CBCS Scheme
15ME72

Seventh Semester B.E. Degree Examination, December 2019/January 2020

Fluid Power Systems

Time 3 hrs. Max Marks:80

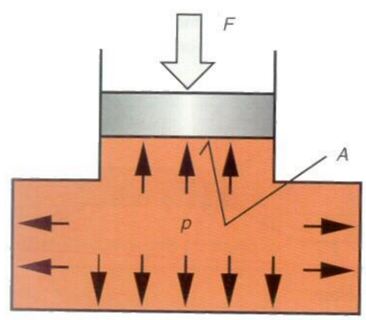
Note: Answer any FIVE full questions, choosing one full question from each module.

<u>Module-1</u>

1 a. Define Pascal's law and its applications.

Pascal's Law is the most fundamental principle in fluid power. It deals with hydrostatics, the transmission of force through a confined fluid under pressure.

Pascal's law reveals the basic principle of how fluid power systems perform useful work. This law can be stated as follows: "Pressure applied to a confined fluid is transmitted undiminished in all directions throughout the fluid and acts perpendicular to the surfaces in contact with the fluid".



Pressure in an enclosed fluid can be considered uniform throughout a practical system. There may be small differences arising from head pressures at different heights, but these will generally be negligible compared with the system operating pressure. This equality of pressure is known as *Pascal's law,* and is illustrated in figure above.

The applied force develops a pressure, given by the expression:

$$p = f/a$$

The force on the base is:

$$F = p \times A$$

from which F can be derived as:

$$F = f \times A/a$$

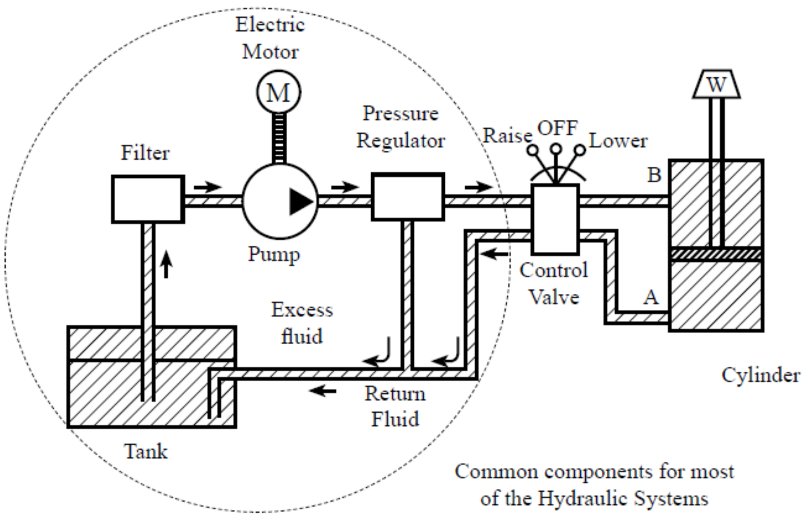
The above expression shows an enclosed fluid may be used to magnify a force.

b. Brief the various components of hydraulic system and its fluid power symbol.

A hydraulic control system is a group of hydraulic components arranged in an order to transmit hydraulic power using oil to perform useful work.

There are eight basic components required in a hydraulic system.

1. A reservoir is used to hold the hydraulic oil.
2. An actuator to convert the fluid power into mechanical power to perform useful work.
3. A pump is used to force the fluid from the reservoir.
4. An electric motor is required to drive the pump.
5. Valves are used to control the direction, pressure and flow rate of a fluid.
6. Piping system carries the hydraulic oil from one place to another.
7. Filters are used to remove any foreign particles so as keep the fluid system clean and efficient.
8. Pressure regulator regulates (i.e. maintains) the required level of pressure in the hydraulic fluid.



Common components for most of the Hydraulic Systems

The hydraulic system requires a liquid fluid to operate; this is expensive and messy. The piping must act as a closed loop, with fluid transferred from a storage tank to one side of the cylinder, and returned from the other side of the cylinder to the tank.

Fluid is drawn from the tank by a pump which produces fluid flow at the required pressure. A prime move generally an electric motor is required to run the pump. Cylinder movement is controlled by a three-position direction control valve (DCV). To extend the cylinder, port A is connected to the pressure line and port B to the tank. To reverse the motion, port B is connected to the pressure line and port A to the tank. In its centre position the valve locks the fluid into the cylinder.

c. What are the primary functions of hydraulic fluid? Name the various fluid properties that a fluid should process.

Functions of Hydraulic fluids

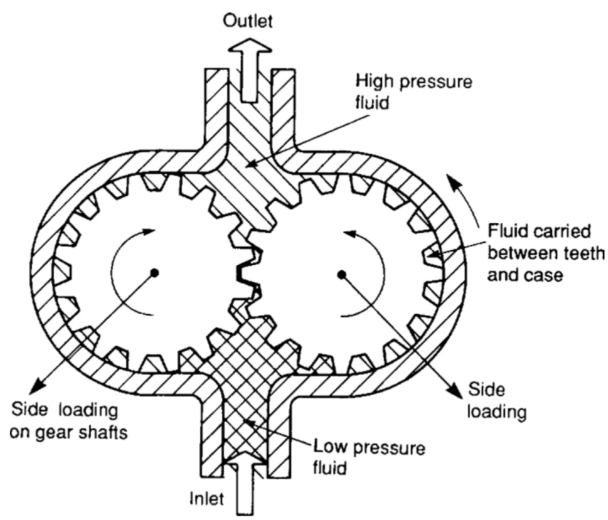
1. The main purpose of the fluid in a fluid power system is to transmit power.
2. Fluid must cool the system by dissipation of heat in a reservoir.
3. Fluids must act as a sealing agent to prevent leaks.
4. Fluids must lubricate sliding and rotating surfaces.
5. Fluids must not corrode components and must have a long life without chemical breakdown.

Characteristics of a hydraulic fluids

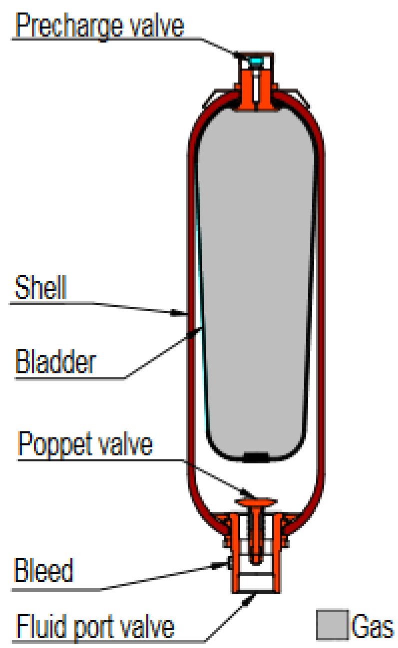
When choosing a hydraulic fluid, following characteristics are considered:

		1. Viscosity is the measure of a fluid's resistance to flow and shear. A fluid of higher viscosity will flow with higher resistance compared to a fluid with a low viscosity. 2. Viscosity Index is how the viscosity of a fluid changes with a change in temperature. A high VI fluid will maintain its viscosity over a broader temperature range than a low VI fluid of the same weight. 3. Oxidation Stability is the fluid's resistance to heat-induced degradation caused by a chemical reaction with oxygen. Oxidation greatly reduces the life of a fluid, leaving by-products such as sludge and varnish. 4. Wear Resistance: It is the lubricant's ability to reduce the wear rate in frictional boundary contacts. 5. Incompressibility: Liquids are of very low compressibility, while gases are highly compressible. Therefore, liquids are usually assumed incompressible. 6. Compatibility: The fluid must be fully compatible with other materials used in the hydraulic system, such as those used for bearings, seals, paints, and so on. 7. Chemical stability is an important property of the hydraulic liquid. It is defined as the ability of the liquid to resist oxidation and deterioration for long periods. Cleanliness in hydraulic systems has received considerable attention. Some hydraulic systems, such as aerospace hydraulic systems, are extremely sensitive to contamination.
OR		
2	a.	With a neat sketch, explain the working of hydraulic filter. **Filters:** They are devices whose primary function is the retention, by some fine porous medium, of insoluble contaminants from fluid. Filters are used to pick up smaller contaminant particles because they are able to accumulate them better than a strainer. Generally, a filter consists of fabricated steel housing with an inlet and an outlet. The filter elements are held in position by springs or other retaining devices. Because the filter element is not capable of being cleaned, that is, when the filter becomes dirty, it is discarded and replaced by a new one. Particle sizes removed by filters are measured in microns. The smallest sized particle that can be removed is as small as 1 μm. A strainer is a device whose function is to remove large particles from a fluid using a wire screen. The smallest sized particle that can be removed by a strainer is as small as 0.15 mm or 150 μm. **Types of Filters** Filters may be classified as follows: **1. According to the filtering methods:** **Mechanical filters:** This type normally contains a metal or cloth screen or a series of metal disks separated by thin spacers. Mechanical filters are capable of removing only relatively coarse particles from the fluid. **Absorption filters:** These filters are porous and permeable materials such as paper, wood pulp, diatomaceous earth, cloth, cellulose and asbestos. Paper filters are impregnated with a resin to provide added strength. In this type of filters, the particles are actually absorbed as the fluid permeates the material. Hence, these filters are used for extremely small particle filtration. **Adsorbent filters:** Adsorption is a surface phenomenon and refers to the tendency of particles to cling to the surface of the filters. Thus, the capacity of such a filter depends on the amount of surface area available. Adsorbent materials used include activated clay and chemically treated paper.

