

TWO MARK QUESTIONS & ANSWERS

CHAPTER 1 : INTRODUCTION TO FLUID POWER

1. *Define the term fluid power.*

Fluid power may be defined as the technology that deals with the generation, control, and transmission of power using pressurized fluids.

2. *Distinguish between fluid transport and fluid power systems.*

✓ The objective of the fluid transport systems is to transport/deliver fluids from one place to another place to achieve some useful purpose.

✓ The fluid power systems use pressurized fluids to produce some useful mechanical movements to accomplish the desired work.

3. *Name three basic methods of transmitting power.*

1. Electrical power transmission,

2. Mechanical power transmission, and

3. Fluid power transmission,

(a) Hydraulic power transmission, and

(b) Pneumatic power transmission.

4. *Under what situations, electrical, mechanical, and fluid power transmissions are suitable ?*

✓ Electrical power transmissions are suitable for power transmission over long distances.

✓ Mechanical power transmissions are suitable for the transmission of motion and force over relatively short distances.

✓ Fluid power transmissions are suitable for power transmission over intermediate distances.

5. *What is the fundamental difference between hydraulics and pneumatics ?*

The hydraulic system employs pressurised liquid (such as oil) as the fluid medium whereas the pneumatic system employs compressed air.

6. *List any four advantages of using the fluid power.*

1. Ease and accuracy of control.

2. Multiplication of force.

3. Constant force or torque.

4. Simplicity, safety, and economy.

7. Why are hydraulic systems preferred for heavy work than the pneumatic systems ?

The hydraulic power systems can generate and transmit large torques and forces with high pressures to any part of a machine. That's why they are preferred for heavy work.

8. In comparison with hydraulic systems, why are pneumatic systems are suitable only for low load and low power applications ?

Since pneumatic pressures are quite low due to the compressor design, the pneumatic systems are suitable only for low load and low power applications.

9. What is it not possible to obtain a precise actuator control in pneumatic systems ?

Due to a high compressibility of air, it is impossible to obtain a precise actuator control in pneumatic systems.

10. List any four applications of fluid power in the manufacturing industry.

1. Hydraulic presses,
2. Pneumatic hand tools,
3. Hydraulic and pneumatic fixtures, and
4. Pneumatic driven automatic indexing machine.

11. What are the two main types of fluid power systems ?

1. Hydraulic power systems, and
2. Pneumatic power systems.

12. What are the basic components that are required for a hydraulic system ?

The six basic components of a hydraulic system are :

1. Reservoir (or tank),
2. Pump,
3. Prime mover,
4. Valves,
5. Actuator, and
6. Fluid-transfer piping.

13. List the basic components of a pneumatic system.

1. Reservoir (or air tank),
2. Compressor,
3. Prime mover,
4. Valves,
5. Actuator, and
6. Fluid-transfer piping.

14. What is the purpose of an actuator ?

An actuator is used to convert the fluid energy into mechanical force or torque to do useful work.

CHAPTER 2 : FLUIDS AND THEIR PROPERTIES

1. What are the primary functions of a fluid in any fluid power system ?

The primary functions of a fluid are as follows :

1. To transmit power.
2. To lubricate moving parts.
3. To seal gaps and clearances between mating components.
4. To dissipate heat generated by internal friction.
5. To prevent rust and corrosion.

2. Differentiate between a liquid and a gas.

Sl.No.	Liquid	Gas
1.	Posses a definite volume for a given mass, but conforms to the shape of the container.	Has a definite mass, but does not possess a definite volume and conforms to the shape of the container.
2.	Incompressible fluid.	Compressible fluid.
3.	It forms a free surface.	It expands and occupies the whole volume of the container.

3. What is density of a fluid ? What are the three different ways of expressing it ?

- ✓ The density of a fluid is that quantity of matter contained in unit volume of the substance.
- ✓ The three ways of expressing the density are : 1. Mass density, 2. Weight density, and 3. Specific gravity (or relative density).

4. What is meant by 'viscosity' of a fluid ? Also state Newton's law of viscosity.

- ✓ Viscosity is the measure of the ability of a fluid to flow. It is the measure of the fluid's internal resistance to shear or flow at a definite temperature and pressure.
- ✓ **Newton's law of viscosity** : It states that the shear stress on a fluid element layer is directly proportional to the rate of shear strain.

5. What are the undesirable effects when an oil having very high viscosity is used ?

When the oil is too thick (*i.e.*, oil having very high viscosity), the following undesirable effects will result in the system :

1. Increase in load and hence increased power loss.
2. High operating temperatures because there will be internal friction.
3. Excessive wear of parts.
4. Reduced internal leakage.

6. What are the undesirable effects when an oil viscosity is too low ?

When an oil viscosity is too low, then the following undesirable effects will result in the system :

1. Less internal friction.
2. Smaller pressure losses in pipes and valves.
3. Increase in control action and component response.
4. Increased internal and external leakage.
5. Cannot lubricate properly.

7. State the effect of temperature and pressure on viscosity of liquids.

The viscosity of the liquids decreases with increase in temperatures whereas the viscosity increases with increasing pressure.

8. State the effect of temperature and pressure on viscosity of gases.

The viscosity of gases increase with increase in temperature. Over the normal range of pressures, the viscosity of gases is found to be independent of pressure.

9. "The viscosity of liquid decreases but that of gases increases with increase in temperature"—Why?

- ✓ Since the shear stress in the liquids (due to the intermolecular cohesion) decreases with increase of temperature, therefore the viscosity of liquid decreases with increase in temperature.
- ✓ If the temperature of a gas increases, the molecular interchange will increase. Therefore the viscosity of a gas increases with increase in temperature.

10. What is viscosity index? What do you infer from V.I. number of an oil?

- ✓ The viscosity index (V.I) of a liquid is a number indicating the effect of a change in temperature on viscosity.
- ✓ The rate of change in viscosity with changes in temperature is relatively less with high V.I. oils than the low V.I. oils.

11. What is meant by the term compressibility of a fluid? Give the relationship between compressibility and bulk modulus.

- ✓ The compressibility is the fractional change in a unit volume of fluid per unit change of pressure. Mathematically,

$$\text{Compressibility, } C = \frac{(\Delta V/V)}{\Delta P}$$

- ✓ Bulk modulus is the reciprocal of compressibility. Mathematically,

$$\text{Bulk modulus, } K = \frac{1}{\text{Compressibility}} = \frac{\Delta P}{\left(\frac{\Delta V}{V}\right)}$$

12. Why should a hydraulic fluid have high bulk modulus?

The higher the bulk modulus, the less elastic or more stiffer the fluid. High bulk modulus values are desirable since they result in more stable and less elastic systems.

13. Define cloud point of an oil. Also give its significance.

- ✓ **Definition:** Cloud point is defined as the temperature at which wax or other dissolved solids begins to crystallise and become noticeable when liquids are chilled under specified conditions.
- ✓ **Significance:** The cloud point is of interest for use at low temperatures.

