CBCS Scheme

15ME72

Seventh Semester B.E. Degree Examination, December 2018/January 2019

Fluid Power Systems (Model QP)

Time 3 hrs. Max Marks:80

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

		Module-1
1	a.	What are the desirable properties of hydraulic fluids explain any five? **(08 Marks)** The desirable properties of a hydraulic fluids are listed below: 1. Ideal viscosity. 2. Variation of viscosity with temperature (viscosity Index); must be minimal viscosity change with temperature change. 3. Good lubrication capability. 4. Good chemical stability. 5. High specific heat and thermal conductivity to dissipate heat. 6. Low compressibility. 7. Fire resistance property. 8. System compatibility. 9. Foam resistant properties. 10. Environmental Compatibility. Explanation of any five: 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. 8. Cleanliness in hydraulic systems has received considerable attention. Some hydraulic systems, such as aerospace hydraulic systems, are extremely sensitive to contamination.

b. Explain types of filtering methods and filters. **(08 Marks)**

According to the filtering methods:

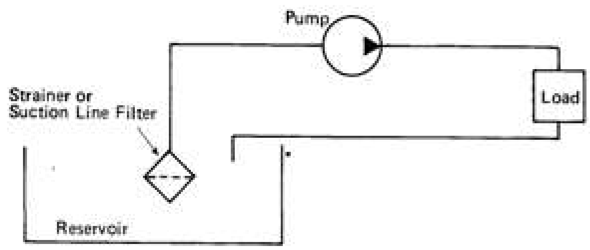
Mechanical filters: This type normally contains a metal or cloth screen or a series of metal disks separated by thin spacers. Mechanical filters are capable of removing only relatively coarse particles from the fluid.

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.

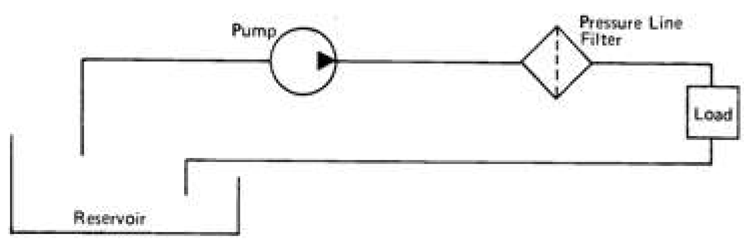
Adsorbent filters: Adsorption is a surface phenomenon and refers to the tendency of particles to cling to the surface of the filters. Thus, the capacity of such a filter depends on the amount of surface area available. Adsorbent materials used include activated clay and chemically treated paper.

According to the location of filters:

Intake or inline filters (suction strainers): These are provided first before the pump to protect the pump against contaminations in the oil as shown in Fig. These filters are designed to give a low pressure drop, otherwise the pump will not be able to draw the fluid from the tank. To achieve low pressure drop across the filters, a coarse mesh is used. These filters cannot filter out small particles.



Pressure line filters (high-pressure filters): These are placed immediately after the pump to protect valves and actuators and can be a finer and smaller mesh. They should be able to withstand the full system pressure. Most filters are pressure line filters.



Return line filters (low-pressure filters): These filters filter the oil returning from the pressure-relief valve or from the system, that is, the actuator to the tank. They are generally placed just before the tank. They may have a relatively high pressure drop and hence can be a fine mesh. These filters have to withstand low pressure only and also protect the tank and pump from contamination.

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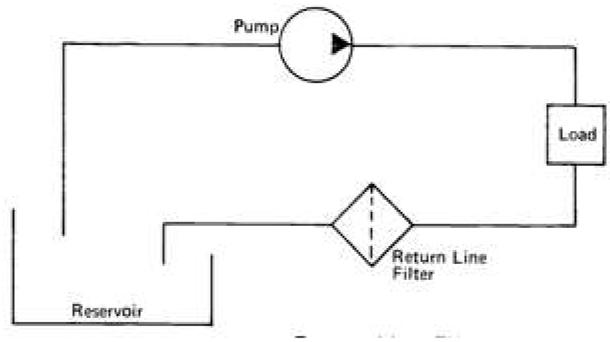
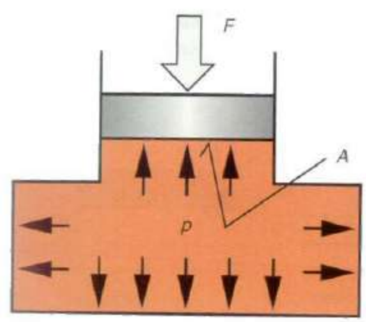
<tr><td></td><td></td><td>
</td></tr>
<tr><td colspan="3">OR</td></tr>
<tr><td>2</td><td>a.</td><td>State Pascal’s law. Explain Pascal’s law applied for hand operated jack. (08 Marks)
Pascal’s Law is the most fundamental principle in fluid power. It deals with hydrostatics, the transmission of force 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.
The principle of Pascal’s law was successfully applied by an English engineer, Mr. Joseph Bramah, to develop a hydraulic press in which by applying a small input force a large output force was generated.</td></tr>
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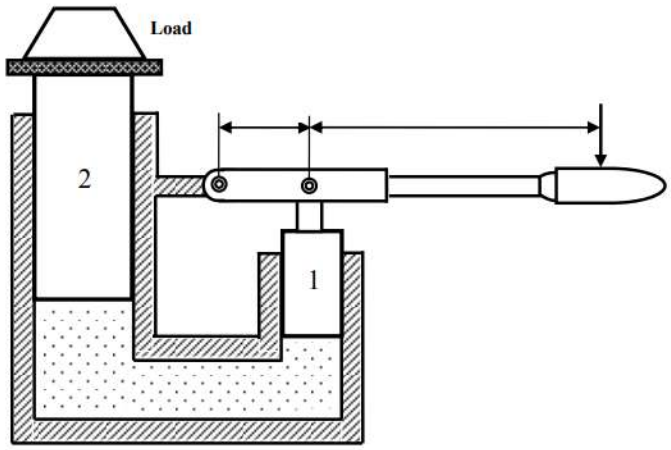
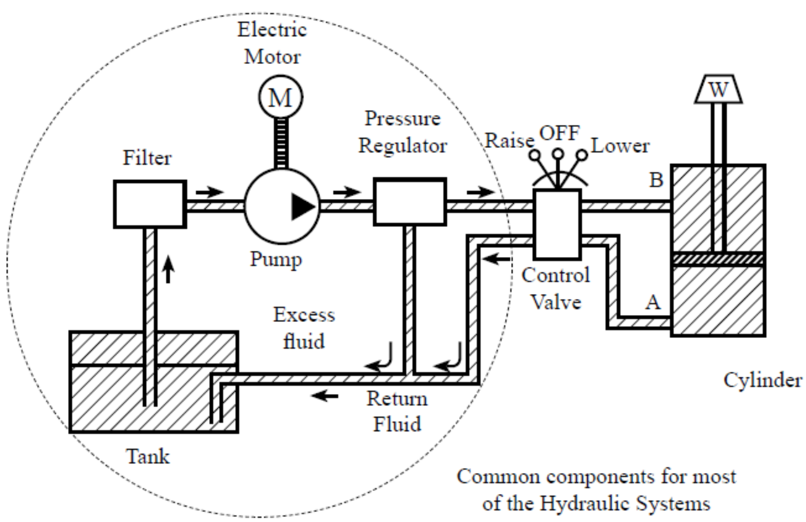


The above figure shows a hand operated hydraulic jack which works on the principles of Pascal's law.

b. Explain the basic structure of a hydraulic system. **(08 Marks)**

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.