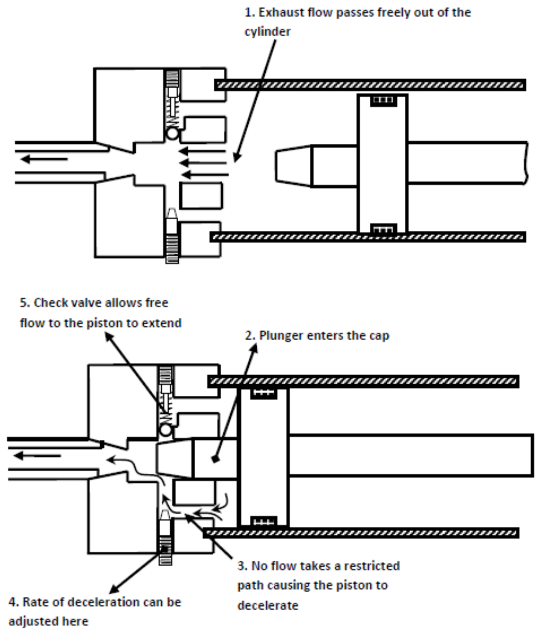
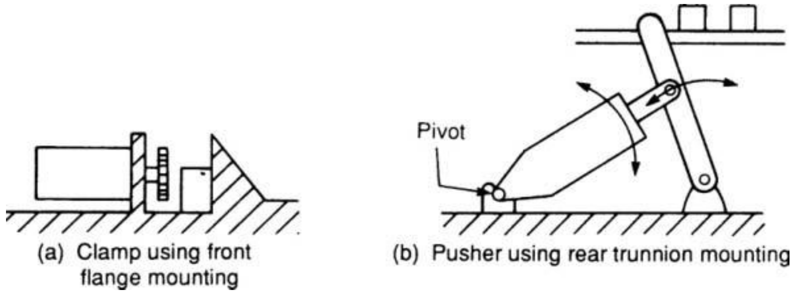
		2. According to the size of pores in the material: **Surface filters:** These are nothing but simple screens used to clean oil passing through their pores. The screen thickness is very thin and dirty unwanted particles are collected at the top surface of the screen when the oil passes, for example, strainer. **Depth filters:** These contain a thick-walled filter medium through which the oil is made to flow and the undesirable foreign particles are retained. Much finer particles are arrested and the capacity is much higher than surface filters.
	b.	What is the purpose of seals in fluid power system? List the various types of seals used in fluid power system. Leakage from a hydraulic or pneumatic system can be a major problem, leading to loss of efficiency, increased power usage, temperature rise, environmental damage and safety hazards. Minor internal leakage (Example: Round the piston in a double-acting cylinder) can be of little consequence and may even be deliberately introduced to provide lubrication of the moving parts. External leakage, on the other hand, is always serious. In pneumatic systems, external leakage is noisy; with hydraulic systems, external loss of oil is expensive as lost oil has to be replaced, and the resulting pools of oil are dangerous and unsightly. Functions of Seals Seals are used in hydraulic systems to prevent excessive internal and external leakage and to keep out contamination. Various functions of seals include the following: 1. They prevent leakage – both internal and external. 2. They prevent dust and other particles from entering into the system. 3. They maintain pressure. 4. They enhance the service life and reliability of the hydraulic system. The following represents the most widely used types of seal configurations. 1. O-rings 2. Compression packings (V- and U- shapes) 3. Piston cup packings 4. Piston rings 5. Wiper rings
	c.	Brief the various advantages of fluid power system. 1. High horsepower-to-weight ratio 2. Safety in hazardous environments because they are inherently spark-free and can tolerate high temperatures. 3. Force or torque can be held constant — this is unique to fluid power transmission. 4. High torque at low speed — unlike electric motors, pneumatic and hydraulic motors can produce high torque while operating at low rotational speeds. Some fluid power motors can even maintain torque at zero speed without overheating. 5. Pressurized fluids can be transmitted over long distances and through complex machine configurations with only a small loss in power. 6. Multi-functional control — a single hydraulic pump or air compressor can provide power to many cylinders, motors, or other actuators 7. Elimination of complicated mechanical trains of gears, chains, belts, cams, and linkages.

		8. Motion can be almost instantly reversed.
Module-2		
3	a.	With a neat sketch explain the working of external gear pump. External gear pumps are the most popular hydraulic pumps in low-pressure ranges due to their long operating life, high efficiency and low cost. These are simplest and most robust positive displacement pump, having just two moving parts, is the gear pump. Its parts are non-reciprocating, move at constant speed and experience a uniform force. Internal construction, shown in Figure, It consist of a pump housing in which a pair of precisely machined meshing gears runs with minimal radial and axial clearance. One of the gears, called a driver, is driven by a prime mover. The driver drives another gear called a follower. As the teeth of the two gears separate, the fluid from the pump inlet gets trapped between the rotating gear cavities and pump housing. The trapped fluid is then carried around the periphery of the pump casing delivered to outlet port. The teeth of precisely meshed gears provide almost a perfect seal between the pump inlet and the pump outlet. When the outlet flow is resisted, pressure in the pump outlet chamber builds up rapidly and forces the gear diagonally outward against the pump inlet. When the system pressure increases, imbalance occurs. This imbalance increases mechanical friction and the bearing load of the two gears. Hence, the gear pumps are operated to the maximum pressure rating stated by the manufacturer. The direction of rotation of the gears should be carefully noted; it is the opposite of that intuitively expected by most people. 
	b.	Explain the various types of accumulators. Explain the construction and working of bladder type accumulator. Accumulators: Hydraulic accumulators are used for temporarily storing pressurized oil. The oil enters a chamber and acts against a piston or bladder to raise a weight, compress a spring or compress a gas. The stored potential energy in the accumulator is a quick secondary source of fluid power capable of doing useful work as required by the system. Accumulators are the equivalent to a capacitor in an electrical system and to a spring in a mechanical system.

		Accumulators form an energy store in a hydraulic system and have two common uses (1) To provide a source of energy that may be required over a short period of time. (2) To smooth out pressure fluctuations in a system e.g. variations in pump delivery and transient pressures due to sudden changes of fluid velocity in the system. There are three basic types of accumulator used in hydraulic system. They are: 1. Weight – Loaded, or gravity, type 2. Spring -Loaded type 3. Gas – Loaded type Gas loaded accumulators fall into two main categories: 1. Non-separator type 2. Separator type a. Piston type b. Bladder type c. Diaphragm type Bladder type In the bladder accumulators, the fluid area is separated from the gas area by a flexible bladder. The fluid around the bladder is in contact with the circuit, so any increase in pressure causes the entry of the fluid into the accumulator and thereby compresses the gas. Vice versa, every drop of pressure in the circuit causes the expansion of the gas, resulting in delivery of the fluid from the accumulator to the circuit. Bladder accumulators can be installed in vertical position (preferable), in horizontal one and, under certain operating conditions, also in an inclined one. In the inclined and vertical positions, the valve on the fluid side should face down. The bladder accumulators include a pressure welded or forged vessel, a flexible bladder and the fittings for gas and oil.

		 Fig Bladder type accumulator
	c.	A Vane pump is to have a volumetric displacement of 82 cm^3. It has a rotor dia of 5 cm, a cam ring dia 7.5 cm, and a vane width of 4 cm. what must be the eccentricity? What is the maximum volumetric displacement possible?

