CBCS SCHEME

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18ME55

Fifth Semester B.E. Degree Examination, Feb./Mar. 2022
Fluid Power Engineering

Time: 3 hrs. Max. Marks: 100

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

Module-1

1 a. Define fluid power system. Sketch and explain the structure of a hydraulic control system. **(08 Marks)**

b. State Pascal's law and explain its applications. **(06 Marks)**

c. A force of 500 N is applied on a plunger of 5 cm diameter of a hydraulic press that moves the piston through a distance of 20 cm. What is the maximum weight of the load that can be placed on the ram and what will be the displacement of the ram, if the diameter of the ram is 40 cm. **(06 Marks)**

OR

2 a. What are the desirable properties of hydraulic fluids? Explain them. **(08 Marks)**

b. Define a seal. Explain in brief, how hydraulic seals are classified. **(08 Marks)**

c. What are the methods to control contamination in a system? **(04 Marks)**

Module-2

3 a. Explain the working principle of an external gear pump. **(05 Marks)**

b. What are the factors considered for selecting a hydraulic pump and explain the pumping theory of positive displacement pumps? **(09 Marks)**

c. A vane pump has its rotor and cam ring diameters of 60 mm and 80 mm respectively. If the volumetric displacement is 90 cm^3/rev and the width of the vane is 3 cm, what is eccentricity? What is the maximum displacement possible? **(06 Marks)**

OR

4 a. Explain the following with neat sketches:
(i) Single-acting cylinder
(ii) Telescopic cylinder **(08 Marks)**

b. What is a hydraulic motor? What are the four broad basis of classification of hydraulic motors? **(05 Marks)**

c. A hydraulic motor has a volumetric displacement of 123 cm^3 operating at a pressure of 60 bar and speed 180 rpm. If the actual flow rate consumed by the motor is 0.004 m^3/sec and actual torque delivered by motor is 100 Nm, find:
(i) Volumetric efficiency (ii) Mechanical efficiency (iii) Overall efficiency. **(07 Marks)**

Module-3

5 a. Explain with a neat sketch, the principle of working of a pilot operated pressure relief valve. Draw the graphical symbol of the valve. **(07 Marks)**

b. With a neat sketch, explain the working of a check valve. **(06 Marks)**

c. Define control valves. Explain the classification of control valves. **(07 Marks)**

OR

6 a. Explain the following with neat sketches:
(i) Sliding spool flow control valve
(ii) Needle flow control valve **(04 Marks)**

b. Explain the concept of meter-in and meter-out circuits. List the advantages and limitations of each of the circuit. **(10 Marks)**

c. What is a regenerative circuit? Sketch schematically regenerative circuit to increase the regenerative speed of the cylinder. **(06 Marks)**

Module-4

7 a. What are the advantages, disadvantages and applications of pneumatic system? **(07 Marks)**

b. Explain the characteristics of compressed air. **(04 Marks)**

c. Explain the construction and working of single and double acting cylinder. **(09 Marks)**

OR

8 a. Briefly explain cylinder cushioning. **(08 Marks)**

b. Explain with a suitable circuit diagram, Quick Exhaust Valve. **(06 Marks)**

c. Explain with a neat sketch, the construction of poppet valves. **(06 Marks)**

Module-5

9 a. Explain the following functions generated in pneumatic systems:
(i) OR gate
(ii) AND gate
(iii) NOT gate **(12 Marks)**

b. Explain direct and indirect actuation of pneumatic cylinders. **(08 Marks)**

OR

10 a. Write short notes on the following:
(i) Solenoid
(ii) Electromagnetic Relay **(08 Marks)**

b. What are the advantages of cascade design? **(03 Marks)**

c. Explain with a neat sketch, coordinated sequence motion of two cylinders. **(09 Marks)**

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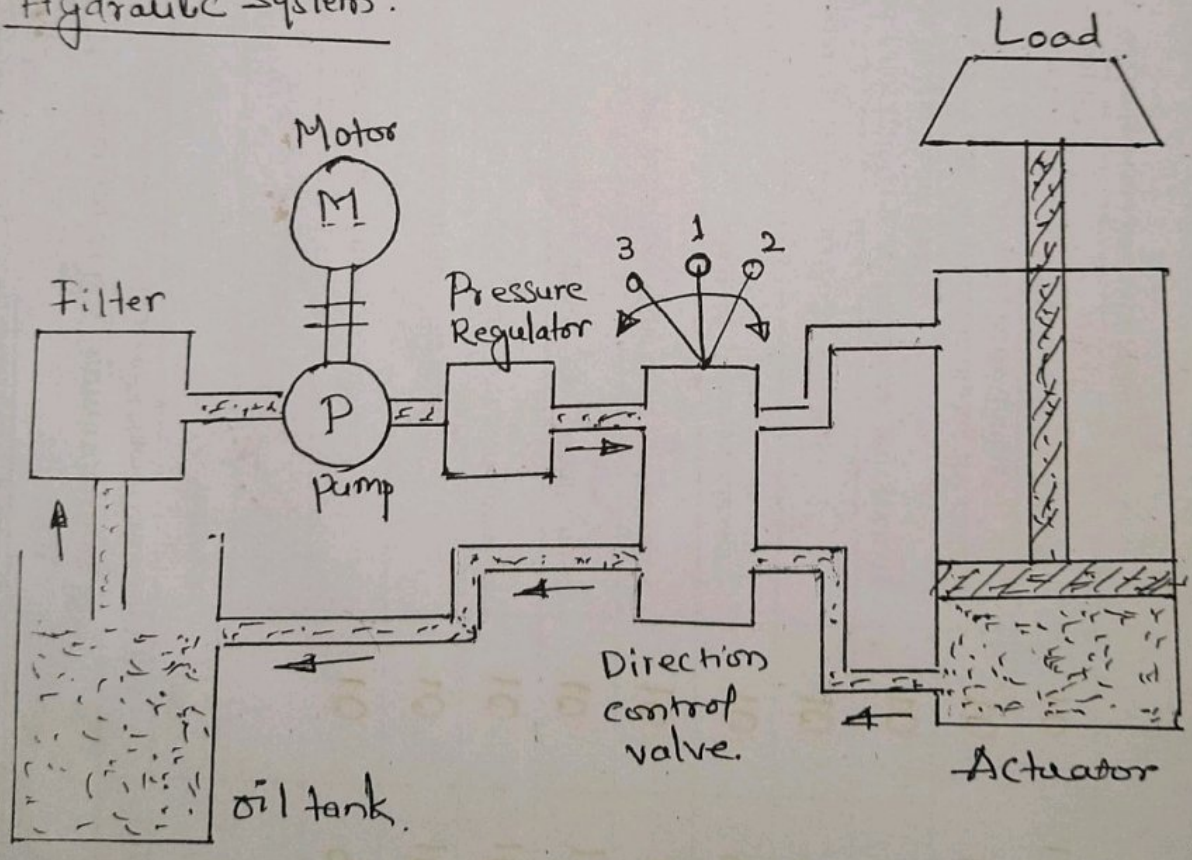
Department of Mechanical Engineering

Question Paper Solution

Subject Name	Fluid power Engineering	Semester/Div	5th "A"	Academic Year : 2021-2022
Code	18ME55	Year of QP	Feb/March 2022	Staff Name: Chandrakanth M.T
Staff Signature			H O D Signature	

1(a) A fluid power system has a pump driven by a prime mover (such as an electric motor or IC engine) that converts mechanical energy into fluid energy. Pressurized fluid is controlled and directed by valves into an actuator device such as a hydraulic cylinder or Pneumatic cylinder, to provide linear motion.

Hydraulic system:



There are six basic components required in a hydraulic system:

(i) A tank (reservoir) to hold the hydraulic oil
(ii) A pump to force the oil through the system
(iii) An electric motor or other power source to drive the pump.

(iv) Valve to control oil direction, pressure and flowrate.

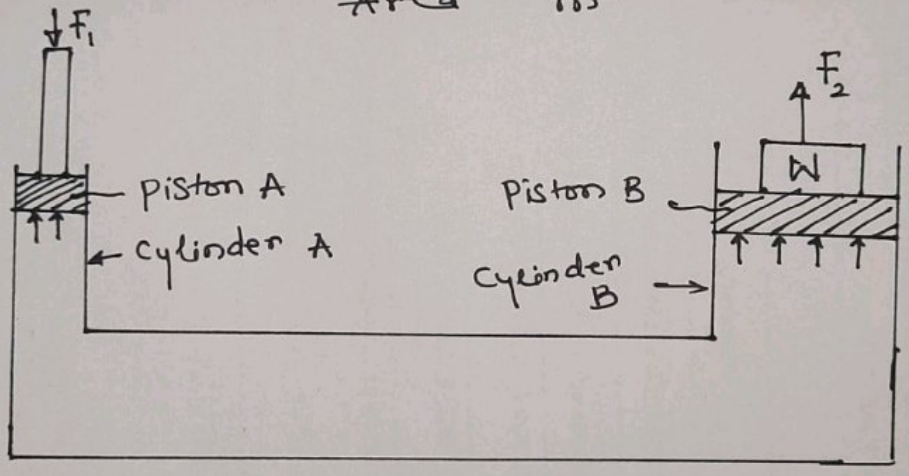
(v) An actuator to convert the pressure of the oil into mechanical force to do the useful work.

(vi) Piping to carry the oil from one location to the other.

1 (b) Pascal's law states that,

" Intensity of pressure at a point in a static fluid is same along the direction / pressure exerted any where in a confined liquid is transmitted undiminished and equal in all direction throughout the liquid "

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}} \quad \frac{N}{m^2} \text{ or } P_a.$$



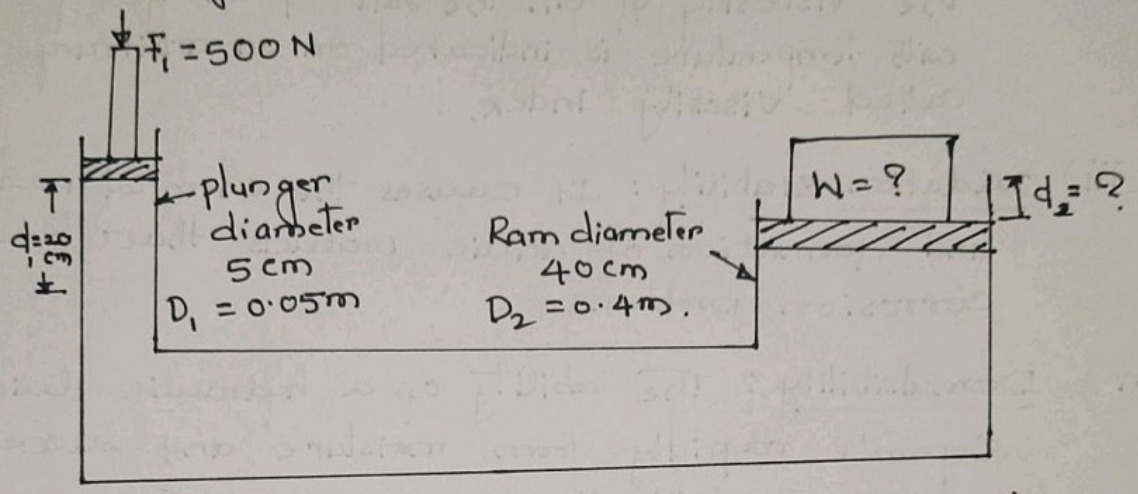
The above fig shows simple line diagram of a hydraulic lift. This is the principle of the working of hydraulic lift. It works based on the principle of equal pressure transmission throughout a fluid (Pascal's law).