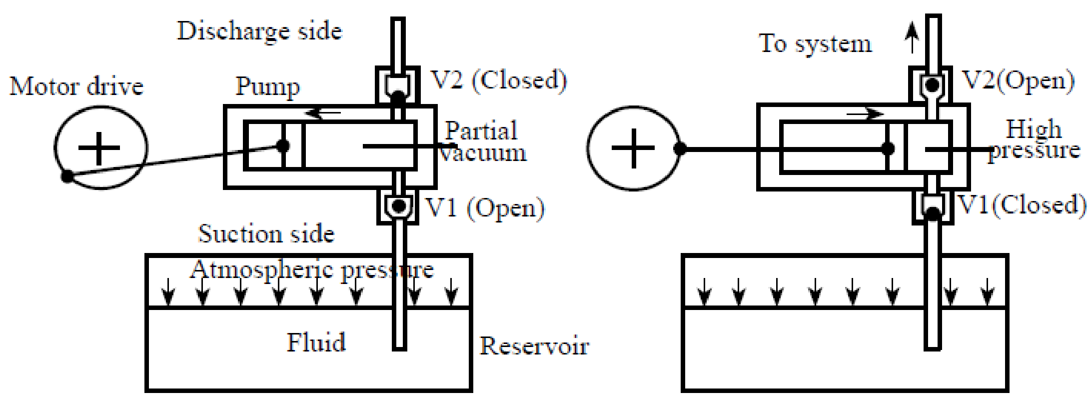


The hydraulic system requires a liquid fluid to operate; this is expensive and messy. The piping must act as a closed loop, with fluid transferred from a storage tank to one side of the cylinder, and returned from the other side of the cylinder to the tank.
Fluid is drawn from the tank by a pump which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

Module-2

3 a. Explain pumping theory and what are the factors considered for selecting hydraulic pump. **(8 Marks)**

A positive displacement hydraulic pump is a device used for converting mechanical energy into hydraulic energy. It is driven by a prime mover such as an electric motor. It basically performs two functions. First, it creates a partial vacuum at the pump inlet port. This vacuum enables atmospheric pressure to force the fluid from the reservoir into the pump. Second, the mechanical action of the pump traps this fluid within the pumping cavities transports it through the pump and forces it into the hydraulic system. It is important to note that pumps create flow not pressure. Pressure is created by the resistance to flow.



(a) Suction stroke (b) Return stroke

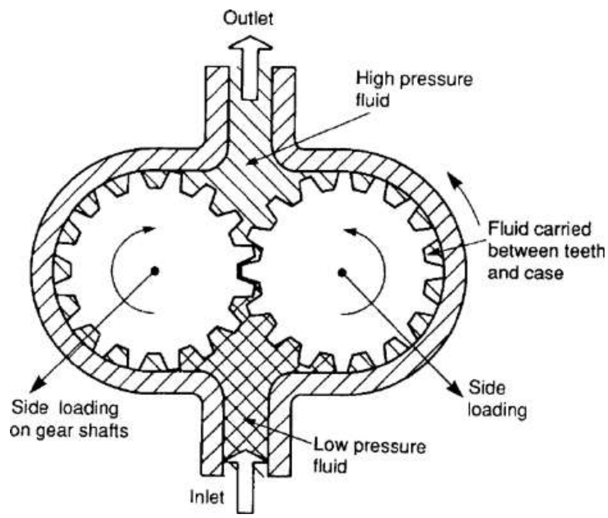
All pumps operate by creating a partial vacuum at the intake, and a mechanical force at the outlet that induces flow. This action can be best described by reference to a simple piston pump shown in Fig.

(a) As the piston moves to the left, a partial vacuum is created in the pump chamber that holds the outlet valve in place against its seat and induces flow from the reservoir that is at a higher (atmospheric) pressure. As this flow is produced, the inlet valve is temporarily displaced by the force of fluid, permitting the flow into the pump chamber (suction stroke).

(b) (b) When the piston moves to the right, the resistance at the valves causes an immediate increase in the pressure that forces the inlet valve against its seat and opens the outlet valve thereby permitting the fluid to flow into the system. If the

		outlet port opens directly to the atmosphere, the only pressure developed is the one required to open the outlet valve (delivery stroke). Pumps are selected by taking into account a number of considerations for a complete hydraulic system involving a particular application. The main parameters affecting the selection of a particular type of pump are as follows: 1. Maximum operating pressure. 2. Maximum delivery. 3. Type of control. 4. Pump drive speed. 5. Type of fluid. 6. Pump contamination tolerance. 7. Pump noise. 8. Size and weight of a pump. 9. Pump efficiency. 10. Cost. 11. Availability and interchangeability. 12. Maintenance and spares. The selection of pump typically entails the following sequence of operations: 1. Select the actuator (hydraulic cylinder or motor) that is appropriate based on the loads encountered. 2. Determine the flow-rate requirements. This involves the calculation of the flow rate necessary to drive the actuator to move the load through a specified distance within a given time limit. 3. Select the system pressure. This ties in with the actuator size and the magnitude of the resistive force produced by the external load on the system. Also involved here is the total amount of power to be delivered by the pump. 4. Determine the pump speed and select the prime mover. This, together with the flow-rate calculation, determines the pump size (volumetric displacement). 5. Select the pump type based on the application (gear, vane or piston pump and fixed or variable displacement). 6. Select the reservoir and associated plumbing, including piping, valving, hydraulic cylinders, and motors and other miscellaneous components. 7. Consider factors such as noise levels, horsepower loss, need for a heat exchanger due to generated heat, pump wear, and scheduled maintenance service to provide a desired life of the total system. 8. Calculate the overall cost of the system.
	b.	Explain external gear pump. **(04 Marks)** 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.



c. A gear pump has a 75mm outside diameter a 50mm inside diameter and a 25mm width. If the volumetric efficiency is 90% at rated pressure, what is the corresponding actual flow rate? The pump speed is 1000 rpm. **(04 Marks)**

Given Data:

External dia: D_o = 75 mm

Inside dia: D_i = 50 mm

Width of teeth: L= 25 mm

Efficiency: 0.9

Speed: 1000 rpm

Volumetric displacement is given by $V_D = \frac{\pi}{4}({D_o}^2 - {D_i}^2)\, L$

$$V_D = 61383.98\ mm^3$$

Theoretical flow rate is given by $Q_T = V_D \times N$

$$Q_T = 61383.98 \times 1000$$

$$Q_T = 613839800\ {mm^3}/{m}$$

Now, actual flow rate is given by $Q_A = \eta_V \times Q_T$

$$Q_A = 55245528\,{mm^3}/{m}$$

$$= 0.0553\ {m^3}/{m}$$

$$Q_A = 55.3\ Lpm$$

OR

4 a. Explain balanced vane motor. **(04 Marks)**

A rotary vane motor consists of circular chamber in which there is an eccentric rotor with sliding vanes in the slots provided on the rotor. The rotor is placed eccentrically with the housing. Fluid enters from the inlet port, rotates the rotor and thus torque is produced. The displacement of a vane hydraulic motor is a function of eccentricity. The radial load on the shaft bearing of an unbalanced vane motor is also large because all its inlet pressure is on one side of the rotor.

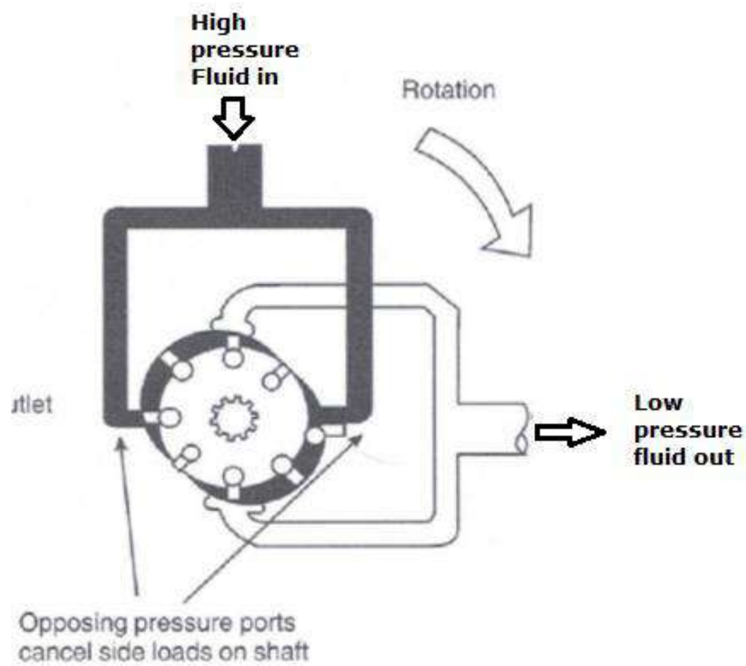


Figure: Balanced Vane motor

Figure shows the balanced vane motor. The radial bearing load problem is eliminated in this design by using a double-lobed ring with diametrically opposite ports. Side force on one side of bearing is canceled by an equal and opposite force from the diametrically opposite pressure port. The like ports are generally connected internally so that only one inlet and one outlet port are brought outside. The balanced vane-type motor is reliable open-loop control motor but has more internal leakage than piston-type.