		Given data: Vane pump, $V_D = 82\ cm^3/rev$ $D_r = 5\ cm$ $D_c = 7.5\ cm$ $L = 4\ cm$ eccentricity is given by $e = \dfrac{2 \times V_D}{\pi (D_c + D_r) L}$ $= \dfrac{2 \times 82}{\pi (5 + 7.5) \times 4}$ $= 1.04\ cm$ $e_{max} = \dfrac{D_c - D_r}{2} = 1.25$ $V_{D_{max}} = \dfrac{\pi}{2} \times (5 + 7.5) \times 1.25 \times 4$ Maximum possible volumetric displacement $V_{D_{max}} = 98.214\ cm^3$
OR		
4	a.	Explain the working of hydraulic cylinder cushioning with a neat sketch. The extension and retraction speeds of hydraulic cylinders are managed by controlling the inlet or exit-oil flow rates. When reaching its end position, the piston is suddenly stopped. In the case of high speed and/or great inertia, the sudden stopping of the piston results in a severe impact force. It affects both the cylinder and the driven mechanism. Therefore, a cushioning arrangement might be necessary to reduce the piston speed to a limiting value before piston reaches its end position. Cushions may be applied at either end or both ends. They operate on the principle that as the cylinder piston approaches the end of stroke; an exhaust fluid is forced to go through an adjustable needle valve that is set to control the escaping fluid at a given rate. This allows the deceleration characteristics to be adjusted for different loads. When the cylinder piston is actuated, the fluid enters the cylinder port and flows through the little check valve so that the entire piston area can be utilized to produce force and motion. A typical cushioning arrangement is shown in Fig.

		 Figure working principle of Cylinder cushioning
	b.	What are the various types of hydraulic cylinder mountings? Brief them with a neat sketch. Cylinder mounting is determined by the application. Two basic types are shown in Figure. The clamp requires a simple fixed mounting. The pusher of requires a cylinder mount which can pivot. Figure 2 shows various mounting methods using these two basic types. The effects of side loads should be considered on non-centreline mountings such as the foot mount. Swivel mounting obviously requires flexible pipes.  Figure 1. Basic mounting types

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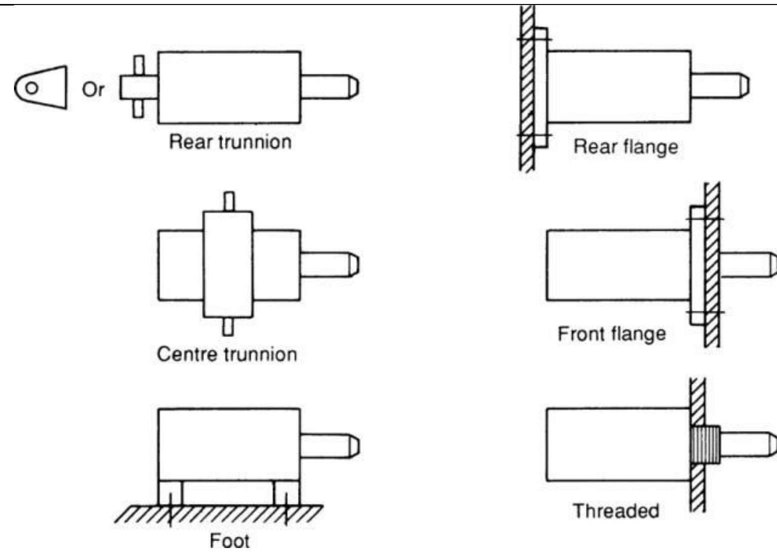

Figure 2. Methods of cylinder mounting

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<tr><td></td><td>c</td><td>

A hydraulic motor has a 100 cm^3 volumetric displacement. If it has a pressure rating of 140 bar and receives oil from a 0.001 m^3/sec theoretical flow rate pump, find the motor (a) speed, (b) theoretical torque, (c) theoretical kW power

Solution:

(a) Speed: We have the theoretical flow rate given by

$$Q_T = V_D \times n$$

$$\Rightarrow 0.001 = 100 \times 10^6 \times n$$

$$\Rightarrow n = 10 \text{ RPS(revolutions per second)}$$

and

$$N = 600 \text{ RPM}$$

(b) Theoretical torque

$$T_T = \frac{p \times V_D}{2\pi} = \frac{140 \times 10^5 \times 100 \times 10^{-6}}{2\pi} = 222.82 \text{ N m}$$

(c) Theoretical kW power

$$P = Q_T \times p = 0.001 \text{ m}^3/\text{s} \times 140 \times 10^5 \text{ N/m}^2 = 14000 \text{ W} = 14 \text{ kW}$$

Alternately,

$$\text{Power} = T_T\omega = 222.82 \times 10 \times 2\pi = 14000 \text{ W} = 14 \text{ kW}$$

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<u>Module-3</u>

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<tr><td>5</td><td>a.</td><td>

Brief the construction feature and working of pressure relief valve.

The pressure relief valves are used to protect the hydraulic components from excessive pressure. This is one of the most important components of a hydraulic system and is essentially required for safe operation of the system. Its primary function is to limit the system pressure within a specified range. It is similar to a fuse in an electrical system. Pressure relief valve 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

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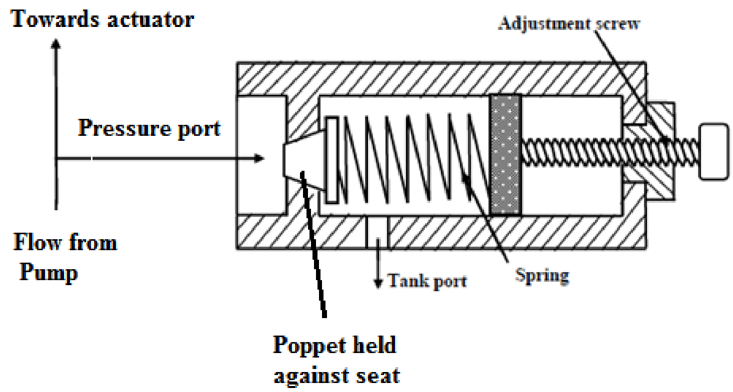
against the spring force. The fluid enters from the opposite side of the poppet. When the system pressure exceeds the preset value, the poppet lifts and the fluid is escaped through the orifice to the storage tank directly. It reduces the system pressure and as the pressure reduces to the set limit again the valve closes.



b. Explain regenerative circuit. **6 Marks**

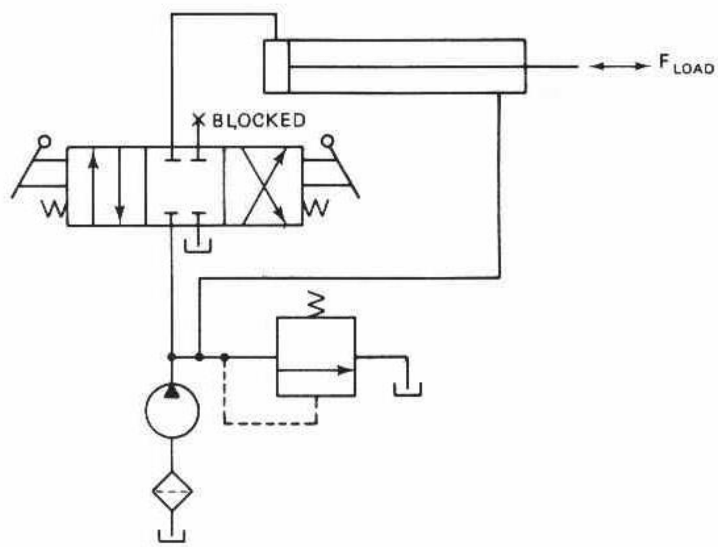


Figure shows a regenerative circuit that is used to speed up the extending speed of a double-acting cylinder. The pipelines to both ends of the hydraulic cylinder are connected in parallel and one of the ports of the 4/3 valve is blocked by simply screwing a thread plug into the port opening. During retraction stroke, the 4/3 valve is configured to the right envelope. During this stroke, the pump flow bypasses the DCV and enters the rod end of the cylinder. Oil from the blank end then drains back to the tank through the DCV.

When the DCV is shifted in to its left-envelope configuration, the cylinder extends as shown in Figure the speed of extension is greater than that for a regular double-acting cylinder because the flow from the rod end regenerates with the pump flow Q_P to provide a total flow rate $Q_{T.}$

Expression for the Cylinder Extending Speed

The total flow rate Q_T entering the blank end of the cylinder is given by

$$Q_T = Q_P + Q_r$$

Where Q_P is the pump flow rate and is Q_r the regenerative flow or flow from the rod end.

Hence, Pump flow rate,

$$= Q_P = Q_T - Q_r$$

But the total flow rate acting on the blank rod end is given by

$$Q_P = A_P V_{ext}$$

Similarly, the flow rate from the rod end is given by

$$Q_r = (A_P - A_r) V_{ext}$$

So pump flow rate is

$$Q_P = A_P V_{ext} - (A_P - A_r) V_{ext}$$

$$Q_P = A_r V_{ext}$$

The extending speed of the piston is given as

$$V_{ext} = Q_P / A_r$$

Thus, a small area provides a large extending speed. The extending speed can be greater than the retracting speed if the rod area is made smaller.

c. With a neat sketch brief the working of check valve.