The construction is such that a narrow cylinder (A) is connected to a wider cylinder (B). They are fitted with airtight piston on either end. The inside of the cylinders is filled with fluid that can't be compressed.

Pressure applied at piston A is transmitted equally to piston B without diminishing the use of the fluid that cannot be compresed.

Thus, piston B effectively serves as a platform to lift heavy objects like big machines or vehicles. A few more applications include a hydraulic jack and hydraulic press, and forced amplification is used in the braking system of most cars.

Q1 (c)



We know that, Pressure on plunger (P_1) = Pressure on Ram (P_2) $\quad \| \; P = \frac{F}{A}$

$$\therefore \quad \frac{F_1}{A_1} = \frac{F_2}{A_2} \Rightarrow \frac{F_1}{A_2} = \frac{W}{A_2} \quad \| \; F_2 = W. \qquad \text{---(1)}$$

Given data: $F_1 = 500$ N.

$$A_1 = \frac{\pi}{4}(D_1)^2 = \frac{\pi}{4}(0.05)^2 = 0.00196 \text{ m}^2$$

$$A_2 = \frac{\pi}{4}(D_2)^2 = \frac{\pi}{4}(0.4)^2 = 0.1256 \text{ m}^2$$

By substituting the values of F_1, A_1 and A_2 in eq^n (1) we get,

$$W = \frac{500 \times 0.1256}{0.00196} = \underline{32{,}040 \text{ N}}$$

$\therefore$ Maximum weight of the load than can be placed on the ram = 32,040 N.

Now, Volume of the plunger = volume of the ram.

$$V_1 = V_2 \qquad \| \; d_1 = 20 \text{ cm}, \; d_2 = ?$$

$$A_1 d_1 = A_2 d_2$$

$$\therefore \; d_2 = 0.0312 \text{ m} = 3.12 \text{ cm}$$

Q2
(a)

The desirable properties of hydraulic fluids are:

(i) Viscosity: It is a measure of the fluid's internal resistance offered to flow.

(ii) Viscosity Index: This value shows how temperature affects the viscosity of oil. The rate of change of viscosity with temperature is indicated on an arbitrary scale called Visosity Index.

(iii) Oxidation stability: It causes the chemical reaction and formation of acidic products that leads to corrosion problems.

(iv) Demulsibility: The ability of a hydraulic fluid to seperate rapidly from moisture and successfuly resist emulsification.

(v) Lubricity: Its the ability of a hydraulic fluid to lubricate the moving parts efficiently is called lubricity.

(vi) Rust Preventation: The moisture entering into the hydraulic System with air causes the parts made of ferrous material to rust.

(vii) Pour point: The temperature at which oil will clot is referred to as the pour point. ie., the lowest temperature at which the oil is able to flow easily.

(viii) Fire point: The temperature at which an oil releases sufficient vapour to support combustion continuously for 5 sec. when a flame is passed over the surface.

(ix) Flash point: The temperature at which oil surface gives off sufficient vapour to ignite when a flame is passed over the surface.

Q2(b) Seal is an agent which prevents leakage of oil from the hydraulic elements and protects the system from dust/dirt.

Hydraulic seals are classified as follows:

(I) <u>According to the method of sealing.</u>

(i) positive sealing: It prevents even a minute amount of oil from getting past. A positive seal does not allow any leakage whatsoever (External or Internal)

(ii) Non-positive sealing: It allows small amount of internal leakage, such as the clearance of the piston to provide a lubrication film.

(II) <u>According to the relative motion existing between the seals and other parts:</u>

(i) Static seals: These are used between mating parts that do not move relative to one another. They are essentially non-wearing and usually trouble-free if assembled properly.

(ii) Dynamic seals: These are assembled between mating parts that move relative to each other. Hence, dynamic seals are subject to wear because one of the mating parts rubs against the seal.

(III) <u>According to geometric cross-section.</u>

(i) O-rings — is the most widely used seal for hydraulic systems. It is a moulded synthetic rubber seal that has a round cross-section in its free state. It can be used for the static and dynamic conditions.

(ii) V-ring seal and U-ring seal: are compression-type seals used in virtually all types of reciprocating motion applications.

(iii) T-ring seal: Is a dynamic seal that is extensively used to seal cylinder-piston, piston rod and other reciprocating parts.

(iv) Piston cup packings: are designed specifically for piston in reciprocating pumps, hydraulic and Pneumatic cylinders.

(v) Piston rings: are universally used for cylinder pistons. It offers substantially less opposition to motion than synthetic rubber.

Q 2(c) Contamination control methods:
There are many ways to reduce the effects of contaminants in a system.

(i) Plumb the system with pipe, tubing and fittings that are reasonably free from dust, scale, dirt and other foreign materials.

(ii) Flush the entire hydraulic system, preferably with the same type of fluid to be used, before normal system operation is begun.

(iii) Filter the hydraulic oil before using, to minimise introducing contaminants into the system.

(iv) provide continuous protection from airborne contamination by sealing the hydraulic system or installing air filter / breather.

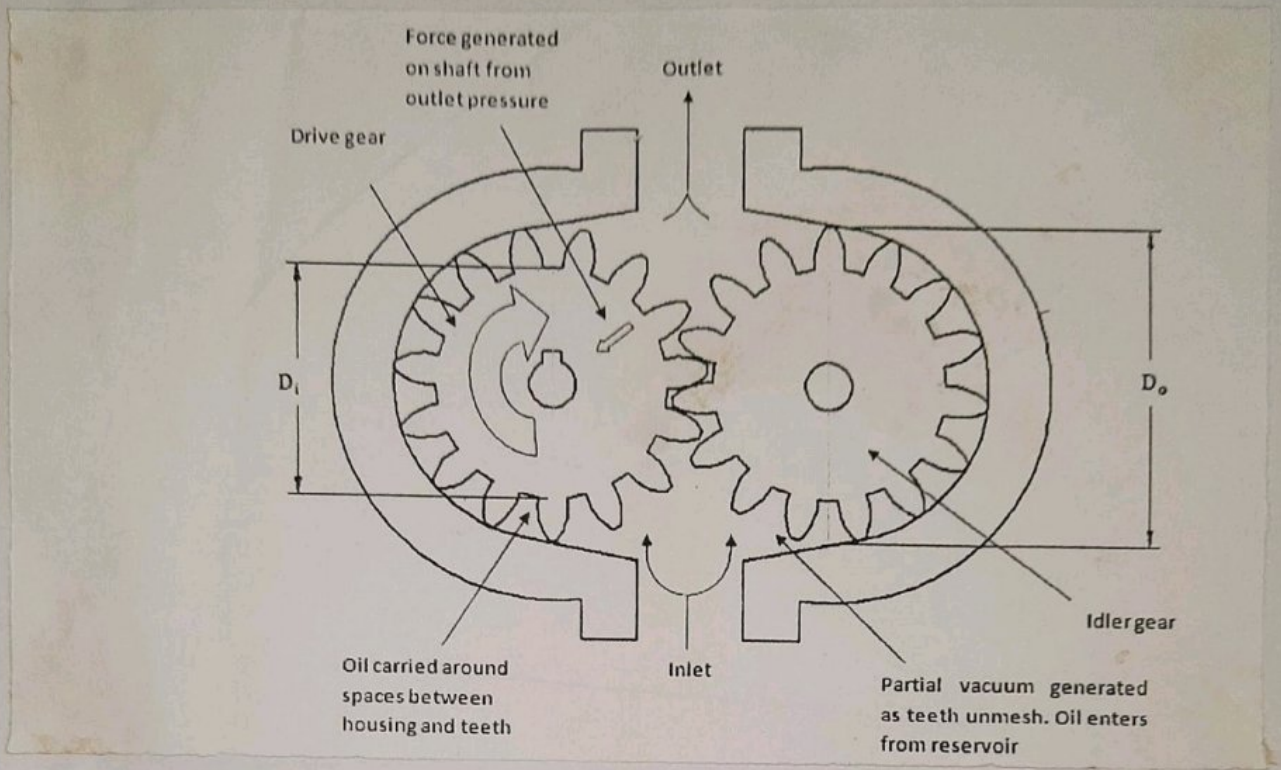
(v) Clean or replace filter elements on a routine basis

(vi) Avoid source of water entry into the hydraulic system.

(vii) Avoid introducing thread sealants into the fluid system.

MODULE – 2

Q3(a) External Gear pump :



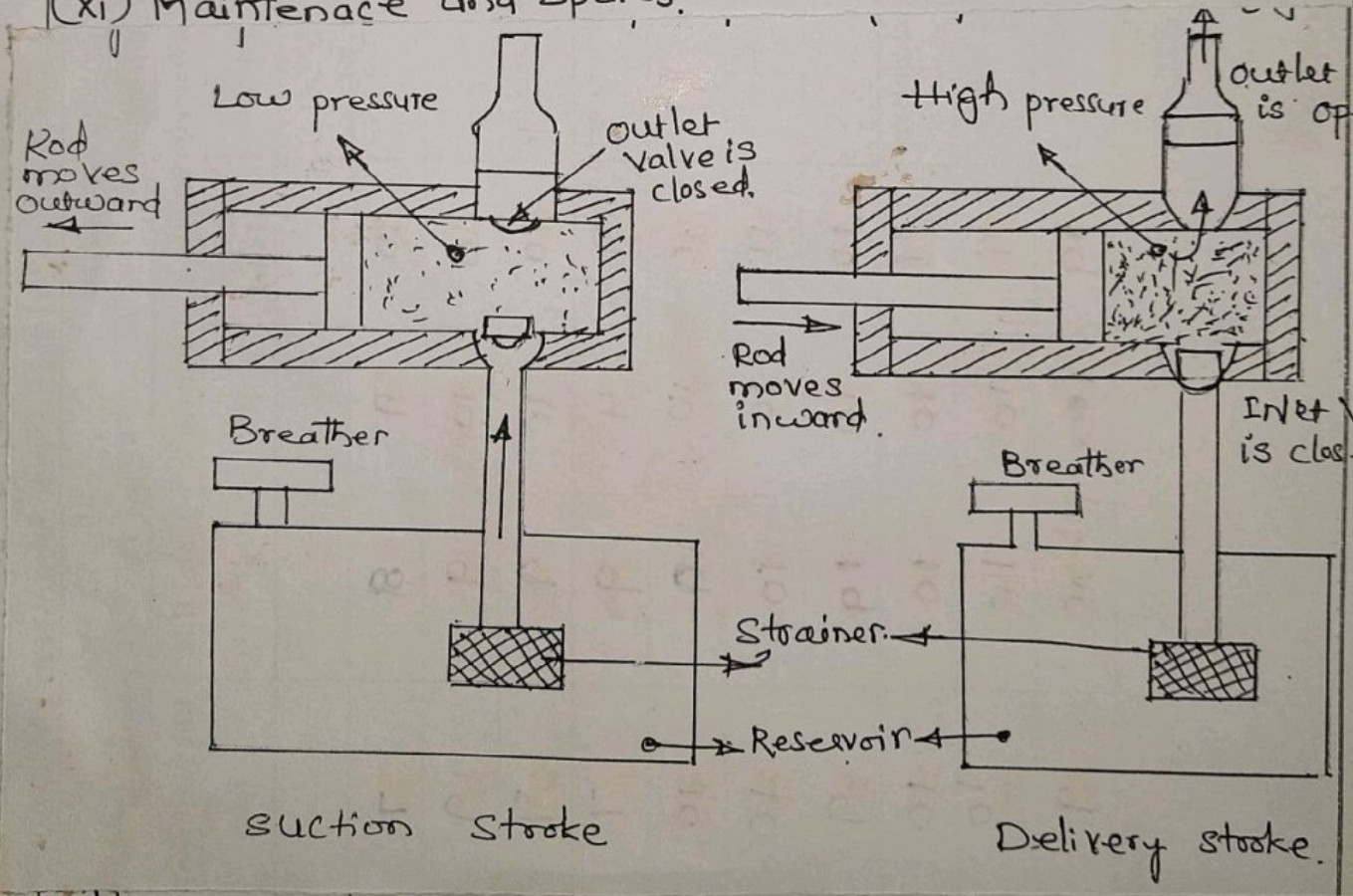
External gear pump are the most popular hydraulic pumps in low-pressure range due to their long operating life, high efficiency and low cost. they are generally used in a simple machine. The external gear pump consists of a pump housing in which a pair of precisely machined meshing gear runs with minimal radial and axial clearance. One of the gear called driver, is driven by a prime mover. The driver drives another gear called a follower.