14. **Define pour point of an oil. Also mention its significance.**
✓ **Definition :** The pour point of an oil is the temperature below which the oil will not flow freely.
✓ **Significance :** This property is very important for hydraulic systems required to operate in extremely cold weather.
15. **Define the terms 'flash' and 'fire' points, relative to hydraulic fluids.**
✓ **The flash point** is the minimum temperature at which sufficient liquid is vaporised under specified conditions to create a mixture that will burnt if ignited.
✓ **The fire point** is the minimum temperature at which sufficient vapour is continuously generated to sustain combustion.
16. **Mention the significance of flash and fire points.**
Flash and fire points indicate the temperature at which the liquid begins to volatilize. A lower flash or fire point is an indication that the liquid has become contaminated with a more volatile product (such as fuel).
17. **What is demulsibility ? Write its significance.**
✓ The property of a hydraulic fluid to separate rapidly and completely from moisture and to resist emulsification is known as demulsibility.
✓ **Significance :** This property is significant because the operation of many hydraulic systems are conducive to the forming of moisture or of stable water-in-oil emulsions.
18. **What is oxidation stability ?**
Oxidation stability is defined as the ability of a liquid to resist reaction with oxygen or oxygen-containing compounds.
19. **Define the following terms, with reference to hydraulic fluids :**
(a) Lubricity, (b) Compatibility, and (c) volatility
(a) **Lubricity** is the ability of a liquid to impart low friction under boundary conditions.
(b) **Compatibility** is the ability of the hydraulic fluid to be compatible with the system.
(c) **Volatility** of a liquid describes the degree and rate at which it will vapourize under given conditions of temperature and pressure.
20. **What is neutralization number of hydraulic fluid ? Write its significance.**
✓ The neutralization number is a measure of acidity or alkalinity of a hydraulic fluid.
✓ High acidity causes the oxidation rate in an oil to increase rapidly.
21. **List few required properties of a good hydraulic fluid.**
 1. Stable viscosity characteristics.
 2. Good lubricity.
 3. Compatibility with system materials.
 4. Stable physical and chemical properties.
 5. Good heat dissipation capability.
 6. High bulk modulus and degree of incompressibility.

22. Name any four hydraulic fluids that are commonly used.

1. Petroleum oils.
2. Water-in-oil and oil-in-water emulsions.
3. Glycols.
4. Phosphate esters.

23. Name any three fire resistant fluids.

1. Water-in-oil emulsions.
2. Water glycols.
3. Phosphate esters.

24. Why is water not commonly used as a hydraulic fluid ?

Because the water exhibits the following disadvantages :

1. Water does not possess lubricating property.
2. Water evaporates soon and hence it can be used only over a limited range of temperature.
3. It is high corrosive in nature.

CHAPTER 3 : FLUID POWER SYMBOLS

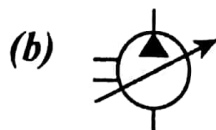
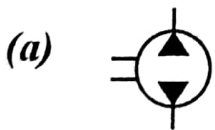
1. What are fluid power symbols ?

Fluid power symbols are used to represent individual components in fluid power circuit diagrams, which identify components and their functions uniquely.

2. Draw the graphic symbols for the following pumps :

(a) Fixed displacement bidirectional pump, and

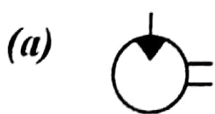
(b) Variable displacement unidirectional pump.



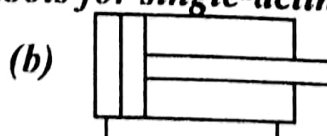
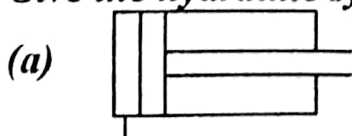
3. Draw the ANSI symbols for the following motors :

(a) Fixed displacement unidirectional motor, and

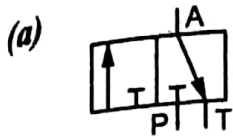
(b) Variable displacement bidirectional motor.



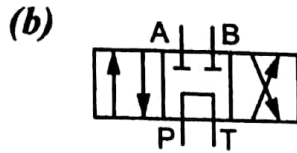
4. Give the hydraulic symbols for single-acting and double-acting cylinders.



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5. Give the fluid power symbols for the 3/2- and 4/3-way valves.



3/2 - way valve

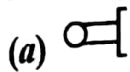


4/3 - way valve

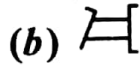
6. How can you indicate the direction of flow (i) for hydraulic fluid, and (ii) for pneumatic fluid.

- (i) Filled triangle Indicates the direction of flow for hydraulic fluid (system).
- (ii) Unfilled triangle Indicates the direction of flow for pneumatic fluid (system).

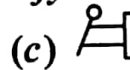
7. For the following graphic symbols shown, identify their mode of operation/actuation.



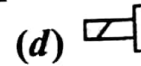
(a) Push button actuation,



(b) Pedal actuation,



(c) Lever actuation, and



(d) Solenoid actuation.

8. Draw the ANSI symbols for the following hydraulic components :

(a) Reservoir,



Vented reservoir

(b) Filter,



Pressurised reservoir

(c) Cooler, and

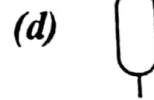


Filter

(d) Accumulator.

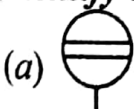


Cooler

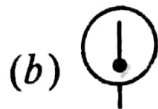


Accumulator

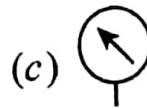
9. The following graphic symbols are used for indicating some measuring devices. Identify them.



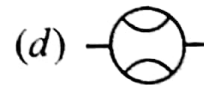
(a) Filling level indicator,



(b) Thermometer,



(c) Pressure gauge,



(d) Flow meter.

CHAPTER 4 : BASICS OF HYDRAULICS

1. Distinguish between gauge and absolute pressures. Give the relationship between them.

✓ If the pressure is measured with reference to the atmospheric pressure, then it is called **gauge pressure**. The pressure measured with respect to vacuum is called an **absolute pressure**.

✓ **Relationship** : Absolute pressure = Gauge pressure + Atmospheric pressure

2. **State Pascal's law (or) State the basic law that is important in applying fluid power.**

Pascal's law states that the pressure generated at any point in a confined fluid acts equally in all directions.

3. **Name any two applications of Pascal's law.**

1. Bramah's hydraulic press.
2. Air-to-hydraulic pressure booster.

4. **What is the purpose of a hydraulic press ?**

The hydraulic press amplifies the hydraulic force in the hydraulic systems. That is, in a hydraulic press a small input force is applied to generate a large output force.

5. **What is the use of air-to-hydraulic pressure booster ?**

The air-to-hydraulic pressure booster is a device used for converting compressed air into the higher hydraulic pressure, which is required for operating hydraulic cylinders.

6. **Differentiate between laminar and turbulent flow.**

- ✓ A laminar flow is one in which paths taken by the individual particles do not cross one another and move along well-defined paths. The laminar flow is characterised by the fluid flowing in smooth layers of laminae.
- ✓ A turbulent flow is that flow in which fluid particles move in a zig-zag way. The turbulent flow is characterised by continuous small fluctuations in the magnitude and direction of the velocity of the fluid particles.

7. **What is Reynold's number ? Write its significance with reference to fluid power systems.**

✓ Reynolds number, $Re = \frac{\rho VD}{\mu} = \frac{VD}{\nu}$

where ρ = Density of the liquid,

V = Velocity of flow,

D = Diameter of the pipe,

μ = Absolute viscosity of the fluid, and

ν = Kinematic viscosity of the fluid.

- ✓ Reynold's number is the basis for determining the laminar and turbulent flow. If $Re < 2000$, then the flow is laminar; and if $Re > 4000$, then the flow is turbulent.

8. **Name two causes of turbulence in fluid flow.**

(i) More resistance to flow.

(ii) Greater energy loss.