Check Valve

2/2 DCV (Poppet design)

Valve Closed b. Valve Opened

Fig 2/2 DCV (Poppet Design)

Figure 4.6a Shows a ball poppet type 2 / 2 DCV. It is essentially a check valve as it allows free flow of fluid only in one direction (P to A) as the valve is opened hydraulically and hence the pump Port P is connected to port A as shown in fig b. In the other direction the valve is closed by the ball poppet and hence the flow from the port A is blocked. A poppet is a specially shaped plug element held onto a seat by a spring. Fluid flows through the valve in the space between the seat and poppet. As shown, light spring holds the poppet in the closed position. In the free-flow direction, the fluid pressure overcomes the spring force at about 35kPa.

If flow is attempted in the opposite direction, the fluid pressure pushes the poppet along with the spring force in the closed position. Therefore no flow is permitted. The higher the pressure, the greater will be the force pushing the poppet against the seat. Thus, increased pressure will not result in any tendency to allow flow in the no flow direction. The symbol for this type of design is same as that of check valve.

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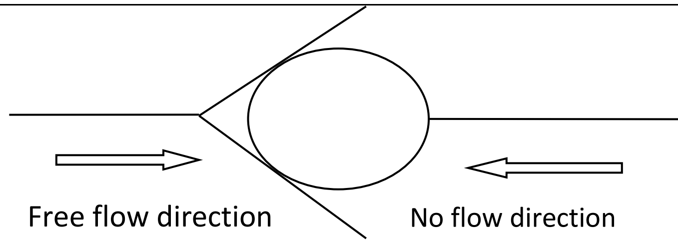
<tr><td></td><td></td><td>
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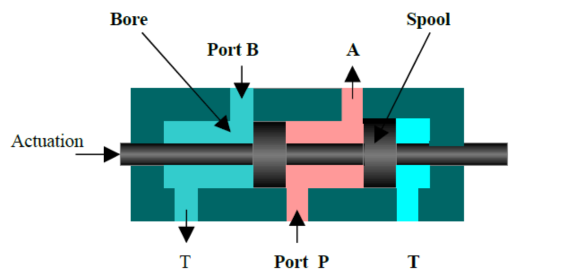
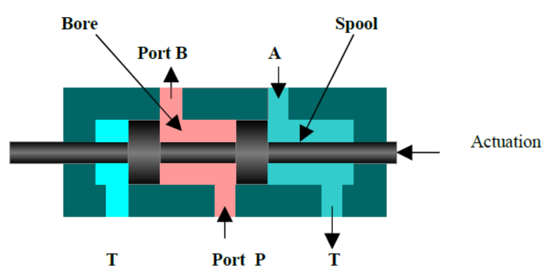
<tr><td colspan="3">OR</td></tr>
<tr><td>6</td><td>a.</td><td>Explain the working of 4/2 manually operated DCV with a neat sketch.
These valves are also used to operate double acting cylinder. These valves are also called as impulse valve as 2 / 4 DCV has only two switching positions, i.e. it has no mid position. These valves are used to reciprocate or hold and actuating cylinder in one position. They are used on machines where fast reciprocation cycles are needed. Since the valve actuator moves such a short distance to operate the valve from one position to the other, this design is used for punching, stamping and for other machines needing fast action. Fig 4.15 a and b shows the two position of 2 / 4 DCV.



a. 1 Position : P to A and B to T



b. 2 Positon, P to B and A to T

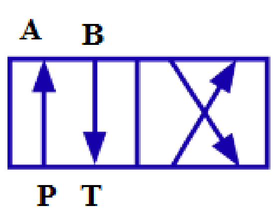


Figure Graphical symbol for 4/2 DCV</td></tr>
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In many applications, it is necessary to perform operations in a definite order. Hydraulic cylinders can be operated sequentially using a sequence valve. Figure 1.7 shows that two sequence valves are used to sequence the operation of two double-acting cylinders. 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.

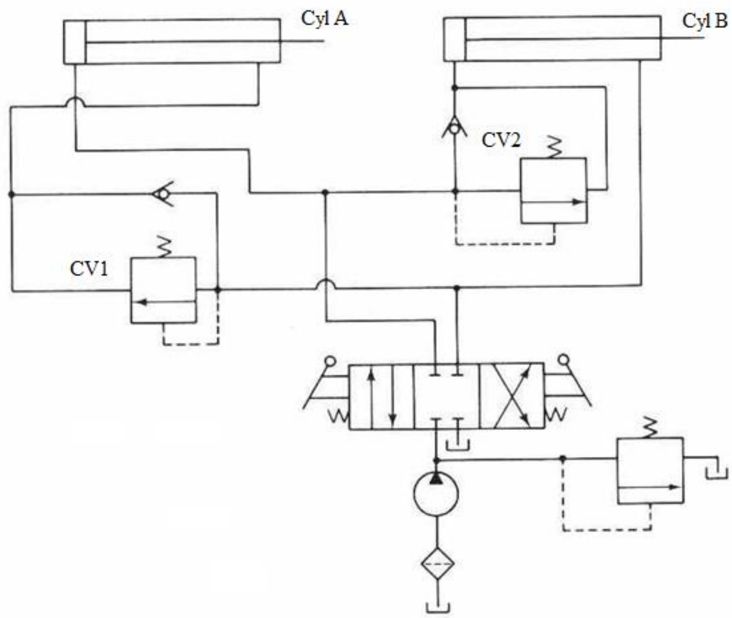


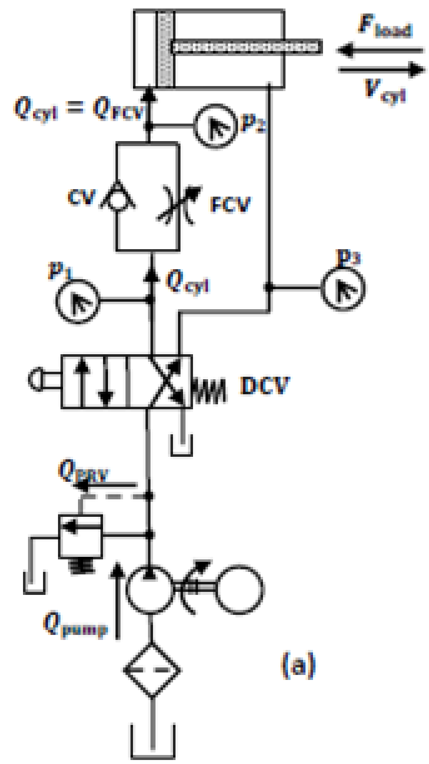
Figure Sequencing circuit.

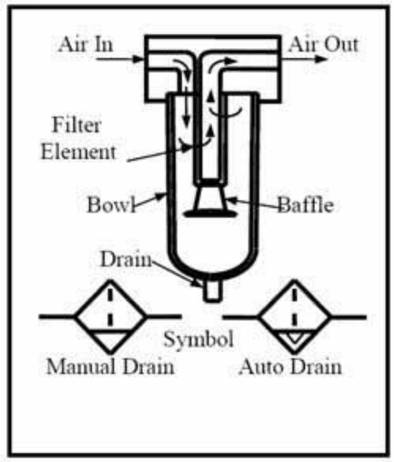
The sequence of operation realized by the circuit shown in Figure 1.7 is:
Step A – Extend Cylinder A (To clamp the work piece)
Step B – Extend Cylinder B while holding pressure on Cylinder A (To perform drilling operation)
Step C – Retract Cylinder B (To retract the spindle after drilling)
Step D – Retract Cylinder A (To unclamp the work piece)

When the DCV is shifted into its left envelope mode, the cylinder A extends completely. When the pressure reaches the pressure setting of sequence valve (SV1), the valve opens and fluid flow is allowed to the cylinder B as a result cylinder B extends. If the DCV is then shifted into its right envelope mode cylinder B retracts fully, and then the cylinder A retracts. Hence this sequence of cylinder operation is controlled by the sequence valves. The spring cantered position of the DCV locks both cylinders in place.

c. Explain the working of metering in hydraulic circuit.

The speed control of a hydraulic cylinder circuit can be done during the extension stroke using a flow-control valve (FCV). This is done on a meter-in circuit and meter-out circuit as shown in Fig.. When the DCV is actuated, oil flows through the FCV to extend the cylinder. The extending speed of the cylinder depends on the FCV setting. When the DCV is deactivated,

		the cylinder retracts as oil from the cylinder passes through the check valve. Thus, the retraction speed of a cylinder is not controlled. 
<u>Module-4</u>		
7	a.	Explain the working of pneumatic filter with a neat sketch. To prevent any damage to the compressor, the contaminants present in the air need to be filtered out. This is done by using inlet filters. These can be dry or wet filters. Dry filters use disposable cartridges. In the wet filter, the incoming air is passed through an oil bath and then through a fine wire mesh filter. Dirt particles cling to the oil drops during bubbling and are removed by wire mesh as they pass through it. In the dry filter the cartridges are replaced during servicing. The wet filters are cleaned using detergent solution.



b. Brief the various components of a pneumatic systems and its fluid power control.