As the teeth of the two gears seperated, 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 and delivered to outlet port. The teeth of precisely meshed gears provide almost a perfect seal between the pump inlet and pump outlet.

Q3(b) Pump selection factors:

The main parameter affecting the selection of a particular type of pump are as follows:

(i) Maximum operating pressure
(ii) Maximum delivery.
(iii) Type of control
(iv) Pump drive speed
(v) Type of fluid
(vi) pump contamination tolerance.
(vii) pump noise
(ix) Size and weight of a pump
(x) Availability and interchangeability.
(xi) Maintenace and spares.



Pumps operate on the principle whereby a partial vaccum is created at the pump inlet due to the internal operation of the pump. This allows atmospheric pressure to push the fluid out of oil tank (reservoir) and into pump intake. The pump then mechanically pushes the fluid out the discharge line.

1. As the piston moves to the left, a partial vaccum is created in the pump chamber that holds the outlet valve is placed against its seat and induces flow from the reservoir, that is at a higher 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).

2. When the piston moves towards right, the resistance at the valve causes the immediate increase in pressure that forces the inlet valve against its seat and opens outlet valve thereby permitting the fluid flow into the system.

Q3(c)

Diameter of rotor, $D_R = 60\ mm = 0.06\ m$

Diameter of cam ring, $D_C = 80\ mm = 0.08\ m$

Volumetric displacement is, $V_D = 90\ cm^3/rev$

Width of rotor, $L = 3\ cm = 0.03\ m$

(i) We know that,

Volumetric displacement

$$V_D = \frac{\pi}{2}(D_C + D_R)eL$$

$$(90 \times 10^{-6}) = \frac{\pi}{2}(0.08 + 0.06)e \times 0.03$$

$$\therefore \text{Eccentricity, } e = \frac{90 \times 10^{-6} \times 2}{\pi(0.08+0.06) \times 0.03}$$

$$\boxed{e = 0.0136}$$

(ii) Maximum displacement ($V_{D\,max}$)

$$V_{D\,max} = \frac{\pi}{4}(D_c + D_R)\,2\,e_{max}\,L$$

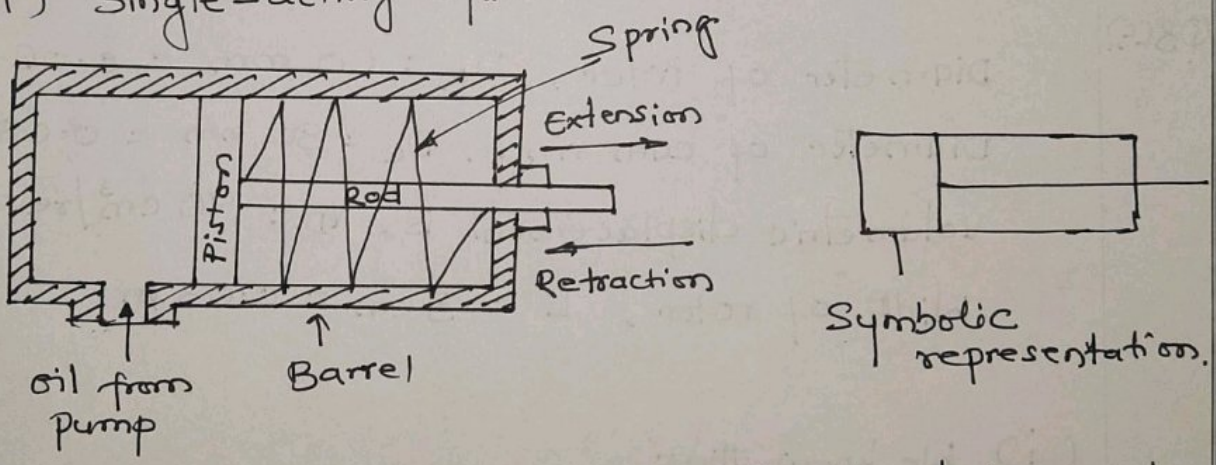
$$e_{max} = \frac{D_c - D_R}{2} = \frac{(0.08) - (0.06)}{2}$$

$$\boxed{e_{max} = 0.01}$$

$$\therefore V_{D\,max} = \frac{\pi}{4}(0.08 + 0.06)\,2 \times 0.01 \times 0.03$$

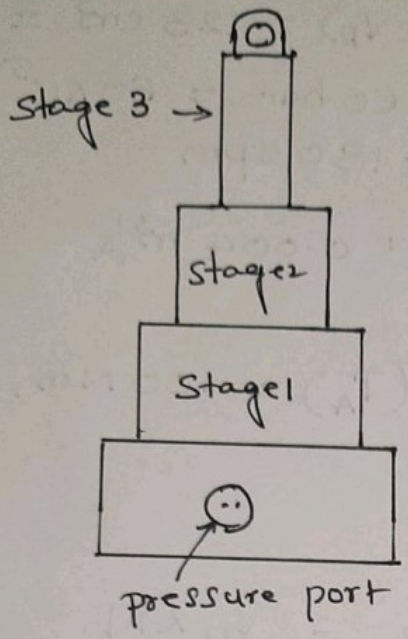
$$\boxed{V_{D\,max} = 6.59 \times 10^{-5}\ m^3/rev.}$$

Q4(a) (i) Single-acting cylinder



A single-acting cylinder is simplest in design and consists of piston inside a cylindrical housing called barrel. One end of the piston there is a rod, which can reciprocate. At the opposite end, there is a port for the entrance and exit of oil. Single-acting cylinder produce force in one direction by hydraulic pressure acting on the piston during extension stroke. The retraction is done either by gravity or by spring.

(ii) Telescopic cylinder:



It has multiple cylinders that are mounted concentrically one within the other. The design is such that the inner most cylinder extends first, while the next cylinder extends after completion of the full stroke of the cylinder. Thus each cylinder extends in stages, one after the other. each stage of the cylinder has a sleeve that fits into the previous stage of the cylinder. The total stroke length achieved will be sum of the strokes of all the stages.

Q4(b) A hydraulic motor is a mechanical actuator that converts hydraulic pressure and flow into torque and angular displacement (rotation).

Four broad basis of classification of hydraulic motors are:

1. Gear motor
2. Vane motor
3. Piston motor [In-line] [with Swash plate]
4. Axial piston motor [Bent-axis]

Q4(c). Given data

Volumetric displacement (V_D) = 123 cm^3 = 123×10^{-6} m^3

operating pressure (p) = 60 bar = 60×10^5

speed (N) = 180 rpm

Actual flow rate by the motor (Q_A) = 0.004 m^3/s.

Actual torque delivered by the motor is (T_A) = 100 Nm.

(i) Volumetric efficiency

Theoretical flow rate, $Q_T = V_D \times N$

$= 123 \times 10^{-6} \times \frac{180}{60}$

$Q_T = 3.69 \times 10^{-4}$ m^3/s

$\therefore$ Volumetric efficiency $(\eta_v) = \frac{Q_T}{Q_A} \times 100$

$\therefore \eta_v =$

(ii) Mechanical efficiency $(\eta_m) = \frac{T_A}{T_T} \times 100$

Theoretical torque $(T_T) = \frac{V_D \times p}{2\pi} = \frac{123 \times 10^{-6} \times 60 \times 10^5}{2\pi}$

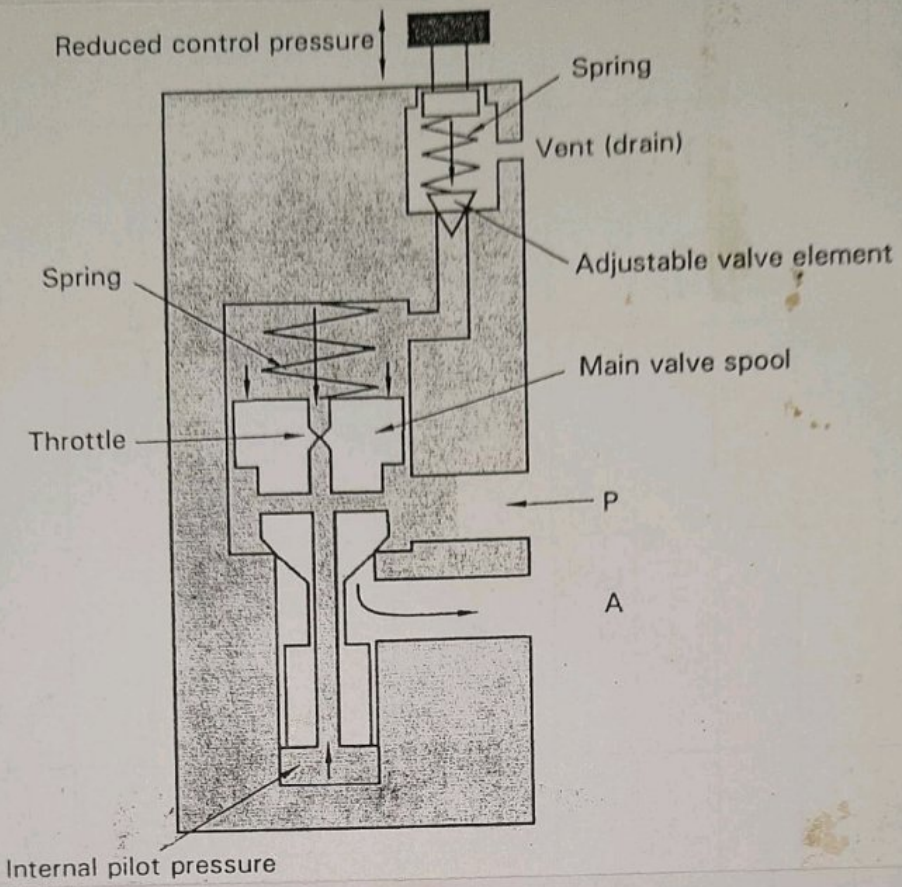
$= 117.45$ Nm

$\therefore \eta_m = \frac{100}{117.45} \times 100 = 85.13\%$.