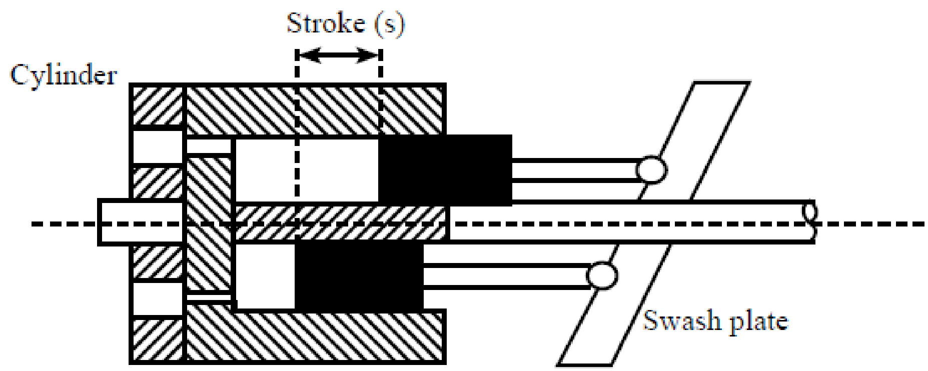
b. Explain swash plate type piston motor. (**4 Marks)**

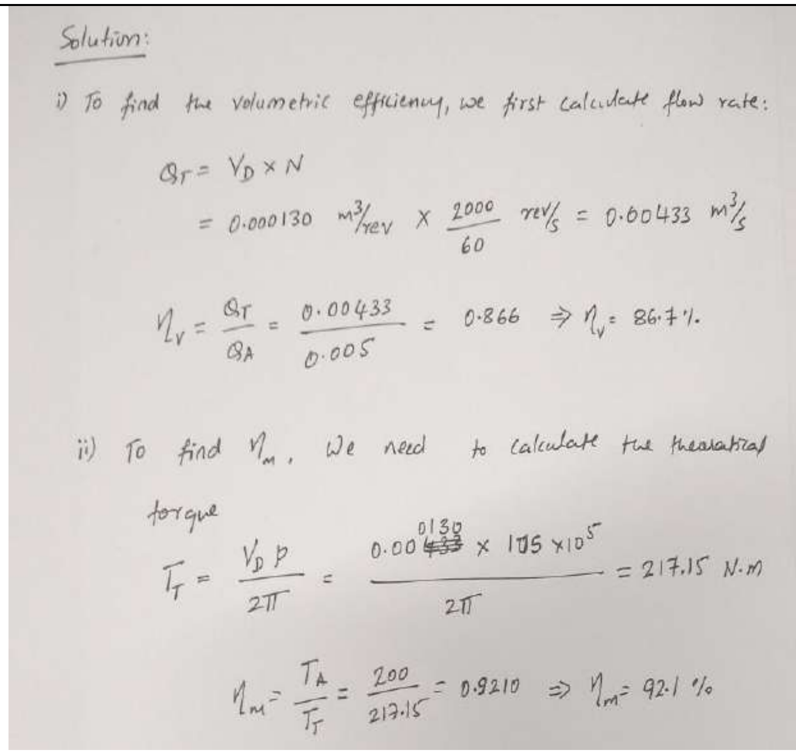
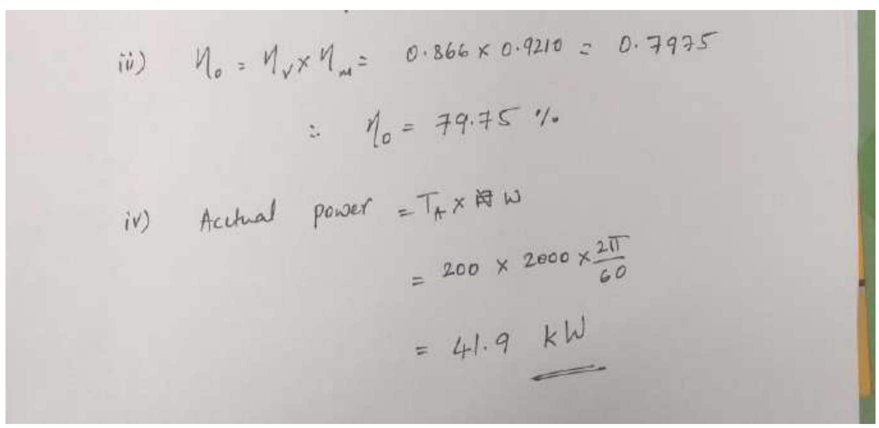
Piston motors are the most like their pump counterparts and incorporate only minor changes to effect the conversion. Piston motors are classified into the following types:

a) Axial piston motors.

b) Radial piston motors.

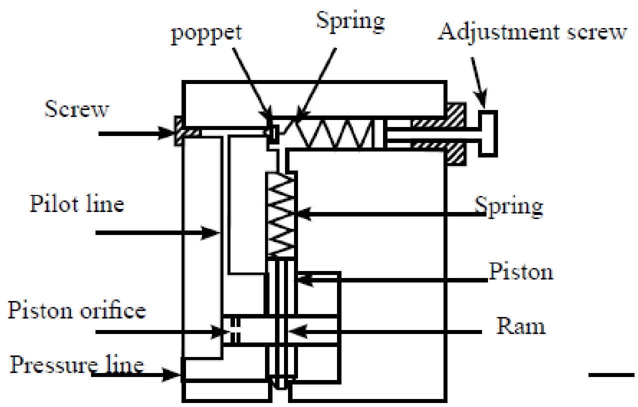
In axial piston motors, the piston reciprocates parallel to the axis of the cylinder block. These motors are available with both fixed-and variable-displacement feature types. They generate torque by pressure acting on the ends of pistons reciprocating inside a cylinder block. As shown in the figure, the inline design in which the motor, drive shaft and cylinder block are centered on the same axis. Pressure acting on the ends of the piston generates a force against

		an angled swash plate. This causes the cylinder block to rotate with a torque that is proportional to the area of the pistons. The torque is also a function of the swash plate angle. The inline piston motor is designed either as a fixed- or a variable-displacement unit. The swash plate determines the volumetric displacement. In variable-displacement units, the swash plate is mounted on the swinging yoke. The angle can be varied by various means such as a lever, hand wheel or servo control. If the offset angel is increased, the displacement and torque capacity increase but the speed of the drive shaft decreases. Conversely, reducing the angle reduces the torque capability but increases the drive shaft speed. 
	c	A hydraulic motor has a displacement of 130 cm3, operates with a pressure of 105 bar and has a speed of 2000 rpm. If the actual flow rate consumed by the motor is 0.005 m3/s and the actual torque delivered by the motor is 200 N-m, find i) Volumetric efficiency ii) Mechanical efficiency iii) Overall efficiency iv) Power developed by motor in kW. **(08 Marks)**

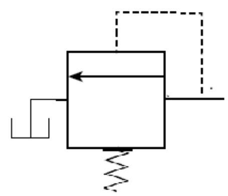
		 Solution: i) To find the volumetric efficiency, we first calculate flow rate: $Q_T = V_D \times N$ $= 0.000130 \ m^3/rev \times \frac{2000}{60} \ rev/s = 0.00433 \ m^3/s$ $\eta_v = \frac{Q_T}{Q_A} = \frac{0.00433}{0.005} = 0.866 \Rightarrow \eta_v = 86.7\%$. ii) To find η_m, We need to calculate the theoretical torque $T_T = \frac{V_D \, p}{2\pi} = \frac{0.000130 \times 105 \times 10^5}{2\pi} = 217.15 \ N.m$ $\eta_m = \frac{T_A}{T_T} = \frac{200}{217.15} = 0.9210 \Rightarrow \eta_m = 92.1\%$  iii) $\eta_o = \eta_v \times \eta_m = 0.866 \times 0.9210 = 0.7975$ $\therefore \eta_o = 79.75\%$. iv) Actual power $= T_A \times \omega$ $= 200 \times 2000 \times \frac{2\pi}{60}$ $= 41.9 \ kW$

Module-3

	a.	Explain pilot operated pressure control valve. **(06 Marks)** A pilot-operated pressure-relief valve consists of a small pilot relief valve and main relief valve as shown in Fig. It operates in a two-stage process: 1. The pilot relief valve opens when a preset maximum pressure is reached. 2. When the pilot relief valve opens, it makes the main relief valve open.



