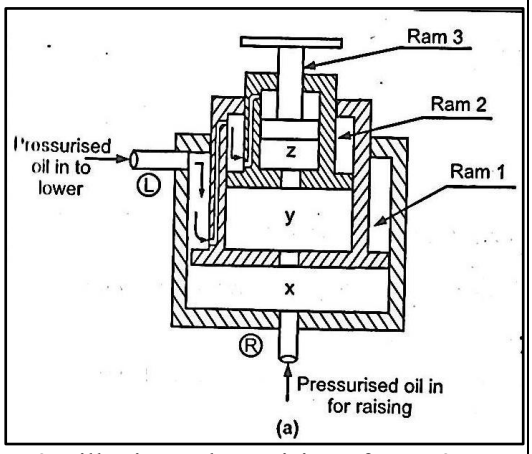
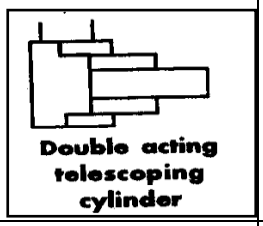


Diagram – 3 marks

Working:

1. Raising or extending the cylinders: hydraulic oil under pressure will enter through port (R). Space 'X' will be filled by oil and Ram 1 will start raising upwards. When its raising stops, the oil now will start entering through and will occupy space 'Y'. Due to this Ram 2 will raise. When raising of Ram 2 stops, the oil will start entering through and will occupy space 'Z'. This will raise final Ram 3 upwards.

2. Lowering the rams: When pressurized oil will enter through port (L), then Ram 1 will come down. After it's lowering Ram 2 will lower and then Ram 3 will lower.



Explanation – 3 marks

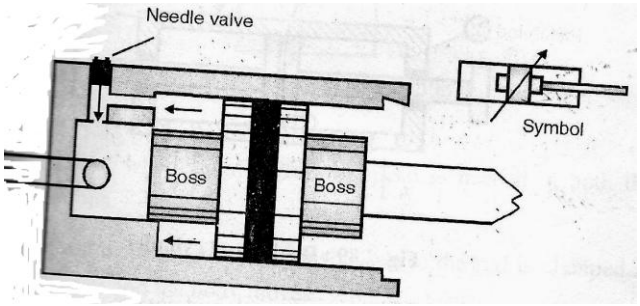
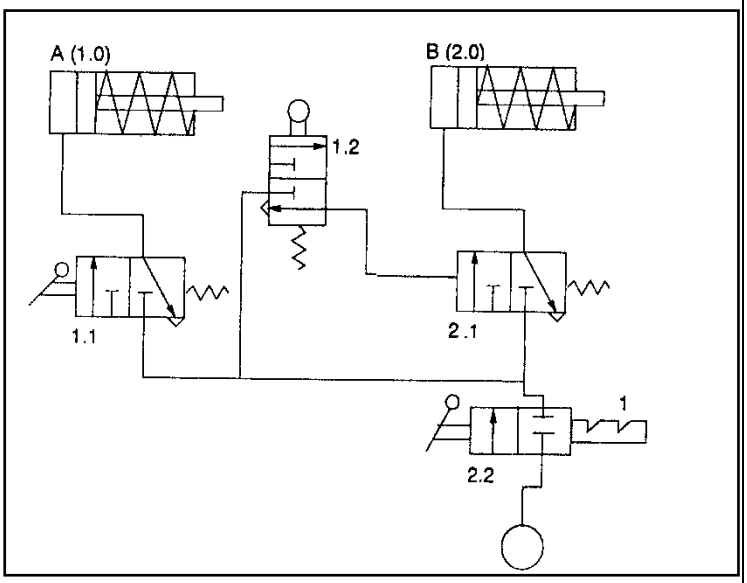
5. **Attempt any TWO**