9. **If the temperature increases so that the fluid viscosity decreases, would the Reynolds number increase, decrease, or remain the same ?**

Since $Re = \frac{\rho VD}{\mu} = \frac{VD}{\nu}$, any decrease in fluid viscosity would increase the Reynolds

number.

10. **What is meant by flow rate ?**

Flow rate (or discharge) is the volume of the liquid flowing through a pipe in a specific period of time. Mathematically, $Q = \frac{V}{t} = A \times V$

11. **State the continuity equation.**

Continuity equation states as : "If no fluid is added or removed from the pipe in any length then the mass passing across different sections shall be same". Mathematically,

$$A_1 V_1 = A_2 V_2 = A_3 V_3$$

12. **State Bernoulli's equation.**

Bernoulli's equation states as follows : "In an ideal, incompressible fluid when the flow is steady and continuous, the sum of potential energy, kinetic energy and pressure energy is constant across all cross sections of the pipe." Mathematically,

$$z_1 + \frac{V_1^2}{2g} + \frac{P_1}{w} = z_2 + \frac{V_2^2}{2g} + \frac{P_2}{w}$$

13. **List out the various energy losses when liquid flows through a pipe.**

1. Major energy losses

This loss is due to friction.

2. Minor energy losses

These losses are due to :

(i) Losses in valves and pipe fittings.

(ii) Sudden enlargement/Contraction of pipe.

(iii) Bend in pipe, etc.

14. **Give the Darcy's equation. What is the use of it ?**

✓ The Darcy's equation for the head losses in pipes is as follows :

$$H_L = f \left(\frac{L}{D} \right) \left(\frac{V^2}{2g} \right)$$

✓ The Darcy's equation is used to calculate the energy losses due to friction in the pipe.

15. **Write down the Hagen-Poiseuille equation.**

The Hagen-Poiseuille, to find frictional losses in laminar flow, is as follows :

$$H_L = \frac{64}{Re} \left(\frac{L}{D} \right) \left(\frac{V^2}{2g} \right)$$

16. **Define the term relative roughness.**

The relative roughness is defined as the pipe inside surface roughness (ϵ) divided by the inside diameter of the pipe (D).

$$\therefore \text{Relative roughness} = \frac{\epsilon}{D}$$

17. **What is a Moody diagram ? Write its use.**

- ✓ The Moody diagram contains many curves. The curves indicate the value of friction factor as a function of Reynolds number and relative roughness.
- ✓ The Moody diagram can be used to determine the friction factor for use in Darcy's equation.

18. **Give the expression to calculate the loss of head in the valves and fittings of a pipe.**

The loss of head in the various valves and fittings is given by :

$$H_L = K \left(\frac{V^2}{2g} \right)$$

19. **Name any three flow-measuring devices.**

1. Rotometer,
2. Turbine flowmeter, and
3. Orifice flowmeter.

20. **Name any two pressure-measuring devices.**

1. Bourdon gauge, and
2. Schrader gauge.

CHAPTER 5 : PUMPS – THE SOURCE OF HYDRAULIC POWER

1. **What is the function of a hydraulic pump ?**

A hydraulic pump is a device which converts mechanical energy into hydraulic energy.

2. **How can you classify pumps ?**

1. Positive displacement pumps.
 - (a) Rotary pumps (such as gear pumps, and vane pumps)
 - (b) Reciprocating pumps (such as piston pumps)

2. Non-positive displacement pumps.

3. **What are positive displacement pumps ? Why are they called so ?**

- ✓ The positive displacement pumps discharge a fixed quantity of fluid into the hydraulic system per revolution of pump shaft rotation.
- ✓ Since the flow of fluid is guaranteed on every revolution of the shaft, this type of pump is named as 'positive' displacement pump.

4. **Name any four positive displacement pumps.**

1. External and internal gear pumps.
2. Lobe and screw pumps.
3. Vane pumps.
4. Piston pumps.

5. ***Why are positive displacement pumps universally used in fluid power industries ?***

Positive displacement pumps are primarily used where pressure development is the prime requirement. This type of pumps is capable of delivering high pressure fluid, so it is universally used in fluid power systems.

6. ***What do you mean by non-positive displacement pumps ?***

In non-positive displacement pumps, the fluid flow is achieved by using inertia of the fluid in motion.

7. ***Where are non-positive displacement pumps employed ? Why ?***

The non-positive displacement pumps are suitable for low-pressure, high-volume flow applications. Since these pumps cannot withstand high pressures, they are used only for transporting fluid from one place to another.

8. ***Why are centrifugal (or non-positive displacement) pumps not preferred for fluid power applications ?***

Because the centrifugal pumps cannot withstand high pressures. Also they are suitable for low-pressure high-volume flow applications.

9. ***Name any four types of gear pumps used in hydraulic systems.***

1. External gear pumps,
2. Internal gear pumps,
3. Lobe pumps, and
4. Screw pumps.

10. ***Why all the gear pumps are fixed displacement pumps ? (or) Why gear pumps cannot be used as variable displacement pumps ?***

In gear pumps, the volumetric displacement depends on the design parameters (*i.e.*, diameter and width of gear teeth) of gears and they cannot be varied. So the displacement cannot be varied in gear pumps.

11. ***What type of gears are generally used in gear pumps ?***

The gears in the gear pumps can be of spur gear, helical gear or herringbone gear.

12. ***How can you specify a pump ?***

A pump can be specified by its capacity, discharge pressure, and speed of rotation.

13. ***Which pump—external gear, internal gear, screw, vane and piston—generates the least noise ? Why ?***

Screw pump generates the least noise, because of rolling action of the screw spindles. Also in the screw pump, the fluid does not rotate but moves linearly.

14. ***Name two designs of vane pumps.***

1. Unbalanced vane pumps, and
2. Balanced vane pumps.

15. Distinguish between fixed displacement and variable displacement pumps ?

In fixed displacement pumps, the displacement of the pump cannot be varied by any means. But in variable displacement pumps, the displacement of the pump can be varied by some suitable arrangements.

16. When do you call a vane pump as a balanced or unbalance one ?

A vane pump can be referred as unbalanced pump if all the pumping action takes place on one side of the rotor. But the balanced vane pump has two intake and two outlet ports which are diametrically opposite to each other.

17. How can the unbalanced vane pump be used as a variable displacement pump ?

In unbalance vane pump, the variable displacement can be provided by mechanically varying the eccentricity.

18. What are the advantages of balanced vane pumps over the unbalanced vane pumps ?

1. The balanced vane pumps eliminate the bearing side loads and thus permit higher operating pressures.
2. The balanced vane pumps have much improved service lives over simpler unbalanced vane pumps.

19. What are piston pumps ? Name the two basic types of piston pumps.

- ✓ In piston pumps, the pumping action is affected by a piston that moves in a reciprocating cycle through a cylinder.
- ✓ **Types :** 1. Axial piston pumps, and
2. Radial piston pumps.

20. How can you vary the displacement in an axial piston pump ?

The variable displacement in an axial piston pump can be achieved by altering the angle of the swash plate (or offset angle). Because in axial pumps, this swing angle determines the piston stroke and hence the pump displacement.

21. Differentiate between axial and radial piston pumps.

In axial piston pumps, the pistons move in-line or parallel to the shaft centre-line. But in radial piston pumps, the pistons move perpendicularly to the shaft centre-line.

22. Define volumetric efficiency of a pump. Also write its significance.

- ✓ Volumetric efficiency is the ratio between the actual flow rate produced by the pump and the theoretical flow rate that the pump should produce.

$$\therefore \eta_{vol} = \frac{Q_A}{Q_T} \times 100$$

- ✓ **Significance :** The volumetric efficiency indicates the amount of leakage within the pump.