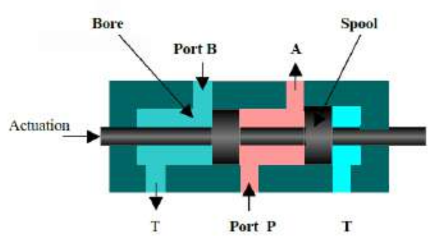
The pilot-operated pressure-relief valve has a pressure port that is connected to the pump line and the tank port is connected to the tank. The pilot relief valve is a poppet type. The main relief valve consists of a piston and a stem. The main relief piston has an orifice drilled through it. The piston has equal areas exposed to pressure on top and bottom and is in a balanced condition due to equal force acting on both the sides. It remains stationary in the closed position. The piston has a light bias spring to ensure that it stays closed. When the pressure is less than that of relief valve setting, the pump flow goes to the system. If the pressure in the system becomes high enough, it moves the pilot poppet off its seat. A small amount of flow begins to go through the pilot line back to the tank. Once flow begins through the piston orifice and pilot line, a pressure drop is induced across the piston due to the restriction of the piston orifice. This pressure drop then causes the piston and stem to lift off their seats and the flow goes directly from the pressure port to the tank.



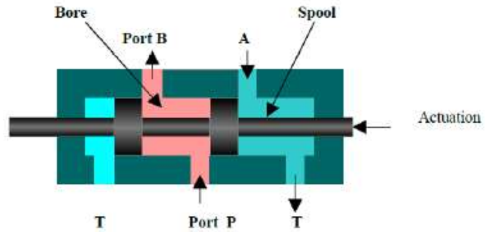
Graphic symbol of a pressure-relief valve is shown in fig. The symbol shows that the valve is normally closed.

b. Explain 4- way spool valve **(05 Marks)**

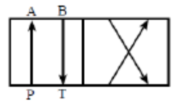
These valves are used to operate double acting cylinder. These valves are also called as impulse valve as 4/2 DCV has only two switching positions, i.e. it has no mid position. These valves are used to reciprocate or hold an actuating cylinder in one position. They are used on machines where fast reciprocation 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.



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



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



Graphical Symbol for 4-way valve

These valves are available with a choice of actuation, manual, mechanical, solenoid, pilot & pneumatic. Four-way valve comes with two or three position. One should note that the graphical symbol of the valve shows only one tank port even though the physical design may have two as it is only concerned with the function.

c. Explain needle flow control valve. **(05 Marks)**

The needle valve is quite commonly used valve. It is also termed as plug valve. Schematic of Needle or plug valve is shown in Figure. This valve has a conical disc which can be adjusted in vertical direction by setting flow adjustment screw. The adjustment of needle alters the orifice size between plug and valve seat. Thus the adjustment of plug controls the fluid flow in the pipeline. The characteristics of these valves can be accurately predetermined by machining the taper of the plug. The typical example of needle valve is stopcock that is used in laboratory glassware. The valve body is made of glass or Teflon. The plug can be made of plastic or glass. Special glass stopcocks are made for vacuum applications.

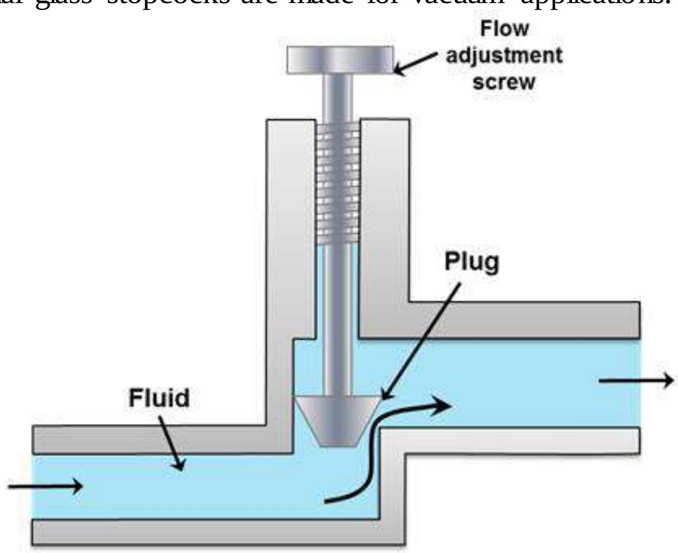
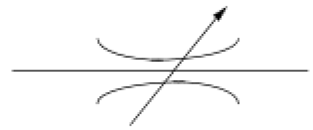


Fig: Needle or plug valve



Graphical symbol for Flow control valve

OR

6 a. Explain regenerative circuit. **6 Marks**

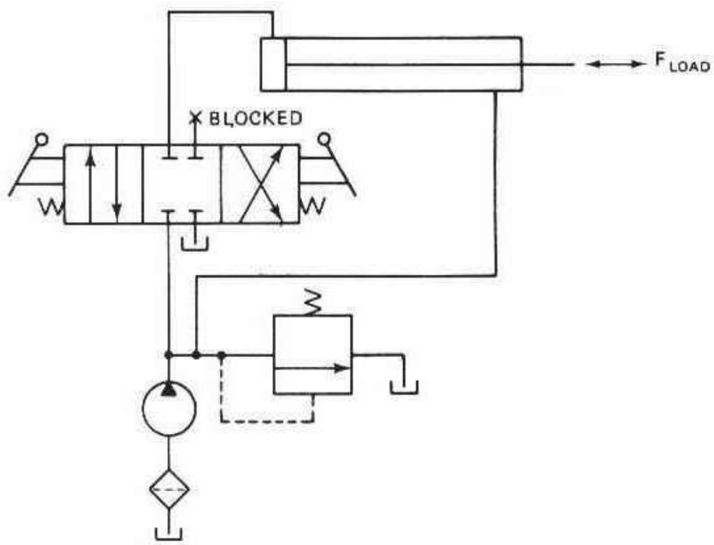


Figure shows a regenerative circuit that is used to speed up the extending speed of a double-acting cylinder. The pipelines to both ends of the hydraulic cylinder are connected in parallel and one of the ports of the 4/3 valve is blocked by simply screwing a thread plug into the port opening. During 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

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

$$Q_P = A_r V_{ext}$$

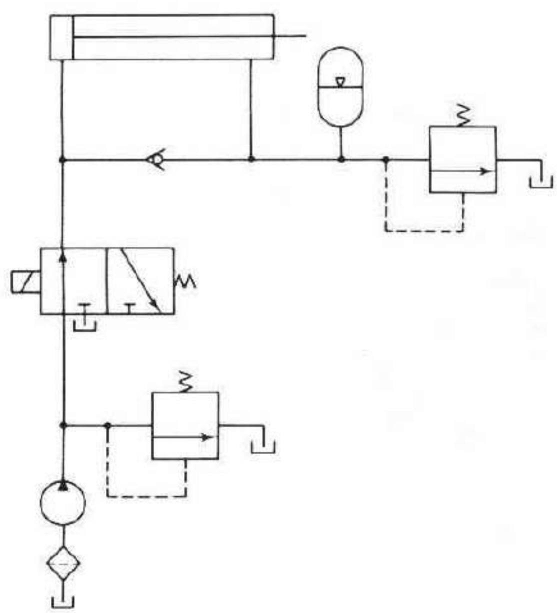
The extending speed of the piston is given as

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

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.

b. Explain hydraulic circuit with accumulator for any one application. **(08 Marks)**

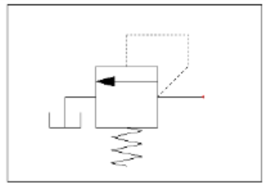
In some hydraulic system, safety dictates that a cylinder be retracted even though the normal supply of oil pressure is lost due to a pump or electrical power failure. Such an application requires the use of an accumulator as an emergency power source. Figure shows such a application in which a solenoid actuated three way valve is used in conjunction with an accumulator. When the three way valve is energized, oil flows to the blank end of the cylinder and also through the check valve into the accumulator and rod end of the cylinder. The accumulator charges as the cylinder extends. If the pump fails due to an electrical failure, the solenoid will de-energize, shifting the valve to the spring - offset position. Then the oil stored under pressure is forced from the accumulator to the rod end of the cylinder. This retracts the cylinder to the starting position. In normal working, when the solenoid is de-energized, the valve shifts to the spring offset position. In this position the accumulator will retract the cylinder.