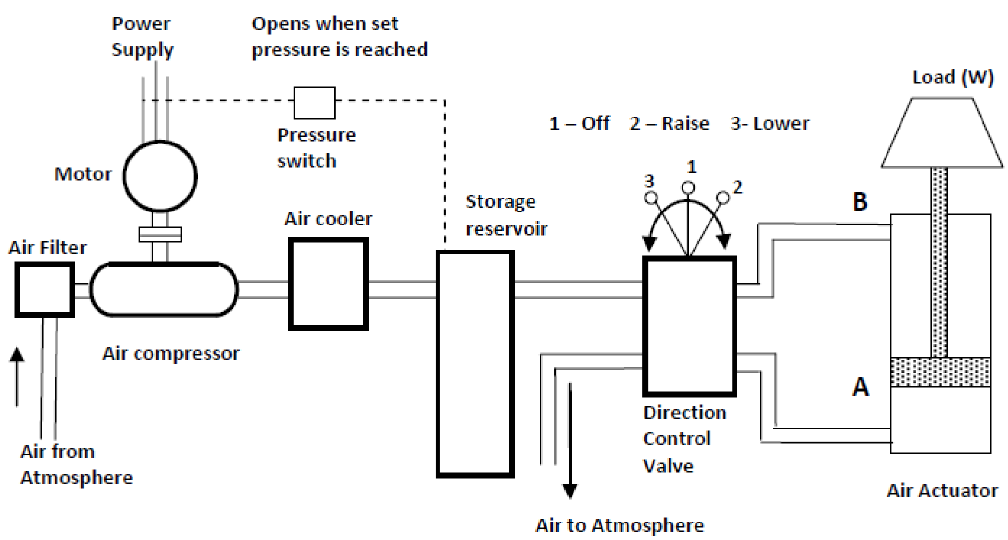


Fig. 4.1 Components of a pneumatic system

Important components of a pneumatic system are shown in fig 4.1
Functions of components

1. Air filters are used to filter out the contaminants from the air.
2. Air cooler are used to reduce the temperature of the compressed air.
3. Compressor is used to compress the fresh air drawn from the atmosphere.
4. External power supply (Motor) is used to drive the compressor.
5. Storage reservoir is used to store a given volume of compressed air.
6. Control valves are used to control the direction, flow rate and pressure of compressed air.
7. Pneumatic actuator converts the fluid power into mechanical power to perform useful work.
8. Piping system carries the pressurized air from one location to another.

Atmospheric air is drawn through air filter and raised to required pressure by an air compressor. As the pressure rises, the temperature of air will also rise and hence air cooler is provided to cool the air with some preliminary treatment to remove the moisture.
The treated pressurized air is stored in the storage reservoir to maintain the required pressure. With the storage reservoir, a pressure switch is fitted to start and stop the electric motor when pressure falls and reaches the required level, respectively.
The cylinder movement is controlled by pneumatic valve. One side of the pneumatic valve is connected to the compressed air and silencers for the exhaust air and the other side of the valve is connected to port A and Port B of the cylinder.
Position of the valve is as follows
Raise: To lift the weight, the compressed air supply is connected to port A and the port B is connected to the exhaust line, by moving the valve position to the "Raise".
Lower: To bring the weight down, the compressed air line is connected to port B and port A is connected to exhaust air line, by moving the valve position to the "lower".
Off: The weight can be stopped at a particular position by moving the valve to position to "Off" position. This disconnects the port A and port B from the pressurized line and the retrieval line, which locks the air in the cylinder.

c. Explain quick exhaust valve with symbol.

A quick exhaust valve is a typical shuttle valve. The quick exhaust valve is used to exhaust the cylinder air quickly to atmosphere. Schematic diagram of quick exhaust valve is shown in Figure 4.38(a). In many applications especially with single acting cylinders, it is a common practice to increase the piston speed during retraction of the cylinder to save the cycle time. The higher speed of the piston is possible by reducing the resistance to flow of the exhausting air during the motion of cylinder. The resistance can be reduced by expelling the exhausting air to the atmosphere quickly by using Quick exhaust valve.

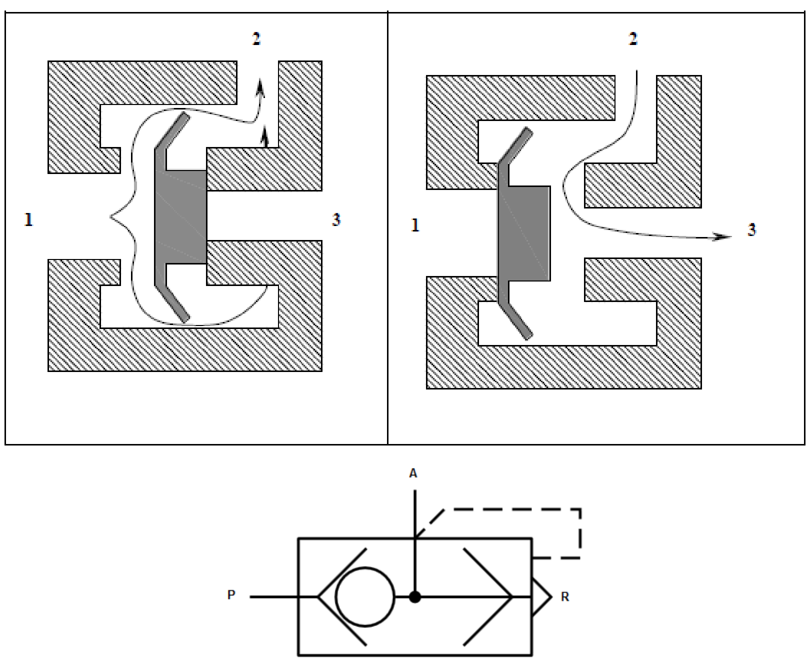
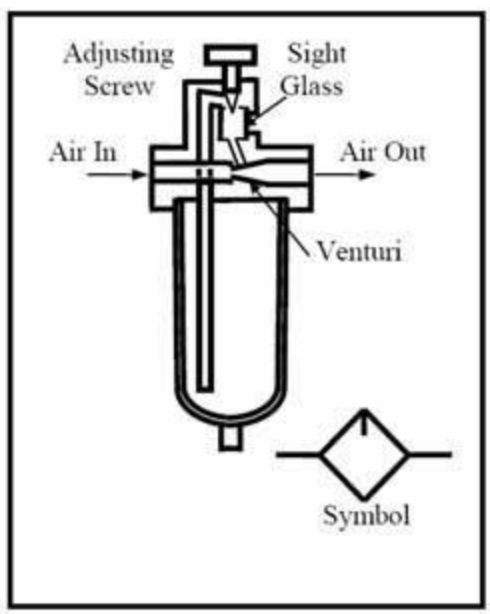
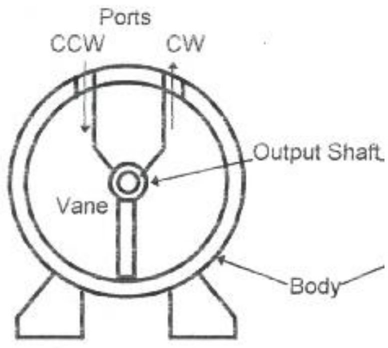


Figure Working of quick exhaust valve and graphical symbol

		The construction and operation of a quick exhaust valve is shown in Figure 4.39. It consists of a movable disc (also called flexible ring) and three ports namely, Supply port 1, which is connected to the output of the directional control valve. The Output port, 2 of this valve is directly fitted on to the working port of cylinder. The exhaust port, 3 is left open to the atmosphere. Forward Motion: During forward movement of piston, compressed air is directly admitted to cylinder inlet through ports 1 and 2. Port 3 is closed due to the supply pressure acting on the diaphragm. Port 3 is usually provided with a silencer to minimize the noise due to exhaust. Return Motion: During return movement of piston, exhaust air from cylinder is directly exhausted to atmosphere through opening 3 (usually larger and fitted with silencer) .Port 2 is sealed by the diaphragm. Thus exhaust air is not required to pass through long and narrow passages in the working line and final control valve.
OR		
8	a.	With a neat sketch explain the working of lubricator. After the combination unit filters and regulates air pressure, some downstream system components may require a small amount of lubrication. (For example: air motors are one item that needs a constant supply of oil to extend their life and maintain torque.) Some cylinders are pre-lubed and most valves require little if any lubrication, so keep oil supply to these units at minimum.  Air line lubricators are designed to send a mist of oil to the parts in the downstream circuit. However, the physical size of some circuits makes it impossible for the mist to stay in suspension long enough to reach some parts. In this case -- and for some air motor applications -- it is necessary to inject oil at the components inlet. There are electric and air-driven lubrication units to meet the needs of these applications.

b. Explain the working of single vane rotary cylinder with a suitable sketch.