23. Define mechanical efficiency of a pump. What does it indicate ?

- ✓ Mechanical efficiency is the ratio between the theoretical power required to operate the pump and the actual power delivered to the pump.
- ✓ It indicates the amount of energy losses that occur due to reasons other than leakages.

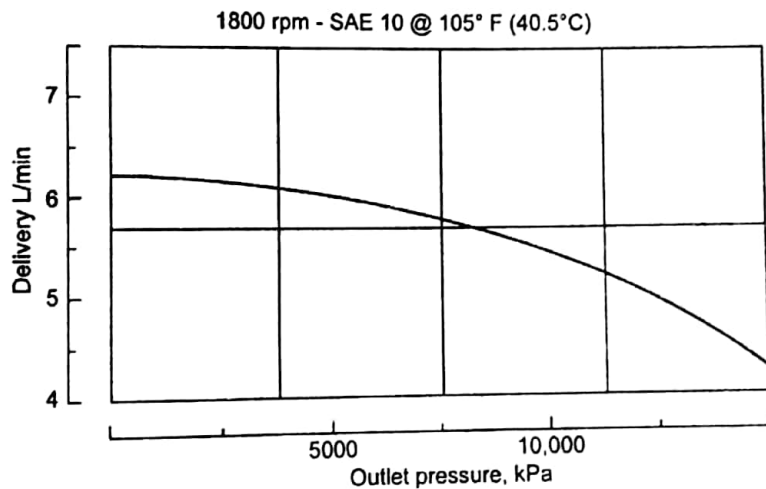
24. What is overall efficiency of a pump ?

- ✓ Overall efficiency is the ratio between the actual power delivered by pump and the actual power delivered to pump.

$$\therefore \eta_0 = \eta_{vol} \times \eta_{mech}$$

- ✓ It indicates the amount of energy losses by all means.

25. Draw the characteristic curve showing the relationship between discharge pressure and rate of delivery of an external gear pump.



26. What do you mean by 'slip' in pumps ?

Slip is the leakage that occurs between the discharge and suction sides of a pump through the pump clearances.

27. What is pump cavitation ? How can you avoid/eliminate it ?

- ✓ The formation, growth, and collapse of vapour filled cavities or bubbles in a flowing liquid due to local fall in fluid pressure is called pump cavitation.
- ✓ Pump cavitation can be avoided by ensuring that the suction pressure is always greater than that required by the pump.

28. What is pump ripple ?

Small variations of fluid flow that takes place during pumping due to some design problems are called pump ripple.

29. List some of the factors one should consider while selecting a pump for a specific application.

- Safe and maximum system working pressure.
- Rated pump performance.
- Suitability of variable displacement control.
- System flow rate requirement.

CHAPTER 6 : HYDRAULIC ACTUATORS : THE TRANSMITTER

1. *What is the function of a hydraulic actuator ?*

A hydraulic actuator is used for converting hydraulic energy into mechanical energy.

2. *How can you classify the hydraulic actuators ?*

1. Linear actuators (also called 'hydraulic cylinders'), and
2. Rotary actuators (also called 'hydraulic motors').

3. *What is the function of a hydraulic cylinder ?*

The hydraulic cylinder is used to convert fluid power into linear mechanical force and motion.

4. *Mention few applications of hydraulic cylinders.*

The hydraulic cylinders are basically used for performing work such as pushing, pulling, tilting, and pressing in a variety of engineering applications such as in material handling equipment, machine tools, construction equipment, and automobiles.

5. *Name different types of hydraulic cylinders.*

1. Single acting cylinders,
2. Double acting cylinders,
3. Telescoping cylinders,
4. Tandem cylinders, and
5. Through rod cylinders.

6. *By what means, single-acting cylinders are retracted ?*

The single-acting cylinders are retracted using gravity or by the inclusion of compression spring at the rod end of the cylinders.

7. *Differentiate between a single-acting and a double-acting hydraulic cylinder.*

Single-acting hydraulic cylinders can deliver a force in only one direction. But in double-acting cylinders, liquid pressure can be applied to either side of the piston, thereby providing a hydraulic force in both directions.

8. *What is the purpose of seals in hydraulic system ?*

The seals are used to prevent the internal and external leakages of hydraulic system.

9. *What are the three types of seals used in a double-acting cylinder ? Also write their functions.*

1. *Piston seals* : They are provided in between piston and barrel to avoid any leakage.
2. *Wipe or Scraper seal* : It is fitted on the outside of the piston rod bearing to prevent grit, water or other matter being drawn into the bearing.
3. *O rings* : O rings, also called internal sealing rings, are fitted behind the bearing to prevent high pressure fluid leaking out along the rod.

10. *Why are double-acting cylinders known as differential cylinders ?*

Since the piston rod is attached at one side only, the cylinder exerts greater force when extending [$F = P \times A_{\text{piston}}$] than when retraction [$F = P \times (A_{\text{piston}} - A_{\text{rod}})$]. This results in different pressure levels on either side of the piston and that's why double-acting cylinders are also called as differential cylinders.

11. **What is meant by cylinder cushioning ?**

When the pressurised fluid is allowed to enter inside the cylinder, the piston accelerates and travels in the cylinder barrel. If the piston is allowed to travel at the same speed till the end of the stroke, it will hit the end cap with a great impact. To avoid this impact, the piston needs to decelerate at the end of the travel. The arrangement made at the end caps to achieve the same is called 'cylinder cushion'.

12. **What is a telescopic cylinder ? When is it normally used ?**

- ✓ A telescopic cylinder consists of a series of rams (pistons) nested in a telescopic assembly which provide a long extension.
- ✓ Telescopic cylinders are useful for application requiring a long stroke but with only limited space available for the unextended ram.

13. **What are tandem cylinders ? When are they normally used ?**

- ✓ A tandem cylinder is one in which two or more piston ^{and} rod combinations are assembled as a rigid unit with all pistons mounted on single rod.
- ✓ The cylinders are used to obtain a low-force, high-speed action followed by a high-force, low-speed action.

14. **What do you mean by double-rod cylinder ?**

A double-rod cylinder, also known as through-rod cylinder has piston rods extending from both ends of the cylinder. These cylinders produce equal force and speed on both sides of the cylinder.

15. **Name few cylinder mountings.**

- | | |
|----------------------|------------------------|
| 1. Side foot mount, | 5. Rear flange mount, |
| 2. Centerline mount, | 6. Front flange mount, |
| 3. End foot mount, | 7. Clevis mount, |
| 4. Side-flush mount, | 8. Basic mount, etc. |

16. **What is the function of a hydraulic motor (or rotary actuator) ?**

The function of a hydraulic motor (or rotary actuator) is to convert hydraulic energy into rotary mechanical energy.

17. **Name the basic types of rotary actuators. Which will provide the maximum degree of rotation ?**

- ✓ **Types :**
 1. Continuous rotary actuator, and
(a) Gear motor, (b) Vane motors, and (c) Piston motors.
 2. Limited rotation hydraulic motors.
(a) Vane type, and (b) Piston type.
- ✓ Continuous rotary actuators will provide the maximum degree of rotation.

18. **How do you rate/specify a hydraulic motor ?**

The hydraulic motors are usually specified in terms of the torque developing capacity or differential pressure.