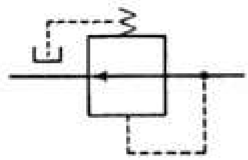
Accumulator as an emergency power source

c. Write symbols for, **(05 Marks)**

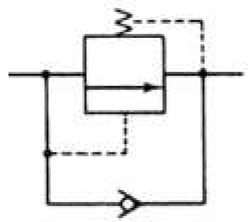
i) Pressure relief valve



ii) Pressure reducing valve



iii) Counter balance valve



Module-4

7	a.	What are the advantages of pneumatic systems? **(05 Marks)**

Pneumatic control systems are widely used in our society, especially in the industrial sectors for the driving of automatic machines. The main advantages of pneumatic systems are

1. **High effectiveness**

Many factories have equipped their production lines with compressed air supplies and movable compressors. There is an unlimited supply of air in our atmosphere to produce compressed air. Moreover, the use of compressed air is not restricted by distance, as it can easily be transported through pipes. After use, compressed air can be released directly into the atmosphere without the need of processing.

2. **High durability and reliability**

Pneumatic components are extremely durable and cannot be damaged easily. Compared to electromotive components, pneumatic components are more durable and reliable.

3. **Simple design**

The designs of pneumatic components are relatively simple. They are thus more suitable for use in simple automatic control systems.

4. **High adaptability to harsh environment**

Compared to the elements of other systems, compressed air is less affected by high temperature, dust, corrosion, etc.

5. **Safety**

Pneumatic systems are safer than electromotive systems because they can work in inflammable environment without causing fire or explosion.

6. **Easy selection of speed and pressure**

The speeds of rectilinear and oscillating movement of pneumatic systems are easy to adjust and subject to few limitations. The pressure and the volume of air can easily be adjusted by a pressure regulator.

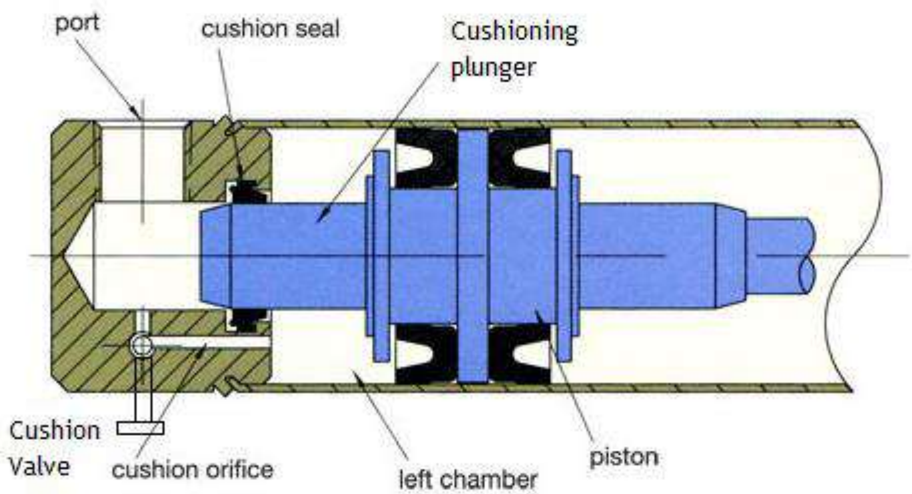
7. **Environmental friendly**

The operation of pneumatic systems does not produce pollution. The air released is also processed in special ways. Therefore, pneumatic systems can work in environments that demand high level of cleanliness. One example is the production lines of integrated circuits.

8. **Economical**

As pneumatic components are not expensive, the costs of pneumatic systems are quite low. Moreover, as pneumatic systems are very durable, the cost of repair is significantly lower than that of other systems.

b. Explain cylinder air cushioning. **(05 Marks)**



Double acting cylinders generally contain cylinder cushions at the end of the cylinder to slow down the movement of the piston near the end of the stroke. Figure shows the construction of actuating cylinder with end cushions. Cushioning arrangement avoids the damage due to the impact occurred when a fast moving piston is stopped by the end caps. Deceleration of the piston starts when the tapered plunger enters the opening in the cap and closes the main fluid exit. This restricts the exhaust flow from the barrel to the port. This throttling causes the initial speed reduction. During the last portion of the stroke the oil has to exhaust through an adjustable opening since main fluid exit closes. Thus the remaining fluid exists through the cushioning valve. Amount of cushioning can be adjusted by means of cushion screw. A check valve can be provided to achieve fast break away from the end position during retraction motion. A bleed screw is built into the check valve to remove the air bubbles present in a hydraulic type system.

c. Explain supply air throttling and exhaust air throttling. **(06 Marks)**

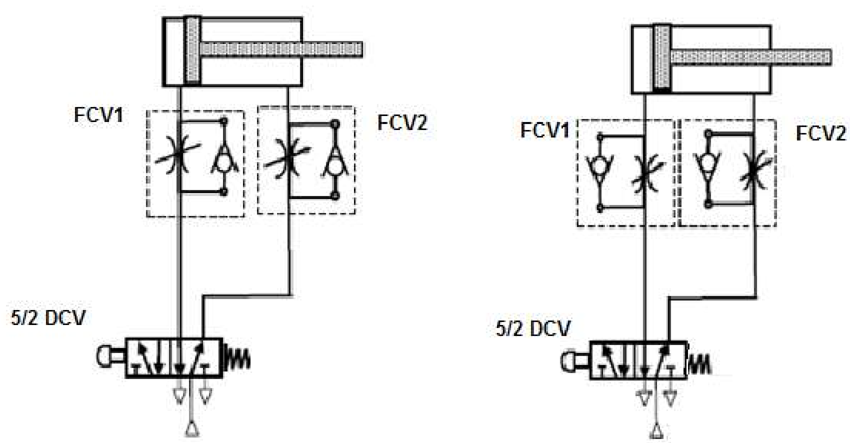
It is always necessary to reduce the speed of cylinder from maximum speed based on selected size of final control valve to the nominal speed depending on the application. Speed control of Pneumatic Cylinders can be conveniently achieved by regulating the flow rate supply or exhaust air. The volume flow 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