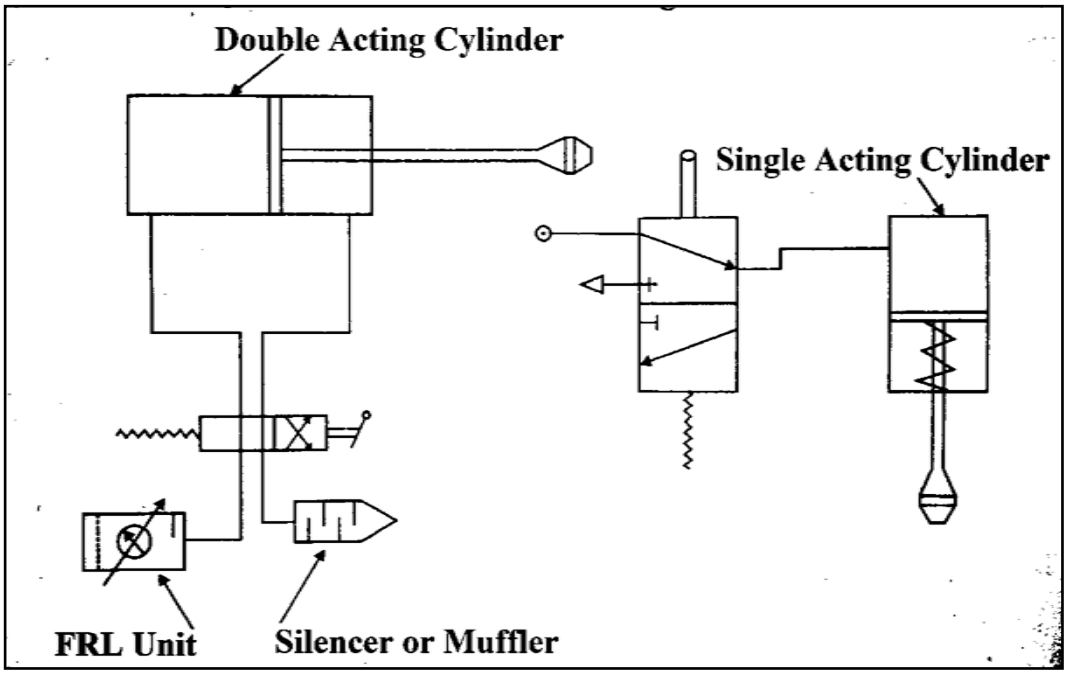
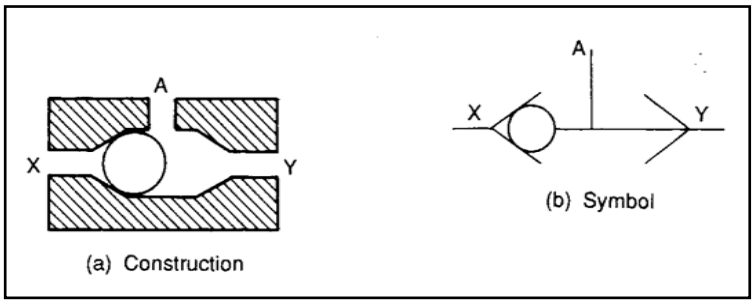
(a) Cushioning of cylinder .

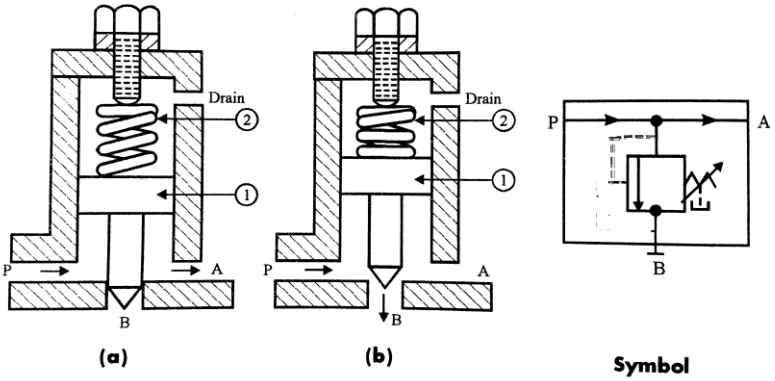
Cushioning of cylinder means gradual deceleration of the piston near the end of its stroke. It means slowing down the speed of the piston near the end of cylinder body.It is very helpful to reduce shock or impact load on the cylinder end covers specially when a heavy load is connected to the rod or the cylinder and is working at very high speed.The cushion assembly is around 25 mm long for a standard cylinder. It consists of a small passage to allow entrapped oil to the port with cushion needle with an

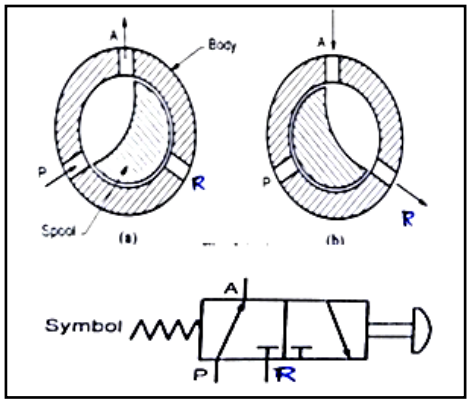
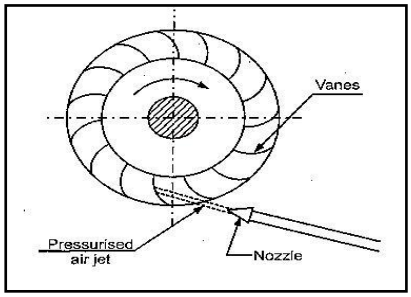
Diagram – 4 marks