(iii) overall efficiency $(\eta_o) = \frac{\eta_v \times \eta_m}{100}$

Module-3

Q5(a)



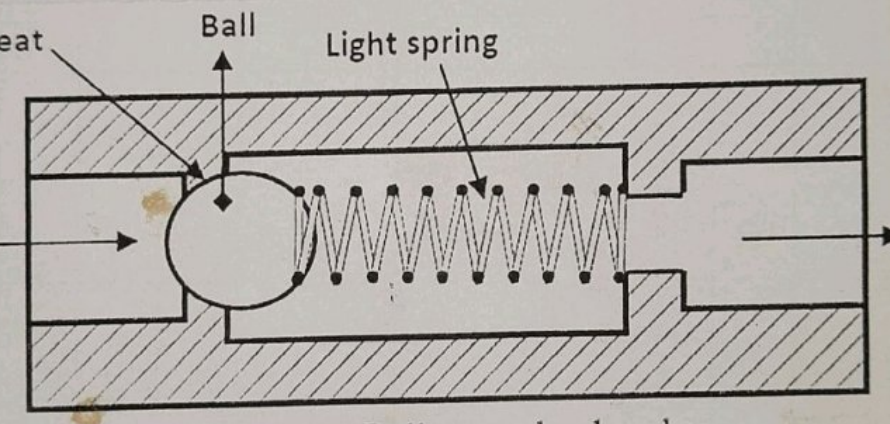
When the system pressure is large, it is necessary to provide a spring with comparable high system pressure. In a compact hydraulic system, a high pressure spring requiring higher cross sectional area is not preferable. In addition when the flow rate is high it is very common to use an indirectly operated valve like a pilot operated valve.

The above fig shows pilot operated pressure relief valve. In this valve oil from the main port 'P' is fed through a throttle opening in the main valve spool to act against the valve element. The valve element is held against the valve seat by an adjustable spring. One more spring is used to block flow from P to A in addition to throttle oil pressure.

If P is the system pressure, then it acts against the main spool and the bottom of the adjustable valve element through the inbuilt throttle.

Due to throttling, the pressure in this chamber will be reduced to say P_1. Hence adjustable valve is adjusted corresponding to this pressure. when this pressure increases due to some reason, the throttle valve of the pressure in the chamber above the main spool will also change to a higher value. This pressure acts against the adjusted spring force (P_1) in the chamber with higher force hence unseating it and consequently opening pressure in the pilot chamber to the drain line. Due to this, main spool will crack immediately and allows the system pressure to flow to the reservoir till equilibrium pressure is restored.

(5(b)



: Ball-type check valve.

Fig. shows a simplest type of directional valve, known as check valve. Since it contains two parts it is also known as a two way valve and it allows flow only in one direction while preventing flow in the opposite direction. It consists of a body, a poppet and a light spring. The spring holds the poppet in the closed condition or position at a pressure of 34.5 kPa. In the free flow direction, the fluid pressure overcomes the spring pressure and flow commences. If the fluid tries to flow in the opposite direction, the fluid pressure pushes the poppet along with the spring force, in the closed-position. This prevents backward flow of the fluid. As the fluid pressure increases, force pushing the poppet into seat also increases.

Q5(c) In a hydraulic system, oil coming from the pump, has to be fed further to the cylinder or other actuators. For proper functioning of a hydraulic system, it is essential to control the fluid power by properly selecting control devices called valves.

In a hydraulic system to control or to regulate flow medium three basics types of control devices are used. These are,

(i) Directional control valves:

The main function of a directional control valve is to determine the path of the fluid flowing in a given circuit. This can be done by using check valve, three way and four way valves, shuttle valves etc.

(ii) Pressure control valves:

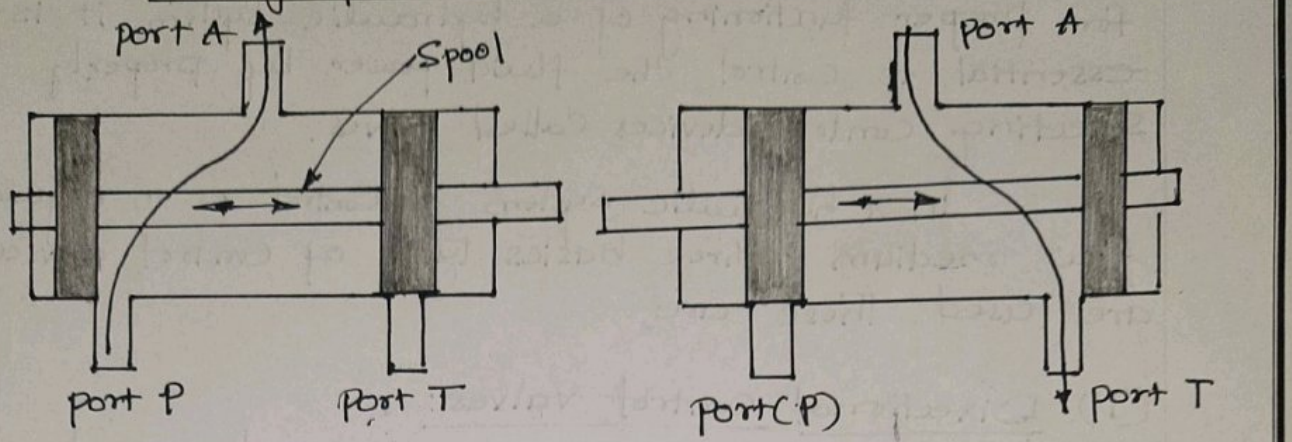
The main function of a pressure control valve is to protect the system against over pressure. This may happen either due to gradual pressure build up or due to sudden rise in pressure. The former happens due to decrease in fluid demand whereas the latter happens due to sudden opening or closing of valve. Gradual pressure build up can be controlled by pressure relief valve, pressure reducing valve, unloading valve, sequence and counterbalance valves. Sudden surge in pressure can be controlled by using shock absorbers.

(iii) Flow control valves:

Main function of a flow control valve is to regulate the speed of the actuators depending on flow rate. This can be done by using a needle valve, non-pressure compensated valve or a pressure compensated valve

Q6(a)

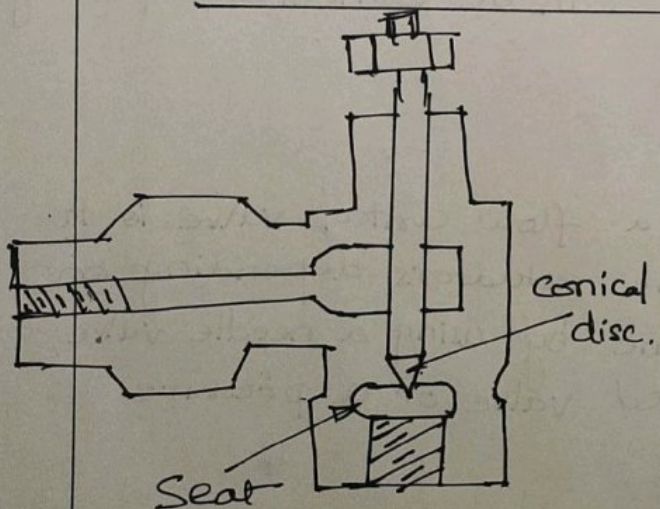
(i) Sliding spool flow control valve.



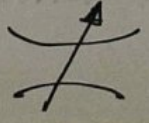
Position 1 Position 2

It has a cylinder body with three ports P, T and A. port P recieves the fluid into the cylinder, port A is connected to an actuation system and port T is connected to the return line. In operation, in the position, the fluid supply under pressure is connected to P and port T is closed. That means pressure now flows through port A, and activates the device connected in that line. When the spool is moved to the position 2, the port P is closed, there by cutting the supply, while port T is opened. Since there is pressure in the line (through port A), the pressure is relived through the open port T and the fluid freely flows out the pump.

(ii) Needle flow control valve.



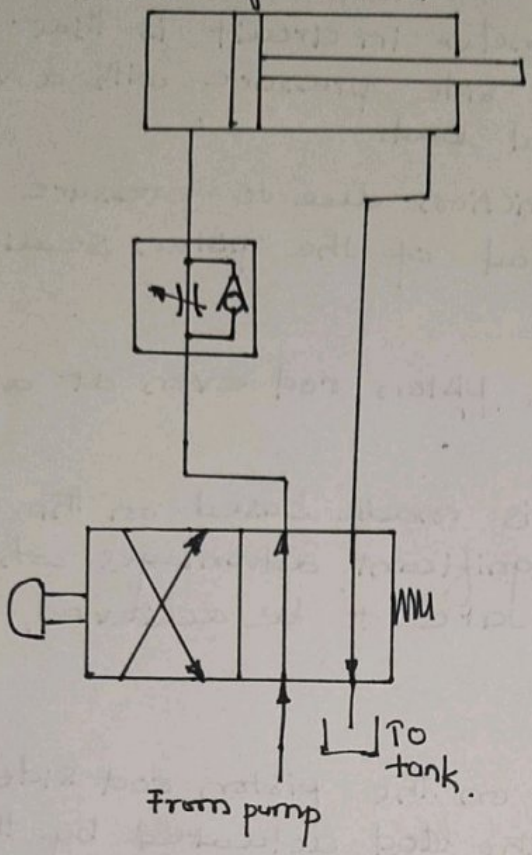
A Needle valve consists of a sharp, pointed conical disc and matching seat to give fine control of flow in a small diameter piping. For a given opening position the needle behaves like an orifice.



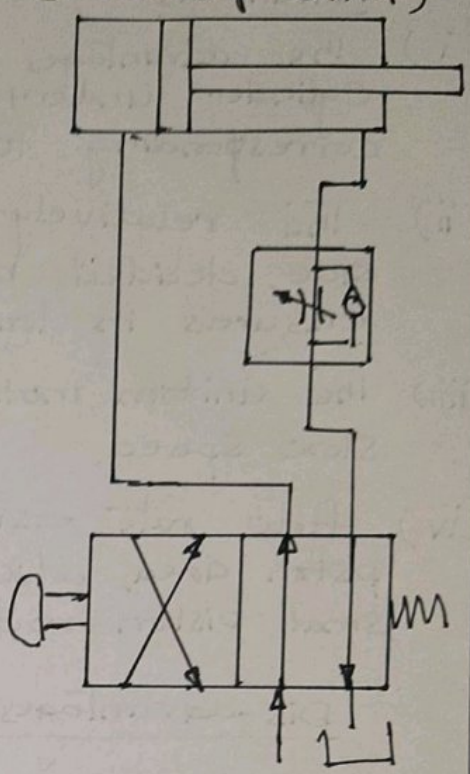
Graphical Symbol.