1. Supply air throttling

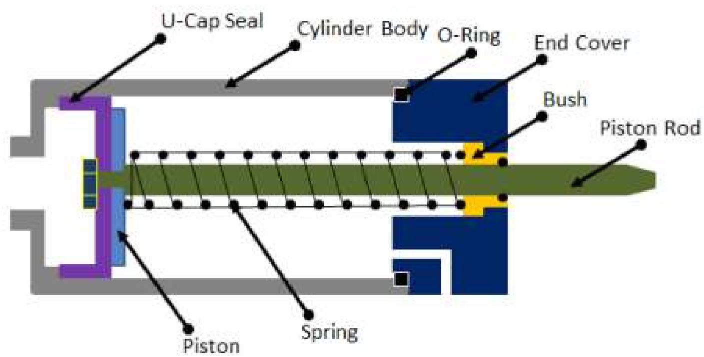
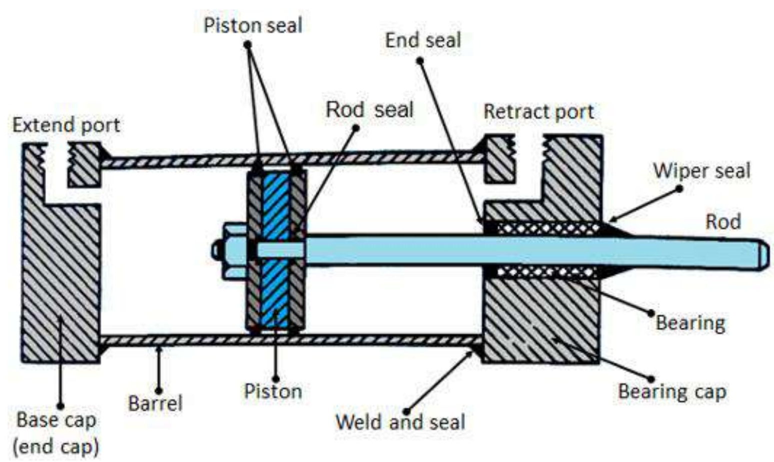
This method of speed control of double acting cylinders is also called meter–in circuit. For supply air throttling, one way flow control valves are installed so that air entering the cylinder is throttled. The exhaust air can escape freely through the check valve of the throttle valve on the outlet side 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.



a) Supply Air throttling b) Exhaust air throttling

2. Exhaust air throttling

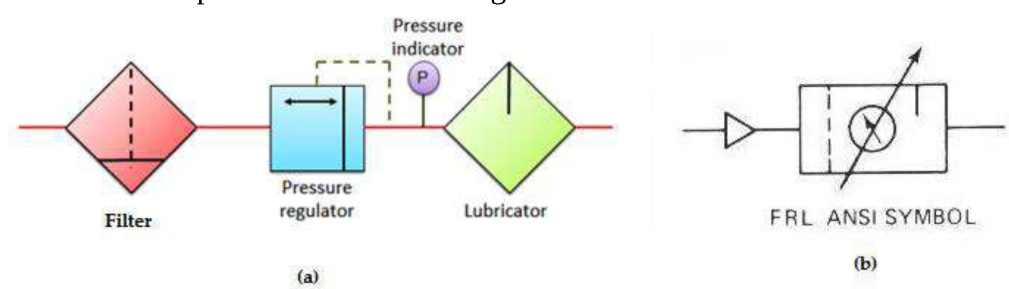
In exhaust air throttling flow control valves are installed between the cylinder and the main valve in such a way that the exhaust air leaving the cylinder is throttled in both directions of the motion of the cylinder (figure 5.5 b). This method of speed control of double acting cylinders is also called meter-out circuit. The supply air can pass freely through the corresponding check valves in each case. In this case, the piston is loaded between two cushions of air while the cylinder is in motion and hence a smooth motion of the cylinder

		can be obtained. The first cushion effect is due to supply air entering the cylinder through check valve, and second cushion effect is due to the exhaust air leaving the cylinder through the throttle valve at a slower rate. Therefore, exhaust air throttling is practically used for the speed control of double acting cylinders.
OR		
8	a.	Explain the construction of single acting and double acting cylinders. **(06 Marks)** Single acting cylinders produce work in one direction of motion hence they are named as single acting cylinders. Figure below shows the construction of a single acting cylinder. The compressed air pushes the piston located in the cylindrical barrel causing the desired motion. The return stroke takes place by the action of a spring. Generally the spring is provided on the rod side of the cylinder.  **Fig. Single acting cylinder** The main parts of a hydraulic double acting cylinder are: piston, piston rod, cylinder tube, and end caps. These are shown in Figure The piston rod is connected to piston head and the other end extends out of the cylinder. The piston divides the cylinder into two chambers namely the rod end side and piston end side. The seals prevent the leakage of oil between these two chambers. The cylindrical tube is fitted with end caps.  **Fig. Double acting cylinder**

The pressurized oil, air enters the cylinder chamber through the ports provided. In the rod end cover plate, a wiper seal is provided to prevent the leakage of oil and entry of the contaminants into the cylinder. The combination of wiper seal, bearing and sealing ring is called as cartridge assembly. The end caps may be attached to the tube by threaded connection, welded connection or tie rod connection. The piston seal prevents metal to metal contact and wear of piston head and the tube. These seals are replaceable. End cushioning is also provided to prevent the impact with end caps.

b. Explain FRL circuits.

During the preparation of compressed air, various processes such as filtration, regulation and lubrication are carried out by individual components. Preparatory functions can be combined into one unit which is called as ‘service unit’ or FRL unit. Several manufacturers supply a filter, regulator, and lubricator assembled in one housing. The complete and abbreviated symbols for this component are shown in Fig. below.



c. Explain characteristics of compressed air.

Availability	Air is available practically everywhere in unlimited quantities.
Transport	Air can be easily transported in pipelines, even over large distances.
Storage	Compressed air can be stored in a reservoir and removed as required. In addition, the reservoir can be transportable.
Temperature	Compressed air is relatively insensitive to temperature fluctuations. This ensures reliable operation, even under extreme conditions.
Explosion proof	Compressed air offers no risk of explosion or fire.
Cleanliness	Unlubricated exhaust air is clean. Any unlubricated air which escapes through leaking pipes or components does not cause contamination.
Components	The operating components are of simple construction and therefore relatively inexpensive.
Speed	Compressed air is a very fast working medium. This enables high working speeds to be attained.
Overload safe	Pneumatic tools and operating components can be loaded to the point of stopping and are therefore overload safe.

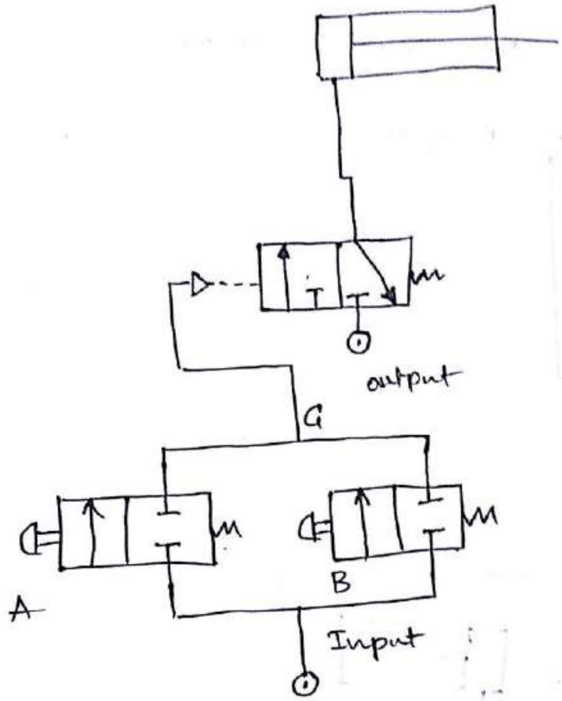
Module-5

9 a. Explain following functions generated in pneumatic systems.

i) OR gate ii) AND gate iii) NOT gate

		OR logic function using 2/2 valve.

i) OR logic function using 2/2 DCV



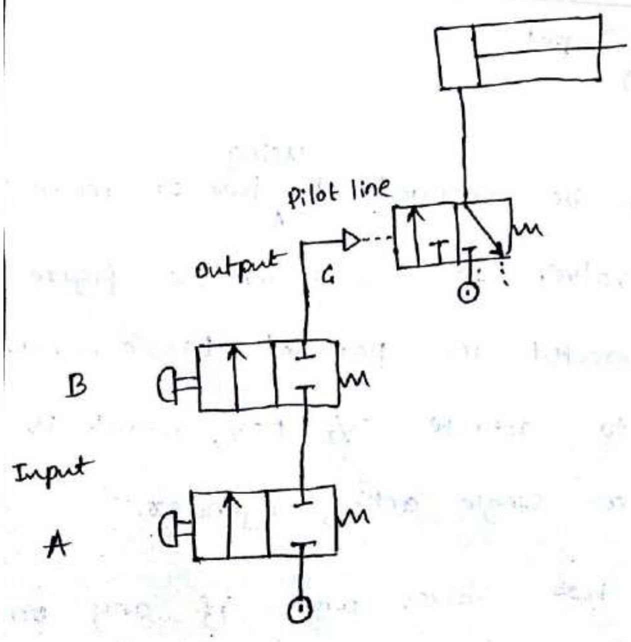
OR function can be generated using two or more 2/2 Direction control valve. As shown in the figure two 2/2 DCV are connected in parallel to generate a pilot signal to actuate 3/2 DCV, which is used to control a single acting cylinder.