In a rotary actuator the force is applied a distance away from the axis of rotation, causing a turning movement. There are two basic constructions of a rotary actuator; rotary vane actuators, and rack and pinion actuators, which operate as follows.



Single Vane

The figure depicts both single-vane-types. The vanes attach to an output shaft and have seals around their periphery. When fluid pressure on a given vane area pushes it through the body cavity, the output shaft turns with a given torque. The maximum rotation of vane rotary actuators is limited to approximately 280° in a single-vane model.

In a rotary vane actuator, compressed air pushes against a vane, which is attached to a central spindle. This acts to turn the spindle, with the air 'behind' the vane released through a port. When the vane reaches a stop at the specified angle of rotation, the air flow is reversed and the spindle rotates back to its original position for the process to repeat. Rotary vane actuators are more limited in rotation and in torque than the rack and pinion version, and are therefore more commonly used for lighter loads.

c. Explain the working of shuttle valve.

A shuttle valve is shown in figure. The shuttle valve consists of a valve body and a synthetic ball or a cuboid valving element moving inside the bore in the valve housing. There are three openings P_1, P_2, and A. if an air signal is fed to port P_1, the ball moves, closing port P_2 and air passes to ‘A’. If the air is fed to port P_2, port P_1 is closed and moves to ‘A’. If air is fed simultaneously to port P_1 and P_2 then also air moves to port A, either from P_1 or P_2 or from both. This element is also called an OR Gate.

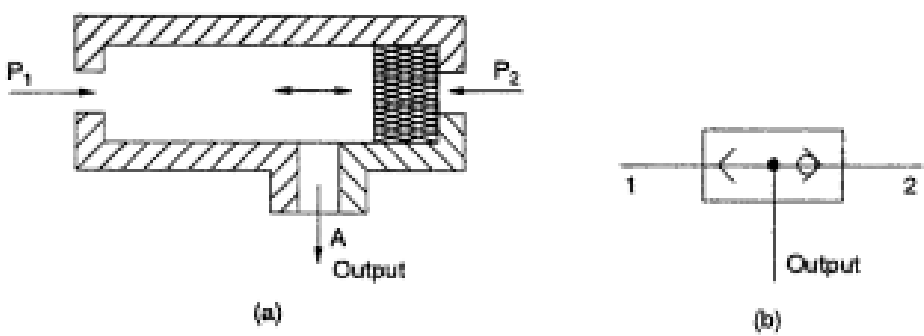


Figure a. Construction of shuttle valve b. graphical symbol

<table>
<tr><td></td><td></td><td></td></tr>
<tr><td>9</td><td>a.</td><td>Explain with a suitable circuit, indirect control of a double acting cylinder using memory valve.

Indirect control of double acting cylinder
A double acting cylinder can be controlled indirectly using 4/2 pilot operated DCV. This pilot operated valve may be termed as the main valve. The signal provided to the pilot operated valve by means of an air impulse. This operation is therefore also called an impulse operation. To control the main valve a 3/2 DCV or 2/2 DCV must be used. In the circuit shown in figure 5.4 two DCV's are connected to a common air source. In the normal position the cylinder will be in the retracted position. To extend the cylinder a pilot signal should be sent to the main valve by actuating push button of the 3/2 DCV. When the push button is released air flow from reservoir to actuator is disconnected, as a result the cylinder retracts.

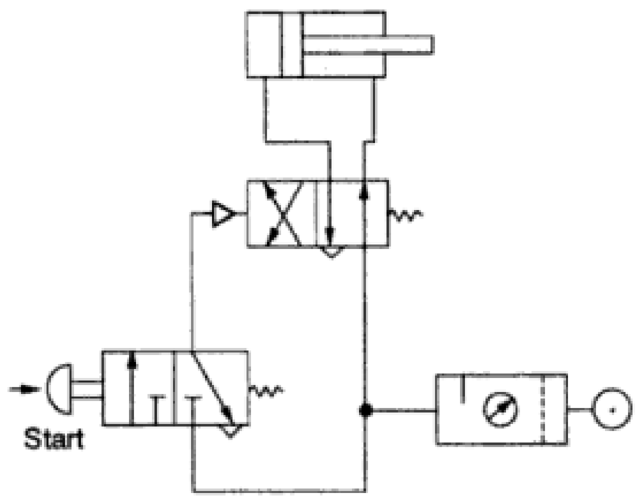
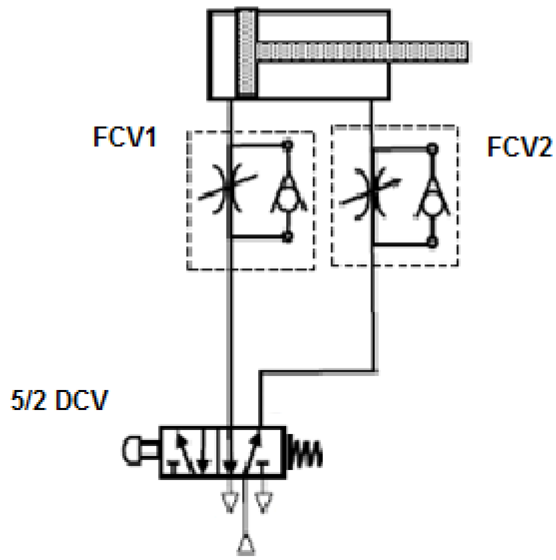


Figure 5.4 Indirect control of Double acting cylinder</td></tr>
<tr><td></td><td>b.</td><td>Explain with a suitable circuit, control of a double acting cylinder
Speed control of cylinders
It is always necessary to reduce the speed of cylinder from maximum speed based on selected size of final control valve to the nominal speed depending on the application. Speed control of Pneumatic Cylinders can be conveniently achieved by regulating the flow rate supply or exhaust air. The volume flow rate of air can be controlled by using flow control valves which can be either two way flow control valve or one way flow control valve. This is also known as a throttle valve or a flow restrictor.
There are two types of throttling circuits for double acting cylinders:
1. Supply air throttling
2. Exhaust air throttling
Supply air throttling</td></tr>
</table>

		This method of speed control of double acting cylinders is also called meter–in circuit (Figure 5.5 a). For supply air throttling, one way flow control valves are installed so that air entering the cylinder is throttled. The exhaust air can escape freely through the check valve of the throttle valve on the outlet side of the cylinder. There is no air cushion on the exhaust side of the cylinder piston with this throttling arrangement. As a result, considerable differences in stroking velocity may be obtained even with very small variations of load on the piston rod. Any load in the direction of operating motion will accelerate the piston above the set velocity. Therefore supply air throttling can be used for single acting and small volume cylinders.  Figure a) Supply Air throttling
OR		
10	a.	With a neat sketch, explain electro pneumatic control of double acting cylinder. A double acting cylinder can be controlled by using a single limit switch and a single solenoid valve as shown in figure 5.38. Figure 5.38a) gives the pneumatic circuit in which the limit switch is labeled 1-LS and the solenoid is labeled SOL A. this method of labeling is required since many systems require more than one limit switch or solenoid. Electrical circuit diagram in figure 5.38b) shows the use of one relay with a coil designated as 1-CR and two separate, normally open sets of contacts with a coil labeled 1-CR (NO). The limit switch is labeled 1-LS (NC), and also included are one normally closed and one normally open push button switch labeled STOP and START, respectively. This electrical diagram is called a "ladder diagram" Because of its resemblance to a ladder. The two vertical electric power supply lines are called "rungs".