Q6(b)

Meter - In Circuit
(primary control)



Meter-out circuit.
(secondary control)



In a meter-in circuit, valve is placed between the pump and the load actuators. Only flow rate to the cylinder is controlled.

In a meter-out circuit the flow control valve is placed in the return line limiting the flow rate of oil from the cylinder.

1. Meter-in circuit.

Advantages

(i) The advantages of the meter in circuit is that the cylinder undertakes one side pressure with a valve corresponding to the real load.

(ii) The relatively small friction due to pressure on one side, decided by the load of the piston sealing ensure's its long life.

(iii) The uniform motion of the piston rod even at a very slow speed.

(iv) flow rate estimation is made based on the large piston area, which is a significant advantages when very small piston-rod speeds are to be achieved.

Dis-advantages

(i) There is no pressure on the piston rod side of the cylinder, due to this the load actuated by the piston rod is not held firmly in position.

(ii) In the case of 'pulling' type load if the load suddenly collapses, the piston rod shoots forwards causing the uncontrolled shift.

(iii) Special counter balance measures are to be taken if the above circuit is to be used for such appl^{n}.

Meter-out Circuit

Advantages:

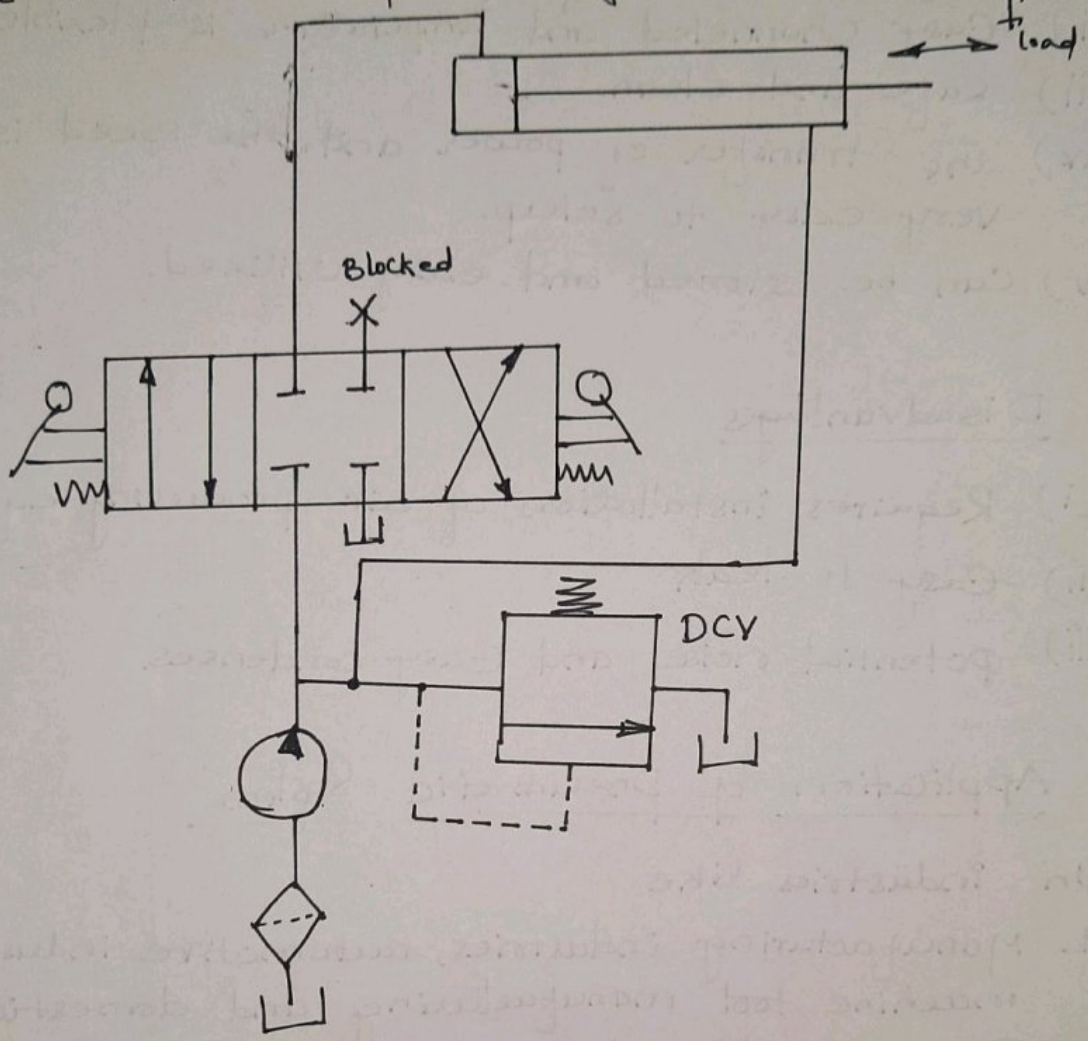
(i) The load is always under pressure from both sides, thus it is counterbalanced.

(ii) Even when the load changes the direction, no uncontrolled jerk motion occurs.

Disadvantages

The left side of the cylinder is always under maximum pressure even with a minimum load. Due to continuous pressure from both sides, there is more friction and less seal life.

Q6(c) A Circuit is said to be operating on the regenerative principle when the fluid returning from another end of the cylinder is forced into the head end of the cylinder.



In a double acting hydraulic cylinder, the extending speed can be further increased using a regeneative circuit. In this circuit the pipelines to both ends of the hydraulic cylinder are connected in parallel and one of the port of the 4-way valve is blocked. During the retraction stroke the cylinder operates in a similar fashion to that of a regular double acting cylinder ie fluid flows through DCV via third envelope. In this mode, fluid from the pump bypasses the DCV and rod end of the cylinder. As the cylinder retracts fluid in the blank end trains to the tank.

Module -4.

Q7(a) **Advantages of pneumatic System**

(i) Infinite availability of the source.
(ii) Easy channeled and temperature is flexible.
(iii) Safe and clean.
(iv) The transfer of power and the speed is very easy to setup.
(v) Can be stored and easy utilized.

Disadvantages

(i) Requires installation of air-producing equipment.
(ii) Easy to leak
(iii) potential noise and Easy condenses.

Application of Pneumatic System.

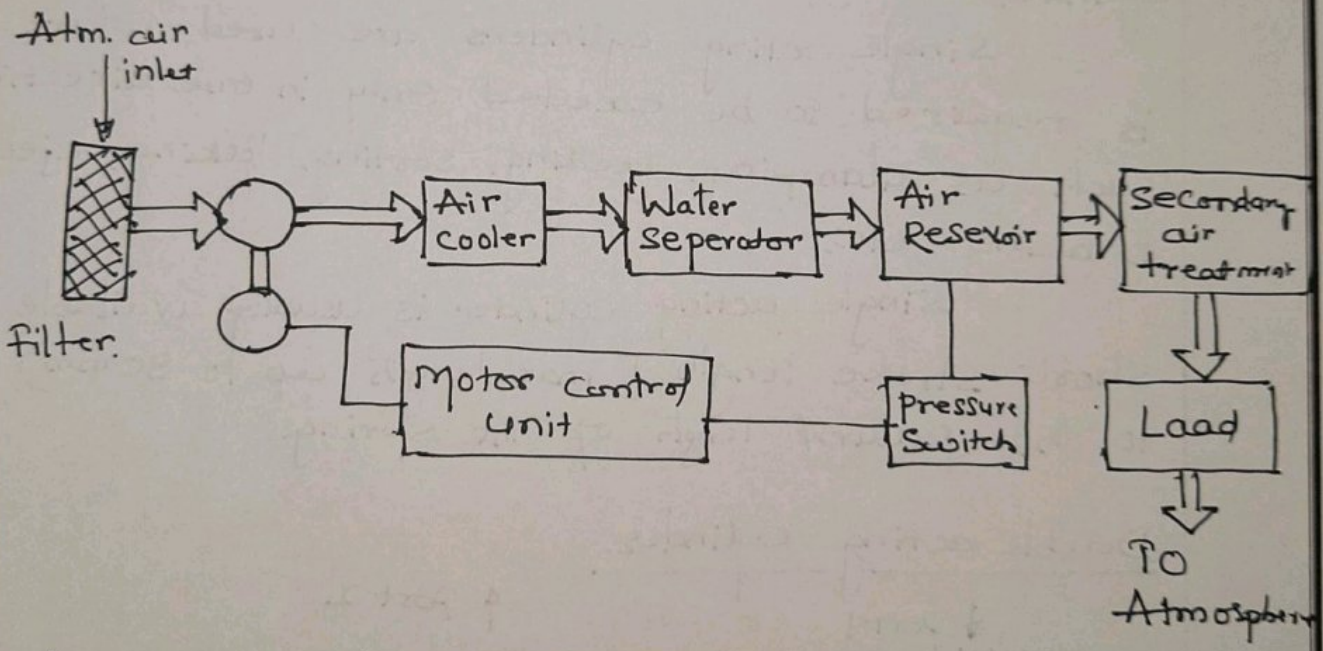
In industries like

1. Manufacturing industries, automotive industry, machine tool manufacturing and domestic and commercial appliance manufacturers.
2. Processing industries, such as chemical, petrochemical, food processing, textiles, papers etc.
3. Used in the brake system of automobile, railway coaches, wagons and printing presses.
4. Application of pneumatic systems is widely in industrial robots.

Q 7(b)

Compressed air is produced using compressors and stored in a reservoir. Before the atmospheric air is drawn into the compressor, it passes through a filter to remove the atmospheric dirt and other particles so that only clean air enters the compressors.

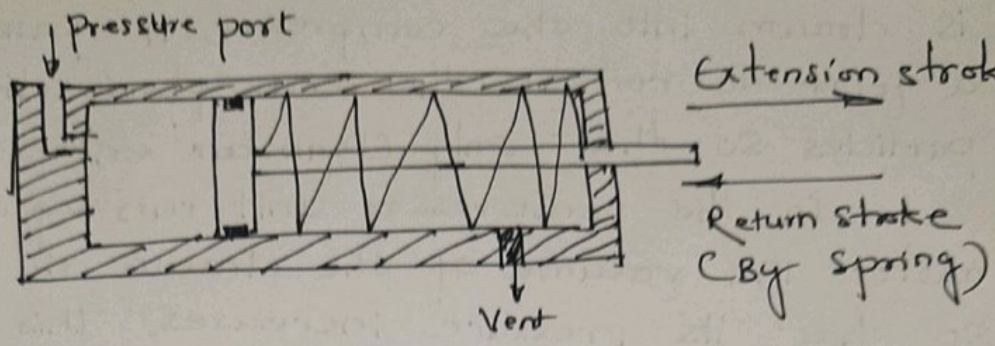
In the compressor unit run by an electric motor the volume of the drawn air is reduced so that its pressure increases. This increase in pressure is associated with an increase in temperature of the compressed air. Hence an air cooler is used to cool the air before it is sent to reservoir.



As air mixture of gases containing 21% oxygen, 78% Nitrogen and 1% other gases like argon and CO_2 by volume. In addition, air contains around 4% of water vapour depending on humidity, after compression and cooling, it condenses into small droplets. This moisture causes corrosion and operational problems. A seperator is used to remove water particles from the compressed air. This air after cooling and separation is sent to the reservoir.