A & B are two Valves and if any one is ~~actted~~ actuated will produce an output C, OR logic function can also be generated using ~~ones~~ two 3-way, 2-position ~~pilot line~~, spring return DCV in conjuction with ~~two~~ one shuttle valve.

Truth table for OR gate.

Input		output
A	B	C
0	0	0
0	1	1
1	0	1
1	1	1

ii) AND Gate:



AND logic can be designed using two 2/2 DCV as shown in the figure above. If both the valves are actuated simultaneously, there is an output generated to actuate the 3/2 DCV which is connected to a hydraulic cylinder to perform works. If one valve (either A or B) is actuated there will be no output produced.

AND logic can also be generated using twin pressure valve.

Truth table for AND logic gate

Input		output
A	B	C
0	0	0
0	1	0
1	0	0
1	1	1

b. 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.

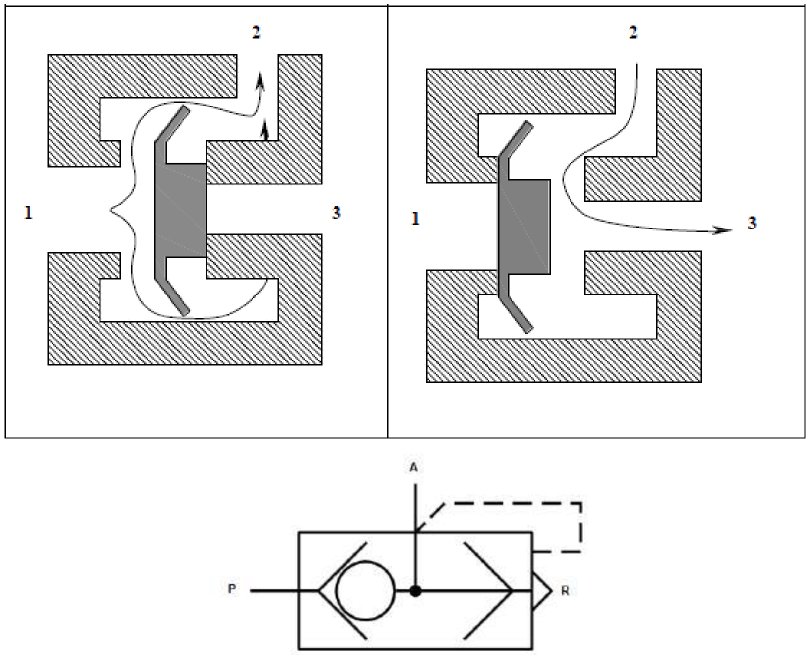


Figure Working of quick exhaust valve and graphical symbol

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

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”.

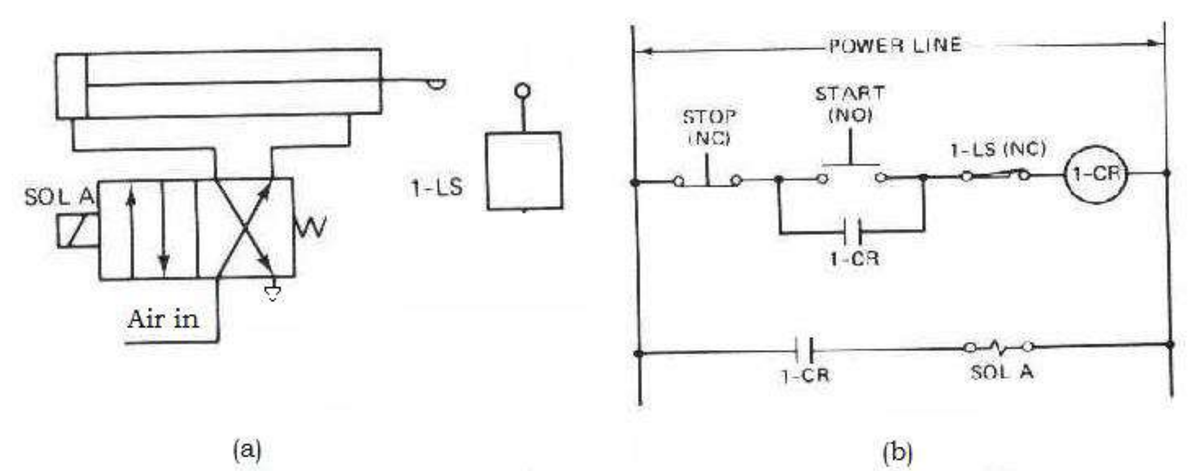


Figure 5.38 control of a double acting cylinder using single limit switch.

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.

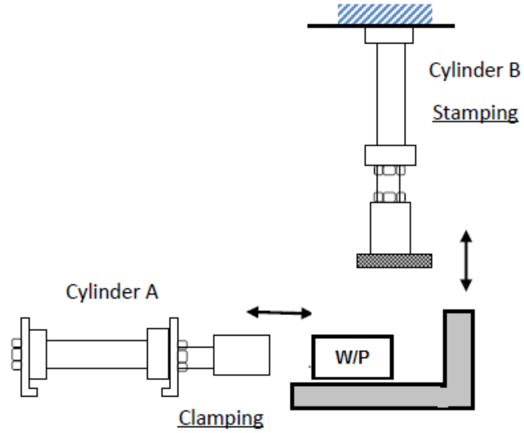
Cascading is a methodological approach to the problem of pneumatic circuit design. Cascading means "in series". In this method the sequence of pneumatic cylinders is controlled by using various type of signalling elements. These signalling elements are of course driven by forward and backward strokes 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+

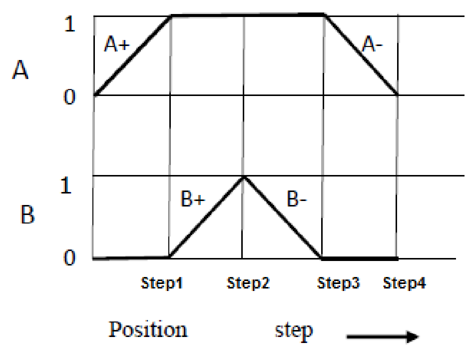
Cylinder A retracting step is designated as A-

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:

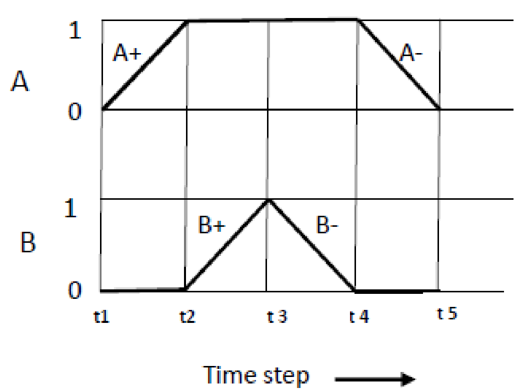
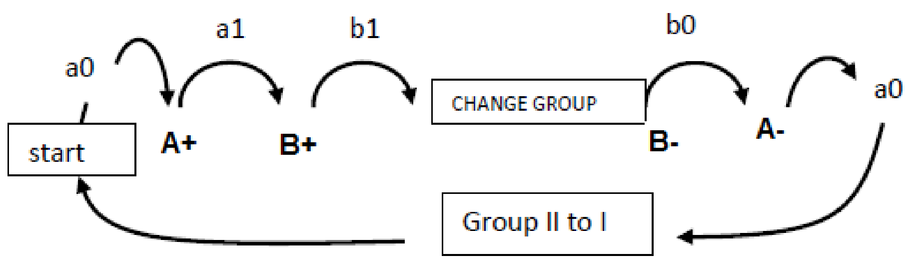


Figure 5.22 Displacement time diagram

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.