19. Which hydraulic motor is generally the most efficient ? Why ?

The piston motors are the most efficient motors. Because they are positive displacement motors.

20. Mention few applications where piston motors are employed.

Piston motors are suitable for low-speed, high torque traction applications such as earth-moving machinery, agricultural tractors, railway locomotive and other industrial applications.

21. What do you mean by a limited rotation hydraulic motor ?

The limited-rotation motors provide rotary output motion over a finite angle. Usually rotation of the shaft of these motors is 90°, 180°, or 270°.

22. Mention few applications of limited rotation hydraulic motors.

The important applications of limited rotation hydraulic motors include conveyor sorting, valve turning, air bending operations, flip over between workstations, positioning for welding, lifting, rotating, and dumping.

23. With respect to hydraulic motors, define the terms volumetric and mechanical efficiency.

$$\checkmark (\eta_{vol})_{motor} = \frac{\text{Theoretical flow rate motor should consume}}{\text{Actual flow rate consumed by motor}} \times 100$$

$$\checkmark (\eta_{mech})_{motor} = \frac{\text{Actual torque delivered by motor}}{\text{Torque motor should theoretically deliver}} \times 100$$

24. What is meant by a fluid transmission device ?

A fluid transmission device converts mechanical power into fluid power, transports this power, and then converts it back into mechanical power.

CHAPTER 7 : HYDRAULIC VALVES : THE REGULATOR

1. What are the three important parameters that should be controlled in a hydraulic system ?

1. Pressure,
2. Flow direction, and
3. Flow rate.

2. What are control (or hydraulic) valves ?

Control valves are devices used to control pressure, flow direction, or flow rate in hydraulic circuits.

3. Name the three basic types of control valves based on their function.

1. Directional control valves,
2. Pressure control valves, and
3. Flow control (or volume control) valves.

4. **What are the three types of control valves based on their configuration ?**

1. Poppet (or seat) valves,
2. Sliding spool valves, and
3. Rotary spool valves.

5. **What are the advantages of sliding-spool type valves over the poppet type valves ?**

1. Different operations can be achieved with a common body and different spools.
2. Reduced manufacturing cost.
3. Reduced fluid leakage rate.
4. All types of actuation are easily adaptable.

6. **What is the function of a DCV ?**

The function of a directional control valve (DCV) is to control the direction of flow in a hydraulic circuit.

7. **What are the function of check valves ?**

Check valves are used :

- (i) to allow free flow in only one direction, and
- (ii) to prevent any flow in the other direction.

8. **What is the difference between a simple check valve and a pilot check valve ?**

The simple check valve does not permit any reverse flow. The pilot-check valve can allow fluid flow in both directions, but the reversed flow depends upon the pilot actuation.

9. **What does a 4/3 control valve represent ?**

A 4/3 control valve has 4 ways and 3 positions.

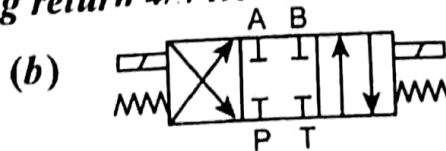
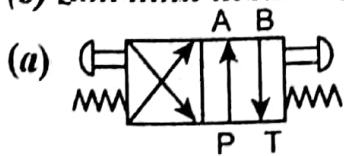
10. **What are the different valve actuation methods used ?**

1. Manual actuation,
2. Mechanical actuation,
3. Electrical actuation, and
4. Fluid actuation.

11. **Draw the graphic symbol for the following DC valves :**

(a) **Push button operated, four way, two position, spring offset DC valve, and**

(b) **Solenoid actuator, spring return 4/3 DC valve.**



12. **What is a solenoid and how does it actuate the spool of a DC valve ?**

A solenoid is an electromagnetic coil. When it is energized, it creates a magnetic force that pulls the armature. The armature is connected to the spool of the valve and the valve is actuated.

13. Mention the application of a (i) 3 way DC valve, and (ii) 4 way DC valve.

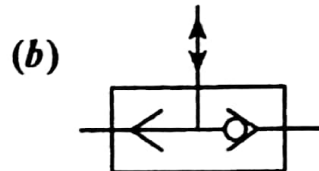
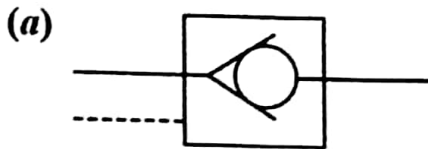
(i) Three way DC valves are used to control single-acting linear actuators.

(ii) Four way DC valves are used to control double-acting actuators.

14. What is the purpose of a shuttle valve ?

Shuttle valves are used when control is required from more than one power source. They are generally used to shift the fluid flow from the second and back up source, when the main source becomes inoperative.

15. Draw the ANSI symbols for (i) a pilot-operated check valve, and (ii) a shuttle valve.



16. What are pressure control valves ? Mention their functions.

✓ Pressure control valves are the devices used to control the fluid pressure in a system.

✓ Functions of pressure control valves are :

(i) To limit the maximum pressure in various circuit components as a safety measure.

(ii) To maintain the desired pressure levels in various parts of the circuits.

(iii) To unload system pressure.

(iv) To assist sequential operation of actuators in a circuit with pressure control.

17. Name various types of pressure control valves.

1. Pressure limiting (or relief) valves,

2. Pressure reducing valves,

3. Sequence valves,

4. Counter balance valves, and

5. Unloading valves.

18. What is the use of a pressure relief valve in a hydraulic system ?

The pressure relief valve protects a system from excessive fluid pressure over and above the design pressure limit.

19. What is the purpose of a pressure reducing valve ?

A pressure reducing valve is used to supply a prescribed reduced outlet pressure in a circuit and to maintain it at a constant value.

20. What are sequence valves ?

The sequence valves are used to control the fluid flow to ensure several operations in a particular order of priority in the system.

21. What is the purpose of a counterbalance valve ?

The counterbalance valve is used to permit free flow in one direction and restricted flow in the opposite direction.

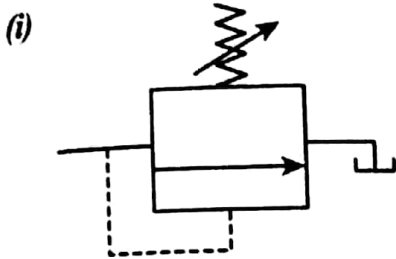
22. **What is the function of an unloading valve ?**

The unloading valve allows pressure to build up to an adjustable setting, then bypasses the flow as long as a remote source maintains the preset pressure on the pilot port.

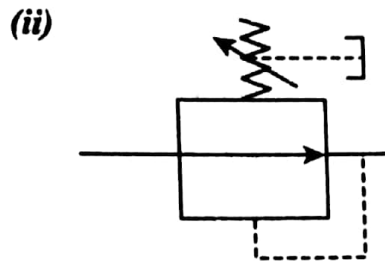
23. **What is the use of a hydraulic fuse ?**

The hydraulic fuse, analogous to an electrical fuse, is used to prevent the system pressure from exceeding beyond the allowable limit in order to protect the system components from damage.

24. **Draw the graphic symbols for (i) a pressure relief valve, and (ii) a pressure reducing valve.**



Pressure relief valve



Pressure reducing valve

25. **What are flow control valves ? Why are they referred as speed-control valves ?**

- ✓ Flow control valves, also known as volume-control valves, are used to regulate the rate of fluid flow to different parts of a hydraulic system.
- ✓ Since control of flow rate is a means by which the speed of hydraulic machine elements is governed, therefore flow control valves are also referred as speed-control valves.