Q7(c)

Single acting cylinder

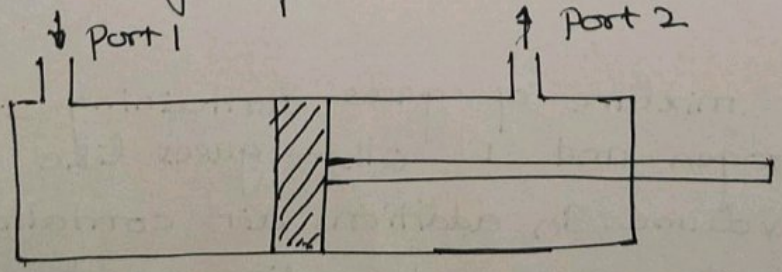


A single acting cylinder has one working port. Forward motion of piston is obtained by supplying compressed air to working port. Return motion of piston is obtained by spring placed on the rod side of the cylinder.

Single acting cylinders are used where force is required to be exerted only in one direction. such as clamping, feeding, sorting, locking, ejecting braking etc.,

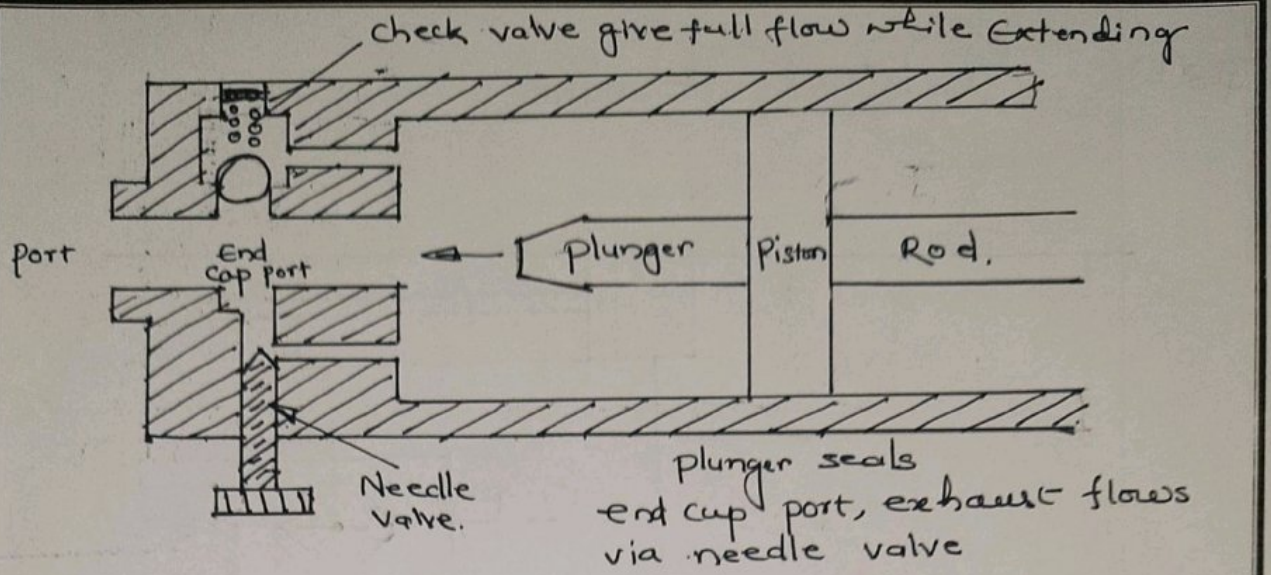
Single acting cylinder is usually available in short stroke length [max. length up to 80mm) due to the natural length of the spring.

Double acting cylinder.



In case of double acting cylinder there is no return spring, however air itself is used for retracting the cylinder the construction principle of double acting cylinder is similar to single acting cylinder. Here two port ar used alternatively for supply and exhaust ports. It has main advantages that cylinder can able to carry out work in both direction of motion.

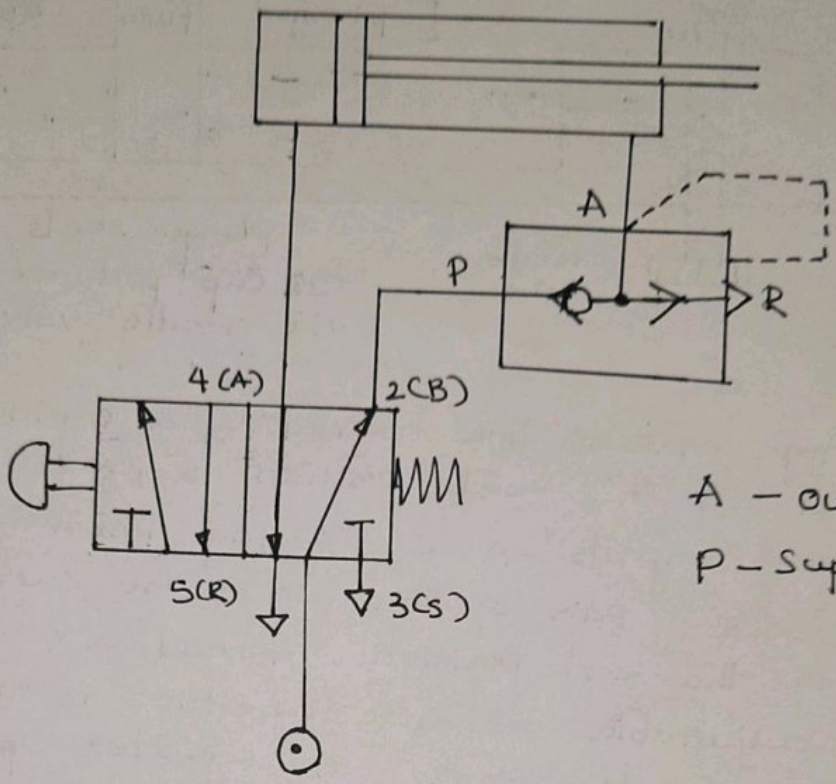
Q 8(a)



If large masses are moved by a cylinder, cushioning is used in the end position to prevent sudden damaging impacts. A cushioning piston interrupts the direct flow path of the air to the outside before reaching the end position. Instead a very small and often adjustable exhaust aperture is open. For the last part of the stroke the cylinder speed is progressively reduced. The cylinder may not reach end position due to the blockage of air if the passage adjustment is very Small.

When the piston reverses, air flows without resistance through the return valve into the cylinder space. With very large forces and high acceleration extra measures must be taken such as external shock absorber to resist the load deceleration. When cushioning adjustment is being carried out it is recommended that in order to avoid damage, the regulating screw should first be screwed in fully and then backed off, Slowly increasing the flow to the optimum valve. It is important to consider fitting a magnet to the cylinder piston.

Q8(b) **Quick Exhaust valve.**

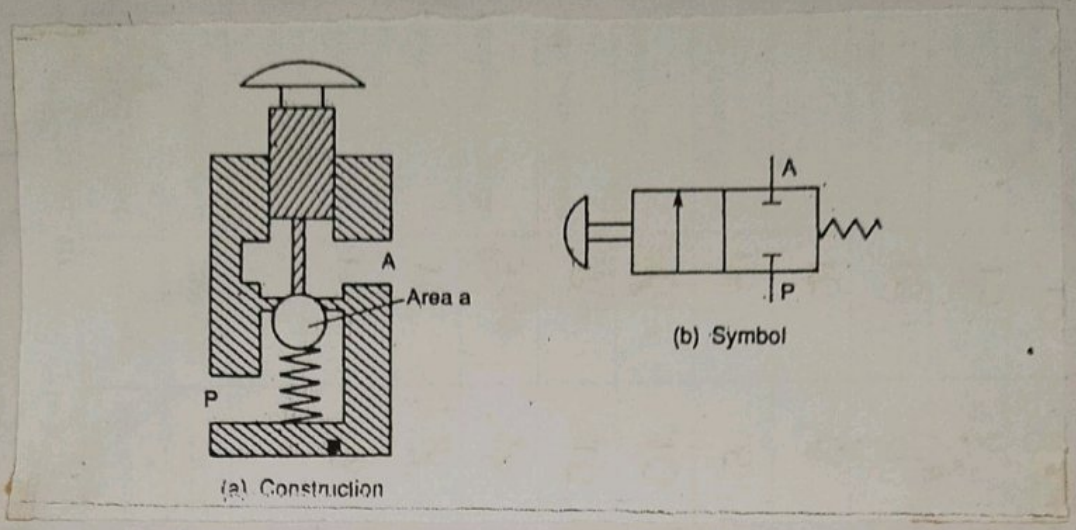


A – outlet valve.
P – Supply connection

Quick exhaust valve are used to increase the piston speed of cylinders. Lengthy return time should be avoided particularly with single acting cylinders.

The principle of Operation is to allow the cylinder to extend or retract at its near max. speed by reducing the resistance to flow of the exhausting air during motion of the cylinder. The air is discharged to atmospheric close to the cylinder through a large orifice opening to reduce resistance. Valve has an outlet (A) and supply connection (P). The flow of air is passed freely through the Opening of the check valve components. Port (R) is blocked by the disc.

Q8(c) **Poppet Valves.**



In a popper valve simple disc, cones or balls are used in conjunction with simple valves seats to control flow. Popper valves are simple, cheap and robust.

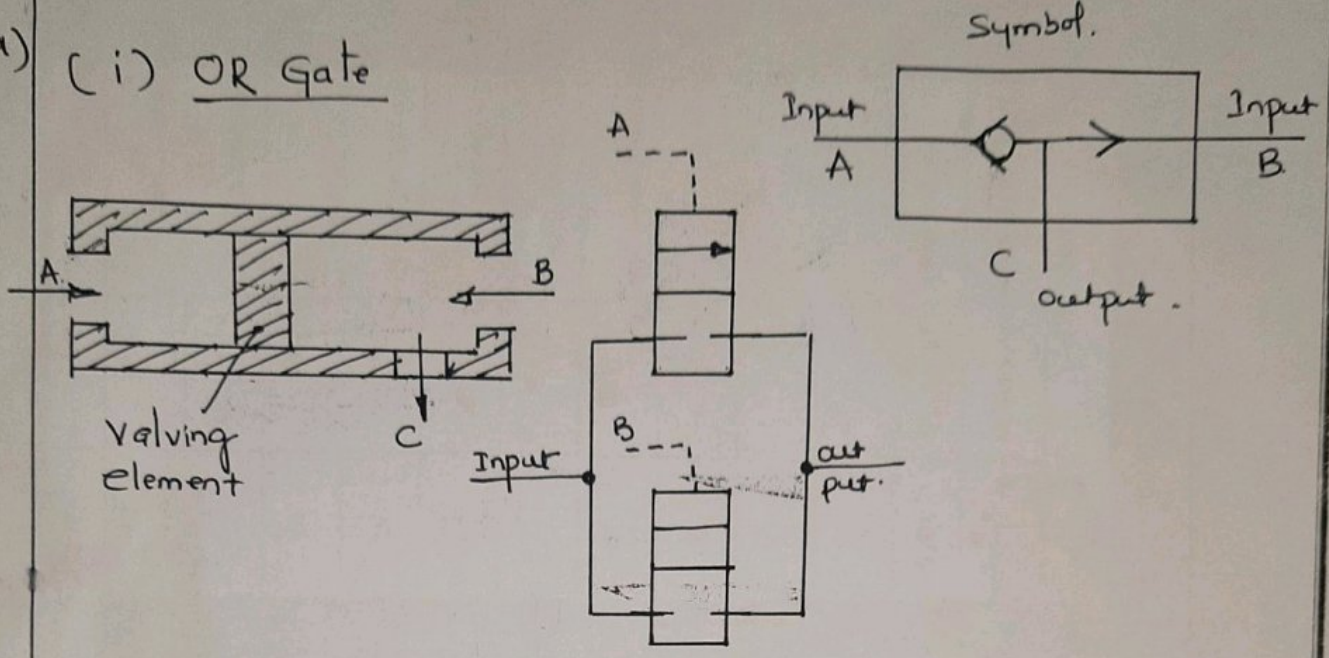
A simple 2/2 popper valve normally close. When pressed, the push-button lifts the ball off its seat and allows fluid from port P to port A. when the push-button is relased, spring and fluid pressure forces the ball up again closing the valve.