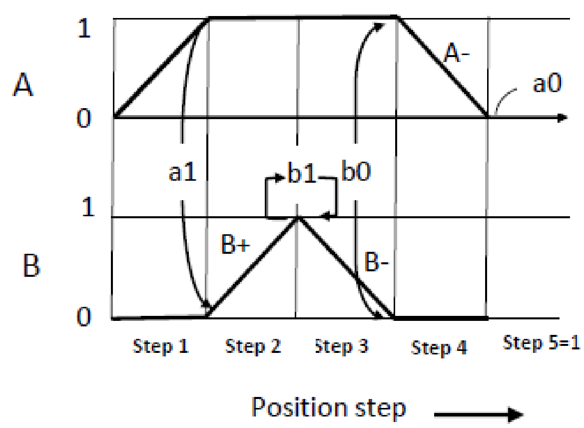


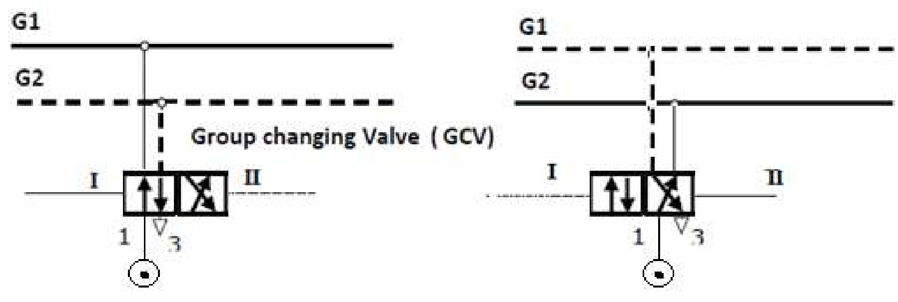
Figure 5.23 Displacement time diagram
Step 7 Draw the power circuit:
i) Divide the given circuits into groups. Grouping should be done such that there is no signal conflict. Do not put A+ and A- in the same group. Similarly B+ and B- should not be put in

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-

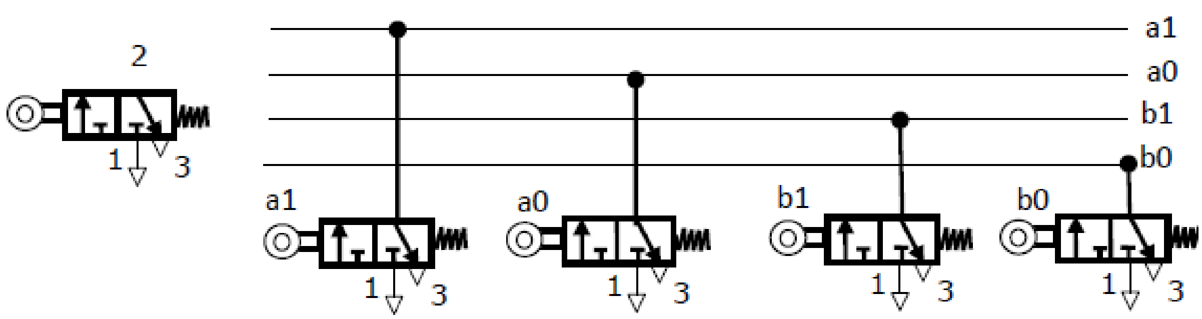
Group 1   Group 2

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



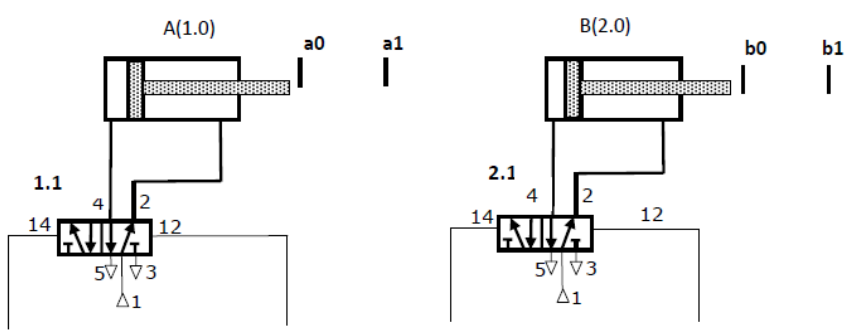
If 'I' signal is given to DCV, air is available in group G1   If 'II' signal is given to DCV, air is available in group G2

Connection of DCV to group changing valve



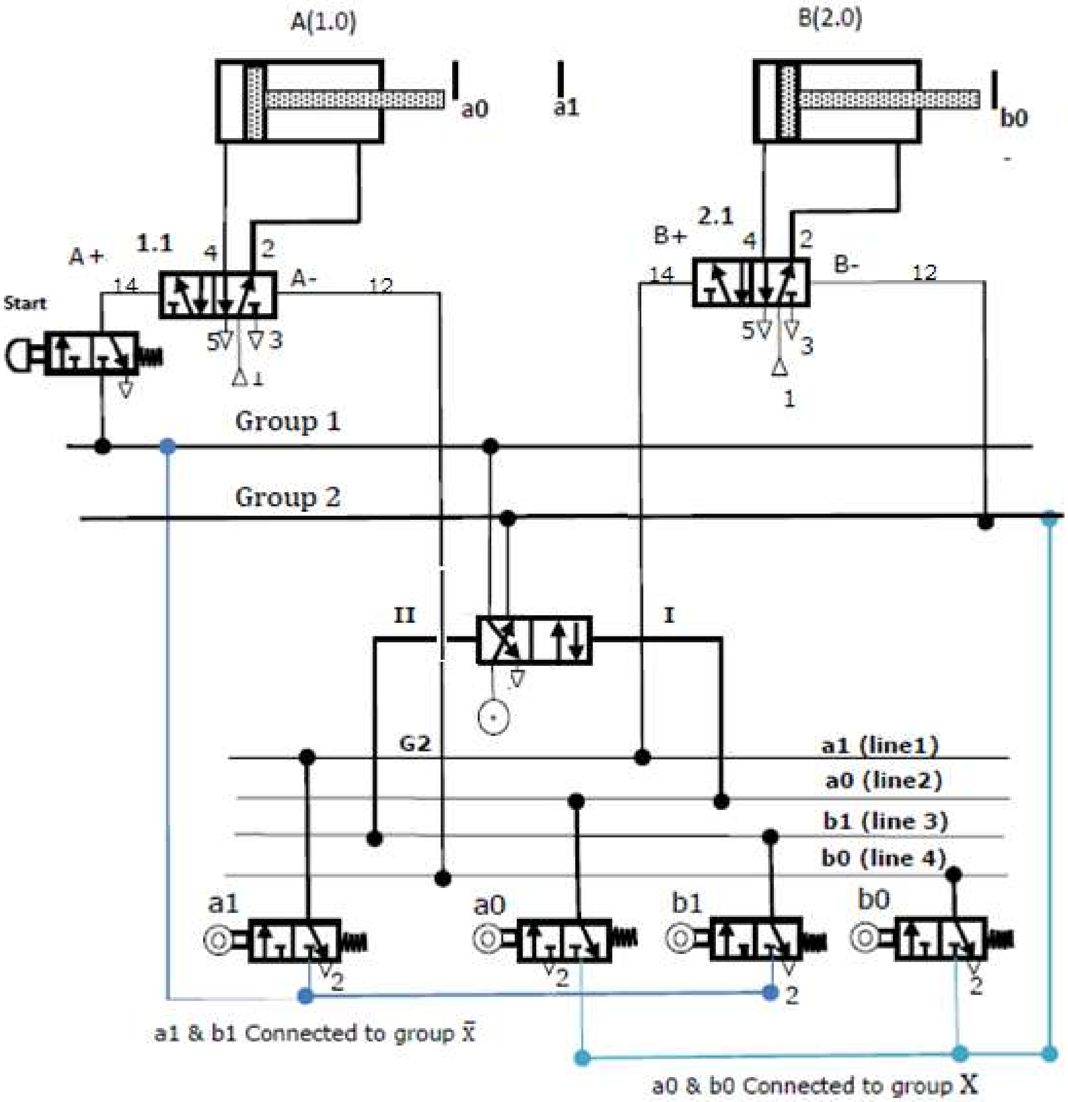
Connection of limit switches and start button

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.