26. **Name few non-pressure compensated flow control valves.**

1. Disk-type globe valve,
2. Plug-type globe valve,
3. Ball-type globe valve, and
4. Needle valve.

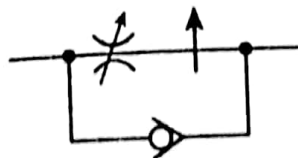
27. **What do you mean by a pressure-compensated flow control valve ?**

The flow rate through any orifice depends upon the pressure difference between its inlet and outlet. Therefore a constant pressure drop across the valve orifice is required to assure accurate flow control. This is accomplished with the pressure-compensated flow control valve.

28. **Why are flow control valves often temperature compensated ?**

Flow control valves can be affected badly by temperature changes which also change the viscosity of the fluid. Therefore often flow control valves have temperature compensation.

29. **Draw the graphic symbol for a pressure-compensated flow control valve.**



Symbol for pressure compensated flow control valve

30. With reference to a flow control valve, define the term capacity coefficient.

The term capacity coefficient may be defined as the flow rate of water in Lpm that will flow through the valve at a pressure drop of 1 kPa.

CHAPTER 8 : ACCUMULATORS AND INTENSIFIERS

1. Name any six ancillary equipment commonly used in the hydraulic system.

- | | |
|----------------------|---------------------------------------|
| 1. Fluid reservoir, | 2. Filters and strainers, |
| 3. Heat exchangers, | 4. Pressure and temperature switches, |
| 5. Accumulators, and | 6. Intensifiers. |

2. What is the purpose of a fluid reservoir ?

- ✓ Fluid reservoirs are basically used to provide a storage facility for the hydraulic fluid used by the system.
- ✓ In addition, the reservoirs also serve to separate entrained air, remove contaminants, and dissipate heat from the fluid.

3. What is the purpose of a heat exchanger in hydraulic systems ?

Heat exchangers, also known as hydraulic coolers, are devices used to dissipate the heat generated in a hydraulic system.

4. Why is pressure measurement considered as a crucial process in the troubleshooting of hydraulic circuits ?

Because pressure measurement can provide a good indication of leakage problems and faulty components such as pumps, motors, valves, and actuators.

5. What is the use of a pressure switch ?

A pressure switch is an instrument that automatically senses a change in pressure and opens or closes an electrical switching element when a predetermined pressure point is reached.

6. What is the use of a temperature switch ?

A temperature switch is an instrument that automatically senses a change in temperature and opens or closes an electrical switching element when a predetermined temperature point is reached.

7. What is the use of a shock absorber in hydraulic systems ?

A shock absorber is a device that brings a moving load to a gentle rest through the use of metered hydraulic fluid.

8. What is the function of an accumulator ? What electrical device is it analogous to ?

- ✓ An accumulator is a pressure storage reservoir in which a non-compressible hydraulic fluid is retained under pressure from an external source.
- ✓ The function of hydraulic accumulator is analogous to that of a capacitor in an electrical circuit.

9. **What are the three basic types of accumulators used in hydraulic systems ?**

1. Weight-loaded (or dead-weight) accumulators,
2. Spring-loaded accumulators, and
3. Gas-loaded accumulators.

10. **What are the uses/functions of accumulators ?**

Accumulators are used as :

- | | |
|-------------------------------|--------------------------------|
| (i) Leakage compensator, | (ii) Auxiliary power source, |
| (iii) Emergency power source, | (iv) Hydraulic shock absorber, |
| (v) Fluid make-up device, | (vi) Holding device, etc. |

11. **Which type of accumulator operates at constant pressure ?**

The weight-loaded type accumulator operates at constant pressure.

12. **What type of gas is used in gas-loaded accumulators ? Why is oxygen not used for this purpose ?**

- ✓ The inert gas such as nitrogen gas is used in gas-loaded accumulator.
- ✓ The air or oxygen are not used due to the danger of explosion.

13. **What is meant by the term 'capacity' of an accumulator ?**

The maximum amount of energy that the accumulator can store is known as the capacity of the accumulator.

14. **What are three significant accumulator operating conditions ?**

1. Recharging condition.
2. Charging (the fluid to maximum pressure) condition, and
3. Discharging (the fluid to minimum pressure) condition.

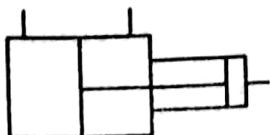
15. **What is the function of a pressure intensifier ? What electrical device is it analogous to ?**

- ✓ Pressure intensifier, also known as pressure booster, is used to compress the liquid in a hydraulic system to a value above the pump discharge pressure.
- ✓ It is analogous to a step-up electrical transformer.

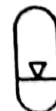
16. **Define the term intensifier ratio.**

$$\text{Intensifier ratio} = \frac{\text{High outlet pressure (P}_i\text{)}}{\text{Low inlet pressure (P}_o\text{)}} = \frac{\text{Area of large piston (A}_o\text{)}}{\text{Area of small piston (A}_i\text{)}}$$

17. **Draw the fluid power symbols for (i) a pressure intensifier and (ii) gas-loaded type accumulator.**



(i) Symbol for pressure intensifier



(ii) Symbol for gas-loaded accumulator

CHAPTER 9 : ELECTRICAL CONTROLS FOR FLUID POWER SYSTEMS

1. *Why are electrical controls of fluid power systems preferred than the manual controls ?*

Because electrical controls offer the following features :

- (i) They can be easily controlled.
- (ii) They improve the overall control flexibility of fluid power systems.
- (iii) They provide quick and accurate control operations.
- (iv) They require less maintenance.

2. *Name any four basic electrical devices commonly used in the control of fluid power systems.*

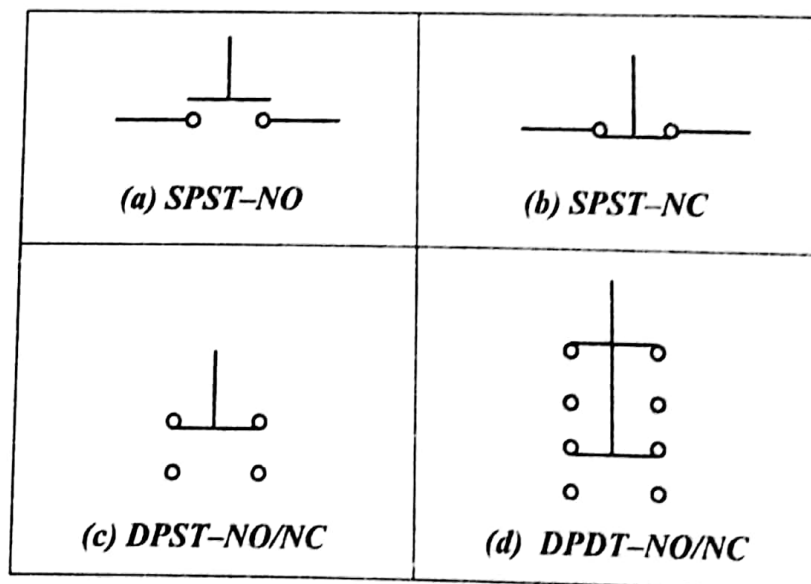
1. Push-button switches,
2. Limit switches,
3. Solenoids, and
4. Relays.

3. *What is the use of a push-button switch ?*

The push-button switch is primarily used for starting and stopping of the machinery.