In a 3/2 poppet valve, If the push-button is pressed port R is first sealed, then the valve disc is pushed down to open the valve and connects port P and A. As beforce, Spring and fluid pressure from port P closes the valve. When push-button is released, port A and R are linked via the hollow push-button stem.

The force required to operate the valve is: $F = p \times a$. Large capacity valves need large valve areas leading to large operating force requirements.

Module-5

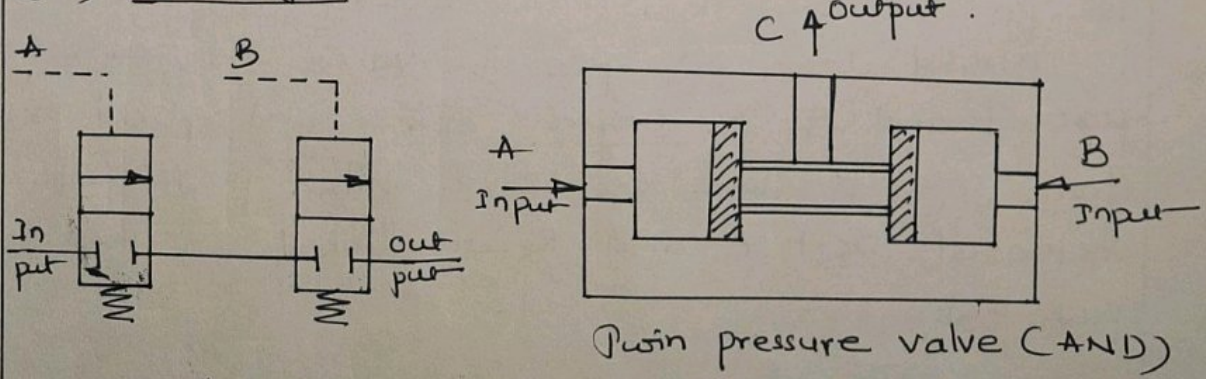
Q9(a) (i) OR Gate



In an OR gate logic circuit, if any one of the several signals is present at the input, it produces an output signals. Hence, all input signals should be absent for the output signal to be absent. A typical OR gate with the use of DCV, in parallel in shown in fig

In this type of logic circuit the DCV are stacked in parallel. 2 DCVs are connected parallel in this example. If the input signal is provided to any one of these DCV it produces an output signals.

(ii) AND gate

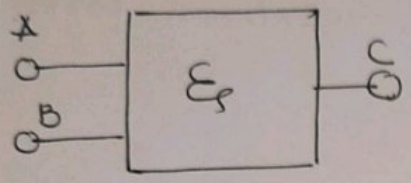


Twin pressure valve (AND)

In AND logic function, two or more input signals must be present to obtain an output signal. If one of the input signals is absent, the output signal is also absent.

In this, two DCVs are connected in series and the supply pressure is input at the first DCV. Now for the output signal to be present, both the input signals at the DCV must be present. That means unless both DCVs are actuated, there is no output from the system.

The symbolic representation of AND logic with table for two signals A and B to produce output C is shown below.

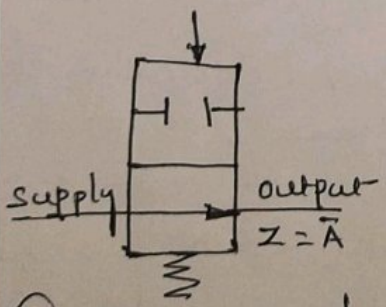


AND logic symbol.

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

Truth table.

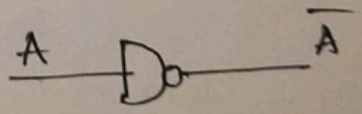
(iii) NOT gate : The NOT function is the process of logical inversion. This means that the output signal is NOT equal to the input signal. Since we have only two signal sates (0 and 1), then an input of 1 gives an output of 0, and vice versa.



(a) MPL component

Input A	output Z = Ā
0	1
1	0

(b) Truth table

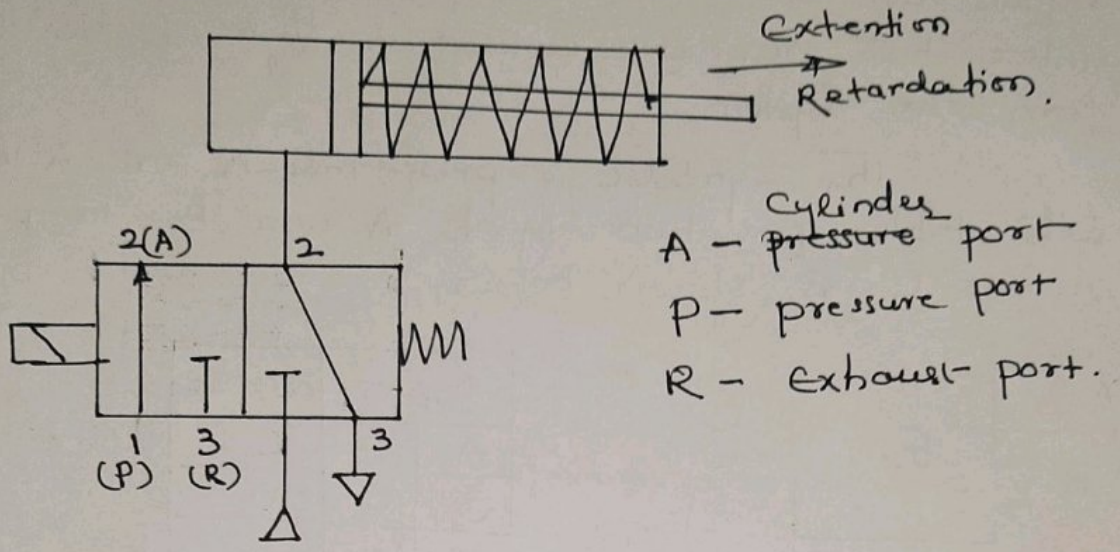


(c) Symbol.

A NOT operation is also known as logical complementing or logical negation in addition to logical inversion. It is represented in Boolean algebra by placing a bar over the variable as follows : $Z = \text{NOT } A = \bar{A}$

Q4(b)

Direct actuation of cylinder



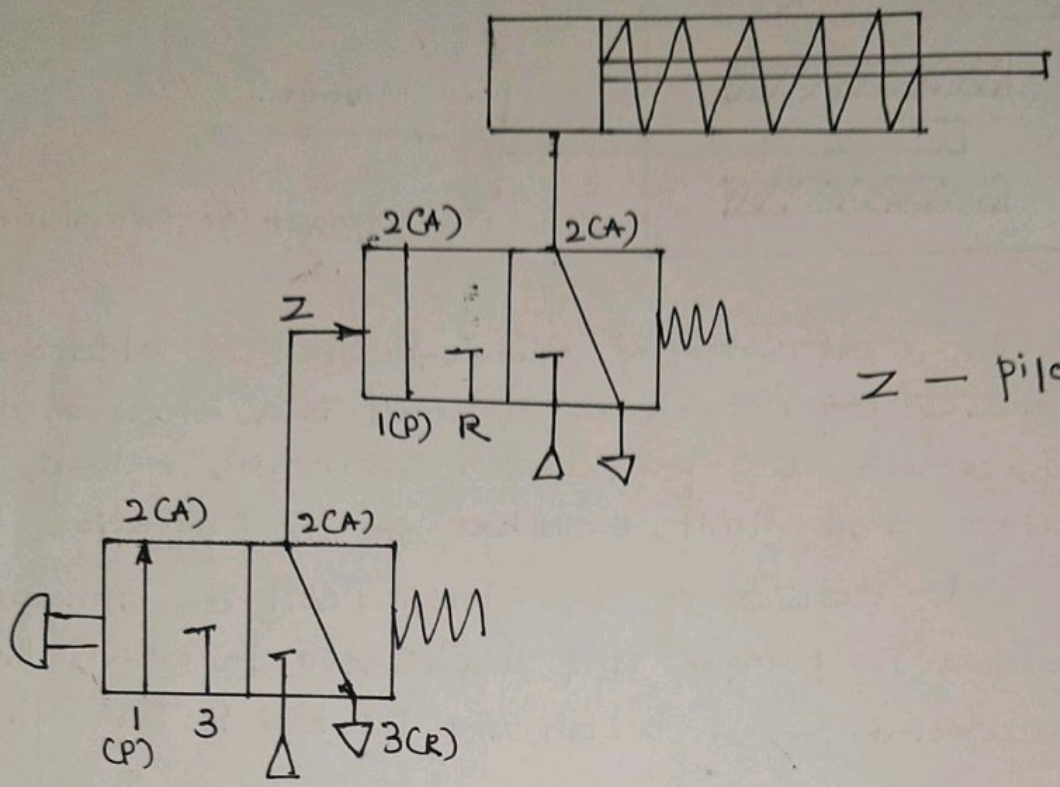
In direct actuation cylinder, the cylinder operation is controlled directly by the operation of DCV. The DCV is directly linked to the cylinder and DCV in turn is operated by some actuation means like pedal or button. A typical pneumatic circuit involving direct actuation of cylinder is shown in fig.

It has a spring returned single acting cylinder, connected to a 3/2 directional control valve. The DCV in its unactuated position, connects the cylinder port to the exhaust so that the cylinder remains in retracted position. Thus, the operation of the DCV directly helps in actuating the cylinder.

In operation, when DCV (Normally closed) is actuated, high pressure air flows from port 1 (P) to port 2 (A) keeping the exhaust port is blocked condition. Due to this the cylinder extends. When DCV is de-actuated (released) the cylinder port 2 (A) is directed to exhaust line 3 (R) keeping 1 (P) pressure port in blocked condition. The cylinder retracts under spring pressure.

Q9(c)

Indirect actuation of cylinder:



Z – pilot valve.