Explanation – 4 marks

		check valve to allow free flow of oil during reverse flow of oil during reverse start of piston travel.The end of the cushion nose is trapped in order to enter more easily into the cushion chamber.The fluid is normally leaves through the outlet port directly, but when cushioning boss enters the recess, the fluid around the piston is trapped. The only way the fluid can escape is through the secondary path which is restricted by a needle valve.The needle valve is adjusted so that the piston is slowed up over the last part of its stroke by a pressure build up in the fluid escaping past the needle valve.  	
(b)		**Sequencing circuit for two single acting air cylinder** Figure shows a simple pneumatic circuit diagram using two cylinders A and B, - both cylinders are single acting actuated sequencially by a roller operated 3/2 directional control valve. With the actuation of the detented D.C. valve 2.2, the line is energised. As valve 1.1 is actuated by a manual lever, cylinder A adavances and actuates valve 1.2 which sends am impulse to the pilot operated valve 2.1 and cylinder B advances. Cylinder A returns when lever is reset. Cylinder B then retracts as the valve 1.2 is released.  	Diagram – 4 marks Explanation – 4 marks

	(c)	**Name of circuit** Pneumatic sequencing circuit of one single acting and one double acting cylinder**.** **Application**: Used to Sequence the Operations – Clamping and Punching operation  	Name – 2 marks Application – 2 marks Circuit and names – 4 marks
	6	**Attempt any FOUR**	
	(a)	Shuttle valve: A shuttle vale also known as a double check valve/ OR gate, allows pressure in a line to be obtained from alternative sources. It is primarily a pneumatic device and is rarely found in hydraulic circuits. Construction is very simple and consists of a ball inside a cylinder. If pressure is applied to port X, the ball is blown to the right blocking port Y and linking ports X and A. Similarly, pressure to port Y alone connects port Y and A blocks port X  	Sketch – 2 marks Explanation – 2 marks

	(b)	Sequence valve A primary function of sequence valve is to direct flow to different components of the circuit in a predetermined sequence. It is a pressure actuated valve which senses a certain change in pressure from the set value. It then takes the actions to direct the fluid in a definite predetermined order. It also maintains the requisite minimum pressure in the primary line while the secondary operations occur. Figure shows operating principle of a direct acting, normally closed sequence valve. In this position, fluid passes through the valve from the inlet port P to primary outlet port A at system pressure. When the first step in the sequence is completed, the system pressure increases to act against the exposed area of the piston. Continued increase in pressure causes the piston to compress the spring and unseat the valve, thereby directing the flow of fluid at high pressure through secondary outlet port B. Fluid pressure is maintained in both branches of the circuit so long as the sequence valve is open. Adjustment of the sequence valve is accomplished by compressing or extending the piston with the cap screw.  	Sketch – 2 marks Explanation – 2 marks
	(c)	Properties of hydraulic fluid 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. 7. **Viscosity**: It is the resistance offered by the liquid to flow. It is inherent property of the liquid and this resistance to flow depends on some other physical properties such as temperature, pressure, etc. 8. **Compressibility**: It is the ability of a fluid to get compressed and liquids are less compressible. Compressibility is the reciprocal of bulk modulus.	Any four 4 marks
	(d)	A rotary spool valve consists of a rotating spool which aligns with ports in stationary valve casing, so that fluid is directed to required port. Pressure port (P), Actuator port (A) and Receiver port (R) are the ports in casing. The port 'P' is a pressure port though which pressurized fluid is coming in the valve. 'R' port is the port through which used fluid is returning to the Receiver.	Sketch – 2 marks

		From fig (a) which indicate first position of the rotary spool type 3/2 DCV connects port P to port A While receiver port R remains closed. In second position shown in fig (b) of rotary spool type 3/2 DCV port A is connected to port R while port P remained closed. 	Explanation – 2 marks
(e)		Types of Air Motor 1) Vane Motor 2) Gerotor Motor 3) Turbine Motor 4) Piston type motors  Figure shows turbine type air Motor. In this air motor, light weight impeller having curved vanes is used. This pressurized air is passed through nozzle. The impact of jet will rotate the impeller. These motors are high speed low torque motors; and being simple in construction and are used in many applications.	Sketch – 2 marks Explanation – 2 marks