4. *What are the four types of push-button switches ? Also draw their graphic symbols.*

- (i) Single-pole single-throw—Normally open type (SPST–NO),
- (ii) Single-pole single-throw—Normally close type (SPST–NC),
- (iii) Double-pole single-throw type (DPST), and
- (iv) Double-pole double-throw type (DPDT).



Graphic symbols for push-button switches

5. *What are limit switches ? How do they differ from push-button switches ?*

- ✓ The limit switches are used to identify the extreme limits of the cylinder actuation.
- ✓ **Difference :** The difference between the push-button and limit switches is that push-button switches are actuated manually whereas the limit switches are mechanically actuated devices.

6. **What is the purpose of a pressure switch ?**

The pressure switches are used to sense a change in pressure automatically, and opens or closes an electrical switch when a predetermined pressure is reached.

7. **What is the use of a temperature switch ?**

The temperature switches are used to sense a change in temperature automatically, and opens or closes an electrical switch when a predetermined temperature is reached.

8. **What is a solenoid ? Also state its use.**

✓ A solenoid is an electromagnetic mechanical transducer that converts an electrical signal into a mechanical output force.

✓ Solenoids provide a push or pull force to remotely operate fluid power valves.

9. **What is the purpose of having an indicator lamp in an electric circuit of a fluid power system ?**

Indicator lamps are used :

(i) to identify which solenoid operator of a DC valve is energized, and

(ii) to indicate whether a hydraulic cylinder is extending or retracting.

10. **What do you mean by an electrical relay ?**

The electrical relays offer simple ON/OFF switching action in response to a signal issued by a control system. Relays are commonly used to open or close the contacts and thereby energize or de-energize solenoids which operate at a high current level.

11. **What is the purpose of a timer ?**

Timers, also known as *time-delay relays*, are time delay switches used to control the time duration of a working cycle.

12. **Explain one situation where you use an electrical timer.**

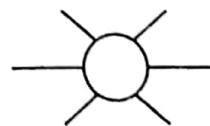
The times can be adjusted to change the dwell period for many machinery operations. For example, in a drilling machine operation the timers provide a dwell, which allows the drill to pause for a predetermined time at the end of the stroke to remove the chips.

13. **Draw the graphic symbols for the following :**

(a) Solenoid, and (b) Indicator lamp.



(a) Solenoid



(b) Indicator lamp

14. **What is a ladder diagram ?**

A ladder diagram is nothing but an electrical diagram showing the hardware connections between the various electrical control devices.

15. **What are the uses of a ladder diagram ?**

Ladder diagrams provide a circuit designer with a practical means to examine input process and output functions to quickly plan the circuit layout design for a particular hydraulic or pneumatic application.

CHAPTER 10 : BASICS OF PNEUMATICS

1. Define 'pneumatics'.

The pneumatics may be defined as that branch of engineering-science which deals with the study of the behaviour and application of compressed air.

2. Why is air used as the fluid medium in all pneumatic systems ?

The air is popularly used as the fluid-medium in pneumatic systems due to the following reasons :

- (i) Air is abundantly available.
- (ii) It is safe to use (as it has the fire-proof characteristics).
- (iii) It is very cheaper in cost.
- (iv) Easier maintenance and easily handling.
- (v) It can be exhausted easily to the atmosphere after use.

3. 'Pneumatic systems cannot provide precise actuator control'—Why ?

Due to the high compressibility of air pneumatic systems cannot provide precise actuator control.

4. 'Pneumatic systems cannot be applied to high-pressure application'—Why ?

Due to compressor design limitations, pneumatic systems can be applied only to low-pressure (less than 17 bars) applications.

5. For what type of application, you would prefer to use pneumatic systems rather than hydraulic systems.

If the application requires speed, a medium amount of pressure, and only a fairly accurate feed, then pneumatic system can be used.

6. Give the composition of air.

The main constituents of air by volume are 78% nitrogen, 21% oxygen, and 1% other gases such as argon and carbon dioxide.

7. What do you mean by standard air ?

Standard air is sea-level air having a temperature of 20°C, pressure of 1.013 bar, and a relative humidity of 36%.

8. State the following perfect gas laws :

(i) Boyle's law, (ii) Charles' law, and (iii) Gay-Lussac's law.

- (i) **Boyle's law** states that if temperature remains constant, the pressure of a confined mass of gas will vary inversely with its volume.
- (ii) **Charles' law** states that pressure remaining constant, the volume of a given mass of gas will vary directly as its absolute temperature.
- (iii) **Gay-Lussac's law** states that volume remaining constant, the pressure of a confined mass of gas will vary directly as its absolute temperature.

1. What is the use of a compressor in a pneumatic system ?

In pneumatic systems, compressors are used to compress and supply the required quantities of air.

2. What does staging mean ?

Staging means dividing the total pressure among two or more cylinders by allowing the outlet from one cylinder into the inlet of the next cylinder and so on.

3. Why are multi-stage compressors preferred over single-stage compressors ?

When the multistage compressors are used, the effective cooling can be implemented between stages. This effective cooling (i) reduces input power requirements, and (ii) increases the efficiency of the compressor.

4. What is the purpose of compressor starting unloader control ?

The 'starting unloader control' is used to start the compressor whenever desired. This arrangement releases the pressure in the piping to the atmosphere so that the compressor can be started whenever needed.

5. How can you specify an air compressor ?

Air compressors are generally specified by the following :

- (i) Outlet pressure of air that can be delivered by the compressor,
- (ii) Capacity of volume of air that can be delivered by the compressor, and
- (iii) Compressor configuration and cylinder geometry.

6. What is the purpose of fluid conditioners ?

The purpose of fluid conditioners is to make the compressed air more acceptable and suitable fluid medium for the pneumatic system components as well as for operating personnel.

7. Name any four fluid conditioners used in pneumatic systems.

- 1. Filters,
- 2. Regulators,
- 3. Lubricators, and
- 4. Mufflers.

8. What is the function of air filters ?

The function of air filters is to remove all foreign matter and allow dry, clean air to flow without restriction to the regulator and then on to the lubricator.

9. What is the purpose of an air pressure regulator ?

The function of the air pressure regulator is to regulate the pressure of the incoming compressed air so as to achieve the desired air pressure at a steady condition.

10. What is the use of lubricators applied in pneumatic systems ?

The function of an air lubricator is to add a controlled amount of oil with air to ensure proper lubrication of internal moving parts of pneumatic components.

11. What do you mean by FRL unit ?

The combination of filter, regulator, and lubricator is often labelled as FRL unit or service unit.

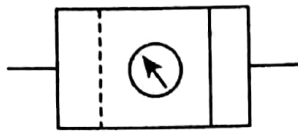
12. Why are mufflers used in pneumatic systems ?

The function of mufflers is to control the noise caused by a rapidly exhausting air-stream flowing into the atmosphere.

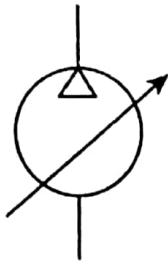
13. What is the need for air dryers ?

The air dryers are needed to remove all water vapour/moisture from the air leaving the compressor.

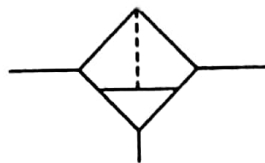
14. Draw the graphic symbol of a FRL unit.



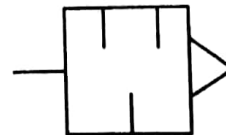
15. Draw the graphic symbol of (a) air compressor, (b) filter, and (c) Muffler.