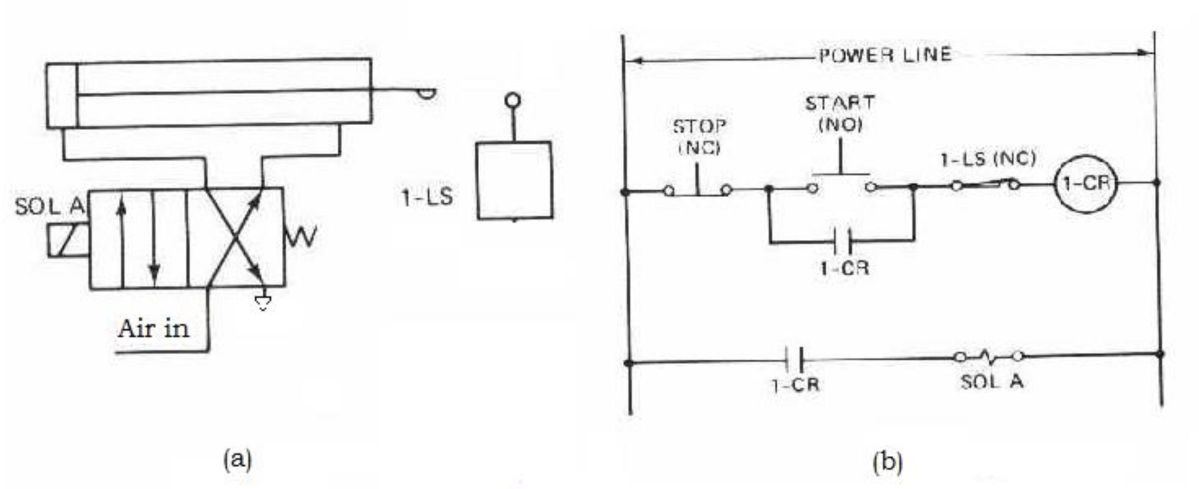


Figure 5.38 control of a double acting cylinder using single limit switch.

When the START button is momentarily pressed, the cylinder extends because coil 1-CR is energized, which closes both sets of contacts of 1-CR. Thus, the upper
1-CR set of contacts serves to keep coil 1-CR energized even though the START button is released. The lower set of contacts closes to energize solenoid A to extend the cylinder. When 1-LS is actuated by the piston rod cam, it opens to de-energize coil 1-CR. This re-opens the contacts of 1-CR to de-energize solenoid A. Thus, the valve returns to its spring-offset mode and the cylinder retracts. This closes the contacts of 1-LS, but coil 1-CR is not energized because the contacts of 1-CR and the START button have returned to their normally open position. The cylinder stops at the end of the retraction stroke, but the cycle is repeated each time the START button is momentarily pressed. When the STOP button is momentarily pressed, it will immediately stop the extension stroke and fully retract the cylinder.

b. Explain with neat sketch sketch coordinated sequence motion of two cylinders.

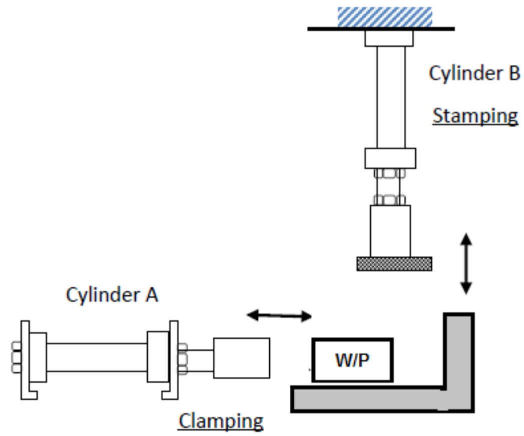
Cascading is a methodological approach to the problem of pneumatic circuit design. Cascading means “in series”. In this method the sequence of pneumatic cylinders is controlled by using various type of signalling elements. These signalling elements are of course driven by forward and backward strokes of cylinders but the air supply to pilot lines is delivered through a cascade system. A reversing valve can be used to eliminate signal conflicts.

In order to develop control circuitry for multi cylinder applications, it is necessary to draw the motion diagram to understand the sequence of actuation of various signal input switches-limit switches and sensors. Motion diagram represents status of cylinder position -whether extended or retracted in a particular step.

Step 1: Write the statement of the problem:

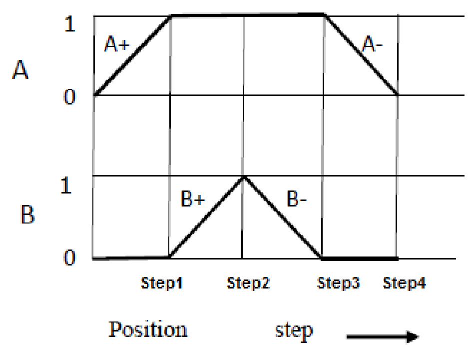
Let A be the first cylinder (clamping) and B be second cylinder (stamping) as shown in the Figure. First cylinder A extends and clamps the work piece under stamping station where cylinder B is located. Cylinder B then extends and stamps the job. Cylinder A can return back only after cylinder B has retracted fully.

Step 2: Draw the positional layout:



Positional diagram

Step3: Represent the control task using notational form:
Cylinder A advancing step is designated as A+
Cylinder A retracting step is designated as A-
Cylinder B advancing step is designated as B+
Cylinder B retracting step is designated as B-
Given sequence for clamping and stamping is A+B+B-A-
Step 4 Draw the Displacement –step diagram:



Displacement step diagram

Step 5 Draw the Displacement –time diagram:

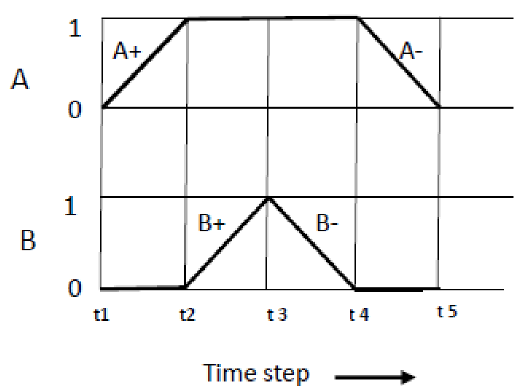
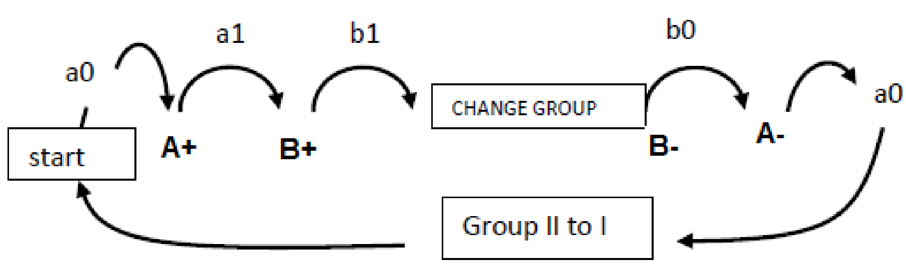


Figure 5.22 Displacement time diagram

Step 6: Analyse and Draw Pneumatic circuit:
Step 6.1 Analyse input and output signals:

Input Signals
Cylinder A - Limit switch at retracted position a0
 Limit switch at extended position a1
Cylinder B - Limit switch at retracted position b0
Limit switch at extended position b1
Output Signal
Forward motion of cylinder A (A+)
Return motion of cylinder A (A-)
Forward motion of cylinder B (B+)
Return motion of cylinder B (B+)
Step 6.2 Using the displacement time/step diagram link input signal and output signal:
Usually start signal is also required along with a0 signal for obtaining A+ motion.
1. A+ action generates sensor signal a1, which is used for B+ motion
2. B+ action generates sensor signal b1, which is used for group changing.
3. B- action generates sensor signal b0, which is used for A- motion
4. A- action generates sensor signal a0, which is used for group changing
Above information (given in figure 5.23) is shown below graphically.



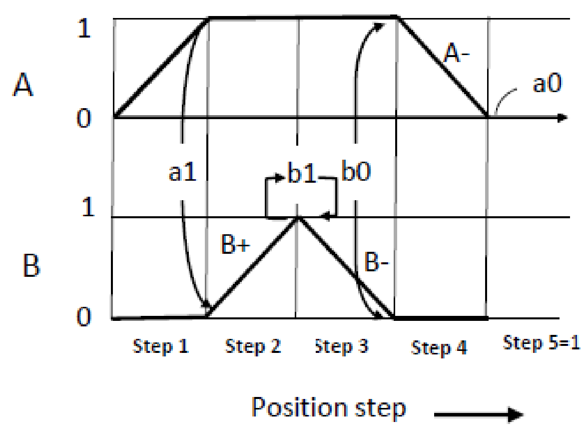


Figure 5.23 Displacement time diagram
Step 7 Draw the power circuit:
i) Divide the given circuits into groups. Grouping should be done such that there is no signal conflict. Do not put A+ and A- in the same group. Similarly B+ and B- should not be put in

the same group. In other word A+ and A- should belong to different group to avoid signal conflict.