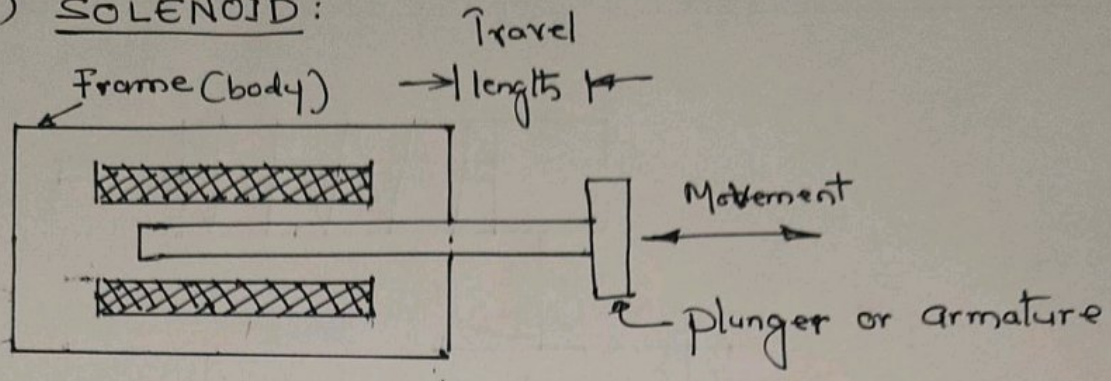
In this case, the DCV is operated by another button operated DCV. The advantages is that small manual force is enough to operate pilot valve, which in turn actuates a large size DCV, hence a large size cylinder can be actuated. Since the cylinder actuation takes place due to the indirect operation of the DCV it is termed indirect actuation.

It has a spring-returned single acting cylinder connected through 3/2 pilot operated DCV. This valve in turn is operated through a push button 3/2 DCV. This push button valve is indirectly actuates the cylinder through DCV.

In operation, when the 3/2 Normally closed push button valve is operated, it allows a low pressure air to be directed to the main DCV spool operation. When the spool in the valve operates, the high pressure air line 1 (P) is connected to the cylinder port 2(A). This causes the extension of the cylinder.

Q10(a)

(i) SOLENOID:



It is the most common element used in electro-pneumatic for actuation. Solenoid is a electromechanical systems, which uses push button switches, relays, contactors and limit switches for its operation.

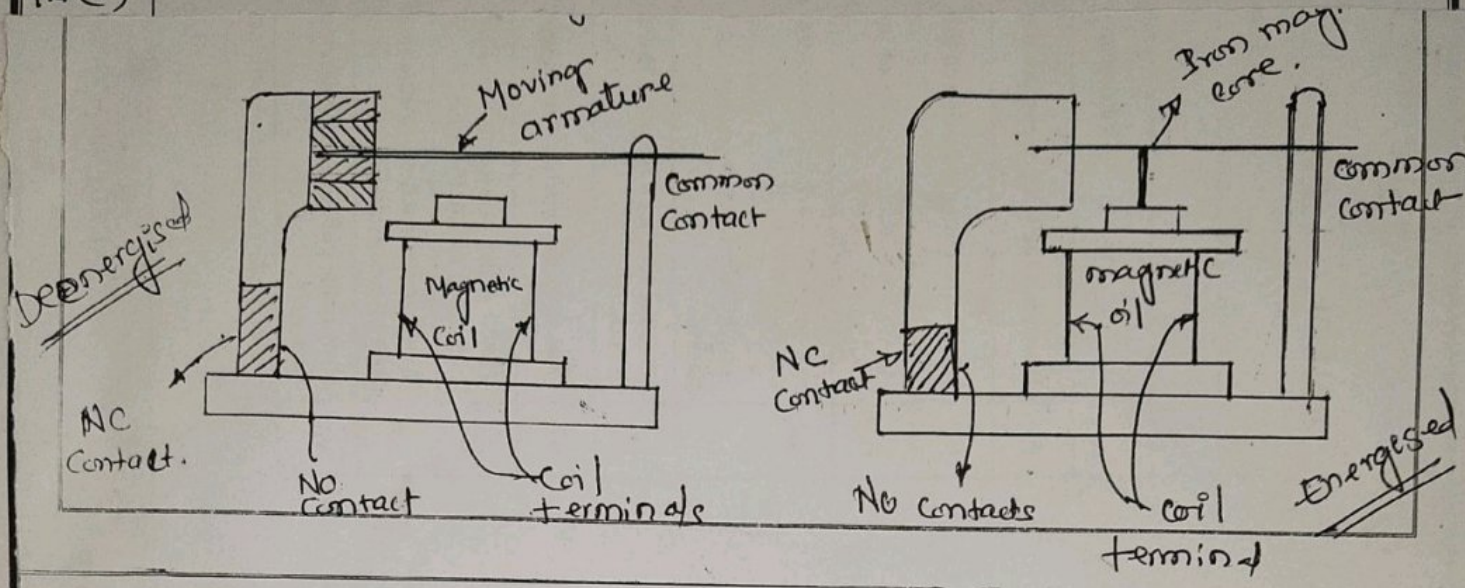
It consists of an electrical coil, an armature (usually a T-plunger) and a cylinder in which the coil is wound on a bobbin and located in the cylindrical frame.

In Operation, when an electric current is passes through the coil, a magnetic field is setup. Normally the armature is kept in extended mode under spring pressure, Due to this magnetic field the plunger is pulled inside the coil. The plunger which is connected to the directional control valve in turn operates the valve, thus controlling the flow path of the air.

(ii) Relay [Electromagnetic Relay]

Electrical relay is another electromagnetic device. It is basically actuates switch. The relay uses a small current magnet to operate the contacts to control a large current in the circuit.

Continue Q9 (a)

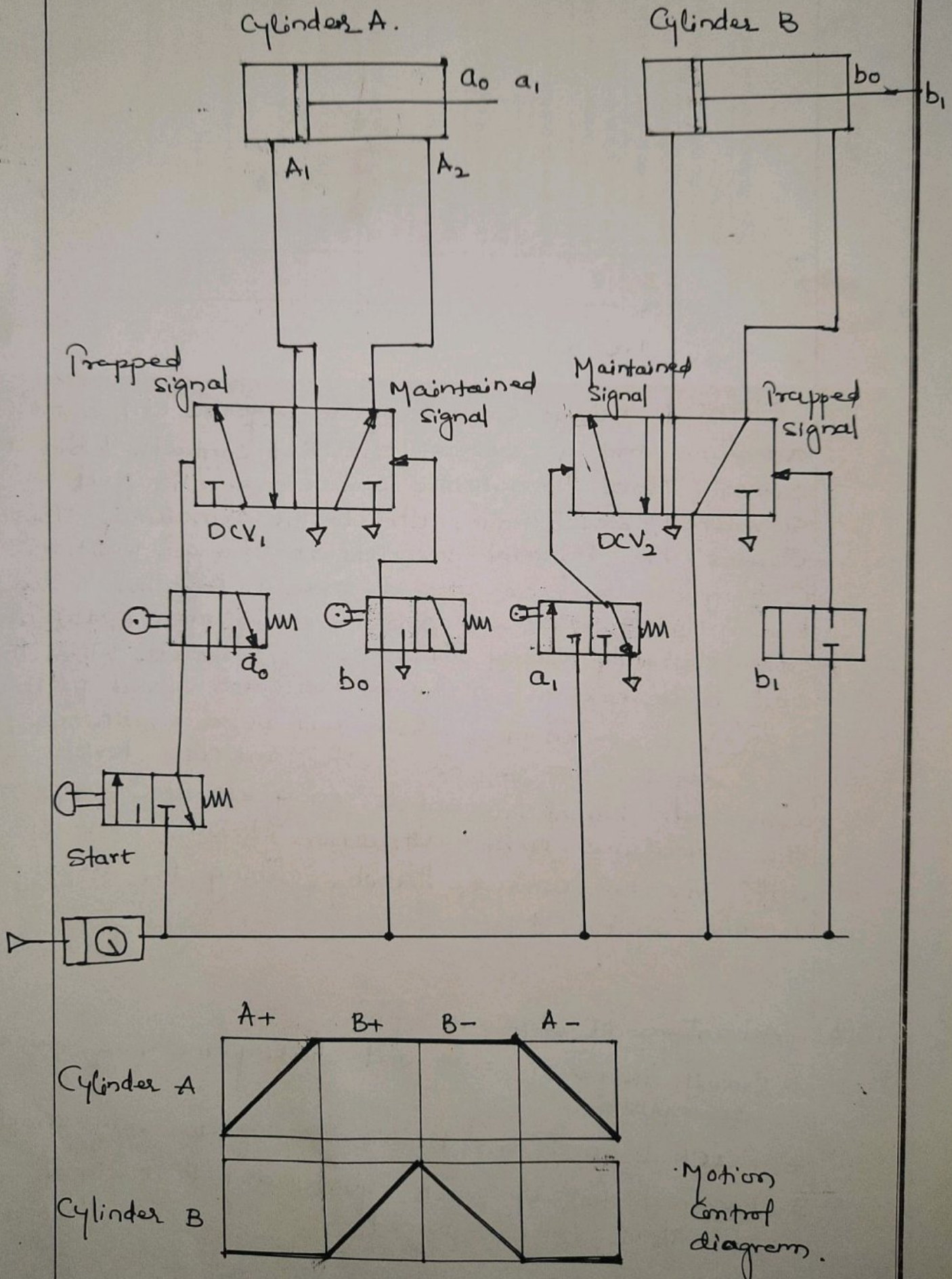


Electrical relay consists of a magnetic coil, a moving armature and a set of electrical contacts. When a current flows through the coil a magnetic field is generated, which inturn attracts the armature. This causes the internal contacts to change position (open to close, or close to open). For the relay shown in fig, there is one normally open (NO) and one normally closed (NC) set of contacts. When the coil is de-energised the contacts are closed position fig (a). That means, there will be a continious flow of current through the switch and the device is activated. When the coil is magnetised (energised) the armature under attraction breaks contact with the NO contact, thereby cutting the supply to the system fig (b)

Q10(b) Advantages of Cascade system

1. Circuit design, drawing and checking are very quickly accomplished.
2. Fault diagnosis and trouble-shooting are very simple.
3. Required task by each cylinder and their signal elements is fully ensured.

Q10(c)



Motion Control diagram.

In some sequential operations where the function of one cylinder is enclosed within the function of another cylinder, the signals remain active and lead to conflicting signals. These are termed trapped signals and maintained signals due to which the circuit does not work as desired.

A maintained signal is a pilot signal which has completed its function and remains effective so that it blocks the effect of other signals.

A trapped signal is a pilot signal applied to a valve with an opposing pilot signal remaining still effective.

As shown in fig an ineffective cylinder sequencing circuit. The circuit does not function due to the presence of trapped and maintained signals. Two situations can be noticed from the circuit.

(a) When the start signal is passed to valve a_0, actuated by the cylinder A at rest, it sends a pilot signal to DCV$_1$ to extend cylinder A. However, cylinder A can not extend since valve b_0 is actuated by the cylinder B at rest. This results in an opposing pilot signal to be applied to DCV$_1$, hence no actuation taken place. Thus, due to the maintained signal of b_0, the a_0 signal gets trapped resulting in nil action.

(b) Similarly, when cylinder B tries to retract b_1, it applies a pilot signal to DCV$_1$. However, since the cylinder A remaining at its extended position actuates valve a_1, which applies an opposing signal to DCV$_2$, thus multiplying the signal. Hence, no actuation results.

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