In our example of A+ B+ B- A- we can group as

A+ B+   B- A-

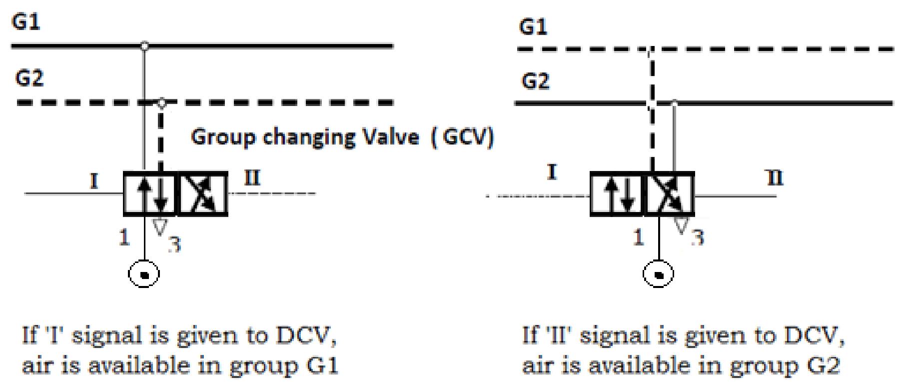
Group 1   Group 2

ii) Choose the number of group changing valve = No of groups - 1

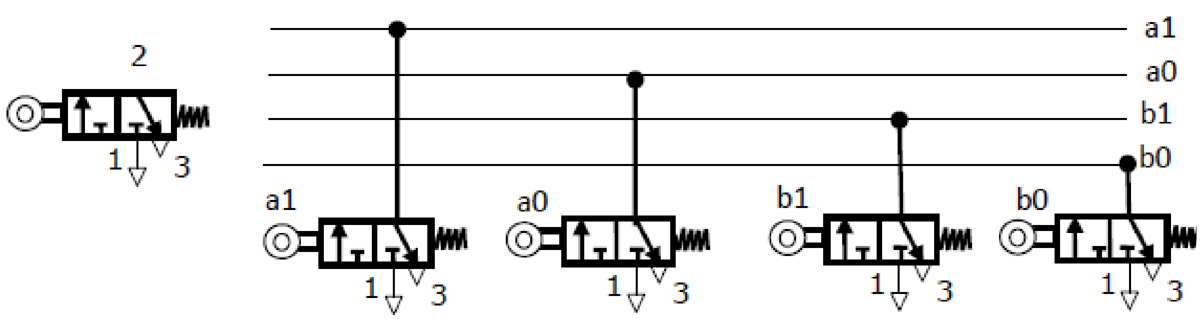
In our example, we have 2 groups so we need one group changing valve

Connect the group changing valve as follows. From the figure it is clear that when the control signals I and II are applied to group changing valve, the air (power) supply changes from Group 1(G1) to Group 2 (G2)

iii) Arrange the limit switch and start button as given below

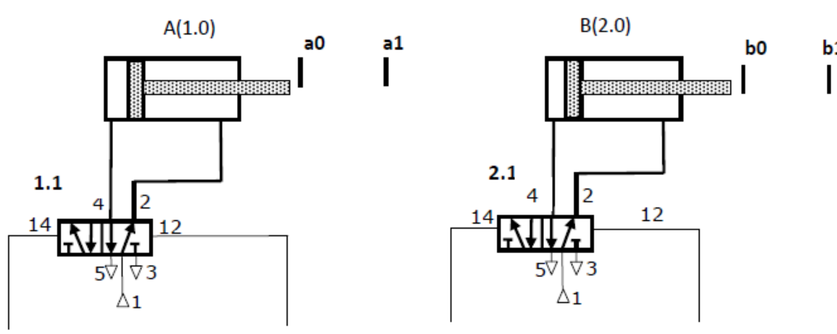


Connection of DCV to group changing valve



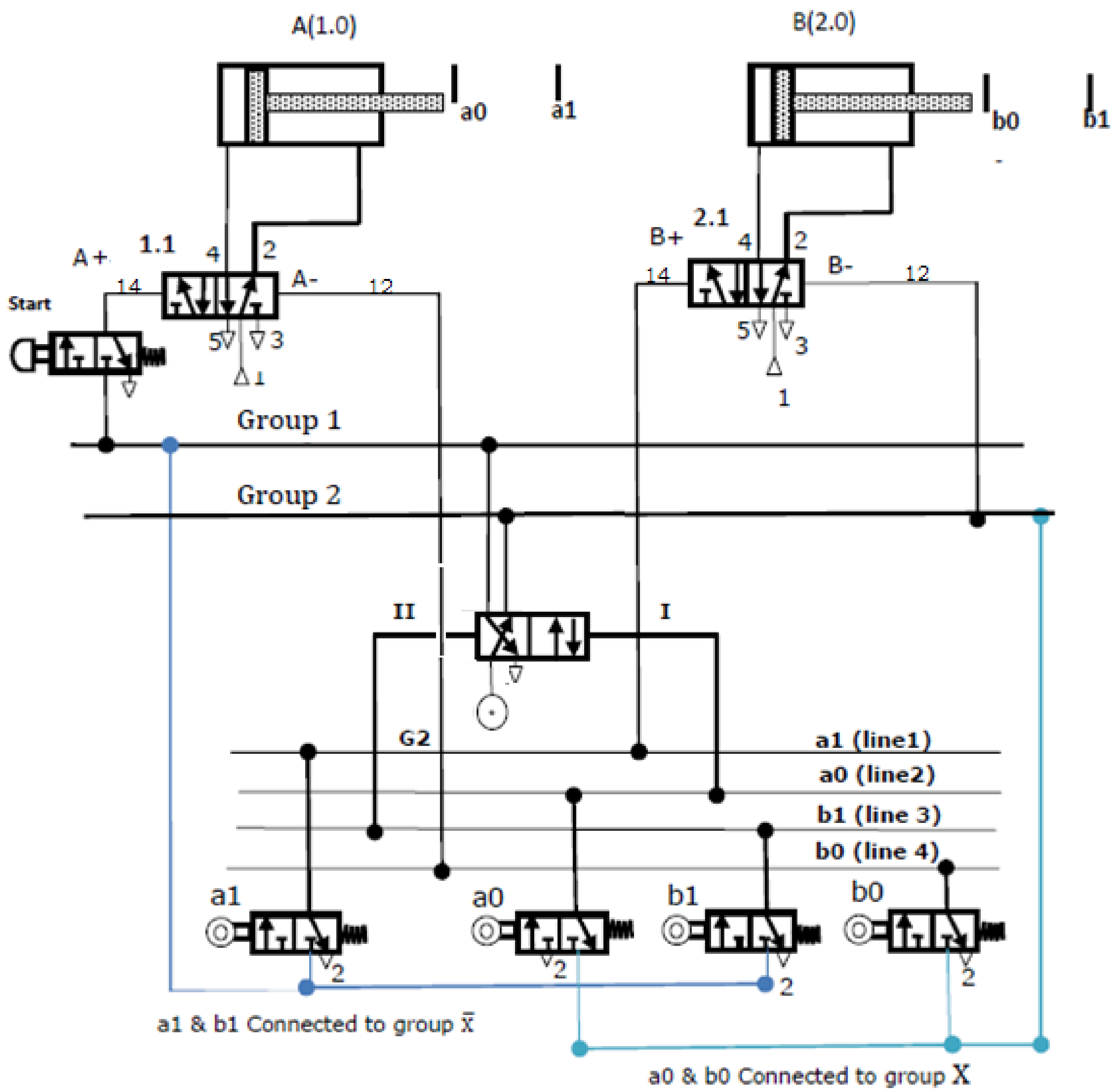
Connection of limit switches and start button

iv) Draw the power circuit:



Power circuit diagram

Step 8 Draw the control circuit:



Pneumatic circuits for A+ B+ B- A-

Step 9 Analysis of pneumatic circuit:

1. Assume that air is available in the line G2 to start with. (Say from previous operation)
2. When the start button is pressed, air supply from Group G2 is directed to line 2 through actuated limit switch a0. Now the air available in line 2 actuates the Group changing valve (GCV) to switch over to position I. This switching of the GCV causes air supply to change from G2 to G1.
3. Now the air is available in line G1. The air supply from group G1 is directed to port 14 of the valve 1.1. As there is no possibility of signal conflict here, valve 1.1 switches over causing the A+ action.
4. Sensor a1 is actuated as the result of A+ action, allowing the air supply from the Group G1 to reach to line 1 through a1. Now the air available reaches port 14 of valve 2.1. As there is no possibility of signal conflict here, valve 2.1 switches over, causing B+ action automatically.

		5. Sensor b1 is actuated as result of B+ action, allowing the air supply in line 3. Air from line 3 allows the air to reach port 12 of Group changing valve (also called reversing valve). As a result, the Group changing valve switches over, causing the group supply to change from G1 to G2. 6. Now the air is available in G2. Air from G2 acts on port 12 of the Valve 2.1. As there is no possibility of signal conflict here, valve 2.1 switches over, causing B- action automatically. 7. Sensor b0 is actuated as the result of B- action. Now the air is available in line 4.Air from line 4 reach port 12 of the valve 1.1. As there is no possibility of signal conflict here, valve 2.1 switches over, causing A- action automatically.