(a) Single, variable displacement compressor



(b) Filter-strainer



(c) Muffler

CHAPTER 12 : PNEUMATIC VALVES AND ACTUATORS

1. What are the functions of air control valves ?

The main functions of pneumatic valves are :

- (i) To start and stop pneumatic energy;
- (ii) To control the directional flow of compressed air;
- (iii) To control the flow rate of the compressed air; and
- (iv) To control the pressure rating of the compressed air.

2. Mention the applications of a 2 way, 3 way, and 4 way D.C valves.

Generally two way DC valves are used as on-off type valves; three way DC valves are used to control single-acting linear actuators; and four way DC valves are used to control double-acting actuators.

3. What is the purpose of a quick exhaust valve ?

The quick (or fast) exhaust valve is used to exhaust the cylinder air to the atmosphere quickly, so as to increase the piston speed of cylinders.

100

4. ***What is the function of an air pressure regulator ?***

The air pressure regulator is used to supply a prescribed reduced outlet pressure in a pneumatic circuit and to maintain it at a constant value.

5. ***What is the function of a flow control valve in a pneumatic circuit ?***

Flow control valves are used to regulate the volumetric flow of the compressed air to different parts of a pneumatic system.

6. ***What is the function of a pneumatic actuator ?***

Pneumatic actuators are the devices used for converting the pressure energy of air into mechanical energy to perform useful work.

7. ***How do pneumatic actuators differ from hydraulic actuators ?***

Generally pneumatic actuators are of lighter construction and of lesser weight when compared to that of hydraulic actuators. This is because the pneumatic actuators are used mostly for low or medium pressure applications only.

8. ***What is the function of a pneumatic cylinder ?***

Pneumatic cylinders are the devices used for converting the air pressure into linear mechanical force and motion.

9. ***What is the function of an air motor ?***

The function of an air motor is to convert the pressure energy of the compressed air into rotary mechanical energy.

CHAPTER 13 : FLUID POWER CIRCUIT DESIGN

1. ***What are the four important factors that should be considered while designing a fluid power circuit ?***

- | | |
|---------------------------------|-------------------------------------|
| 1. Safety of operation, | 2. Performance of desired function, |
| 3. Efficiency of operation, and | 4. Cost. |

2. ***What is meant by hydraulic power pack ?***

- ✓ Hydraulic power pack consists of a pump, drive motor, mechanical couplings, oil reservoir, filters, coolers and valves assembled as a single unit to supply pressurized fluid.
- ✓ It provides pressure, direction, and flow control functions within the basic package.

3. ***What is the use of a regenerative circuit ?***

A regenerative circuit is used to speed up the extending speed of the double-acting cylinder.

4. **Why is the load-carrying capacity of a regenerative cylinder small when the piston rod area is small ?**

We know that,

$$\left. \begin{array}{l} \text{Regenerative cylinder extending} \\ \text{load-carrying capacity} \end{array} \right\}, F_{load} = P \cdot A_r$$

Therefore when piston area (A_r) is small, then the load-carrying capacity of the regenerative cylinder will also be small.

5. **Why is extension stroke faster than retraction stroke in a regenerative circuit ?**

This is because oil flow from the rod end regenerates with the pump flow to provide a total flow rate, which is greater than the pump flow rate to the blank end of the cylinder.

6. **What do you mean by sequencing of cylinders ? Name some applications where it would be desirable to have sequencing of two cylinders.**

✓ In many applications, the operation of two hydraulic cylinders is required to be performed in sequence one after the another. This is known as sequencing of cylinders.

Applications : (i) In a drilling machine, clamping and drilling operations should be performed in a sequence.

(ii) In a punching machine, clamping and punching operations should be performed in a sequence.

7. **What do you mean by synchronizing of cylinders ? Name some applications where it would be desirable to have two cylinders synchronized in movement.**

✓ Synchronization of cylinders is the process of making cylinders to perform identical task at same rate.

✓ **Application :** The application of synchronizing of two cylinders can be found in material handling equipment to push heavy components. Also they are widely used in packing industries.

8. **Name the various methods by which synchronization of cylinders can be achieved.**

1. By using double-end cylinders connected in series,
2. By using mechanically linked pistons,
3. By using hydraulic motors as metering devices.
4. By using flow control valves, and
5. By using air-hydraulic cylinders in series.

9. **Name the three ways of applying flow control valves in a fluid power circuit.**

1. Meter-in circuit,
2. Meter-out circuit, and
3. Bleed-off circuit.

10. ***Differentiate between meter-in and meter-out circuits with respect to speed control circuits.***

- ✓ In meter-in circuit, the flow control valve is located in the line leading to the inlet port of the cylinder.
- ✓ In meter-out circuit, the flow control valve is located in the outlet line of the hydraulic cylinder.

11. ***When do you use (a) a meter-in, and (b) a meter-out circuit in the fluid power application ?***

- ✓ ***Meter-in circuits*** are generally used when the external load opposes the direction of motion of the cylinder. For example, the case of a hydraulic table, feed on a surface grinder.
- ✓ ***Meter-out circuits*** are commonly used when the external load acts in the same direction of motion of the cylinder. For example, the case of a load acting downward on the piston rod of a vertical cylinder.

12. ***What do you mean by bleed-off circuit control ?***

In the bleed-off circuit, the flow control valve is connected with its outlet port which is connected to the reservoir. The flow control valve controls flow to the cylinder by diverting an adjustable amount of pump's flow to the reservoir. Since oil delivered to the cylinder does not have to flow through the flow control valve, this circuit avoids the need of dumping excess oil through the relief valve.

13. ***What is the purpose of a fail-safe circuit ?***

Fail safe circuit is designed to safeguard the operator, the machine, and the workpiece. It prevents any possible injury to the operator or damage to the machine and the workpiece.

14. ***In what ways, pneumatic circuits differ from the hydraulic circuits ?***

1. Unlike in hydraulic circuits, the return lines are not required in pneumatic circuits.
2. Since most pneumatic circuits use a centralized compressor as their source of energy, generally no input device is shown in these circuits.

15. ***What are hydropneumatic circuits ?***

In some applications, the hydraulic and pneumatic circuits are coupled to get best use of the advantages of both oil and air mediums. These combination circuits are known as ***hydropneumatic*** or ***pneumohydraulic circuits***.

16. ***List any four advantages of employing hydropneumatic circuits.***

1. Using the combination circuit, the quick action of air and smooth, high pressure action of oil can be blended.
2. The hydropneumatic circuits will reduce space requirements.
3. These circuits increase the performance of the equipment.
4. These circuits will reduce initial and maintenance cost of original equipment.

17. What is meant by an air-over-oil system ?

The air-over-oil system was both air and oil to obtain the advantages of each medium. By the use of these two media, the quick action of air and the smooth high-pressure action of oil can be blended.

CHAPTER 14 : SERVO SYSTEMS AND PROPORTIONAL CONTROLS

1. What is a servo system ?

A servo system is one in which a comparatively large amount of power is controlled by small impulses or command signals and any errors are corrected by feedback signals.

2. List six elements of a basic closed-loop servo system.

1. Command signal,
2. Servo amplifier,
3. Servo valve,
4. Actuator,
5. Load, and
6. Feedback transducer.

3. Mention the functions of the following :

(a) Servo amplifier, and (b) Feedback transducer.

✓ **The servo amplifier** receives a low-power input signal and amplifies it to a higher power level.

✓ **The feedback transducer** measures the result at the load and sends a feedback signal to the amplifier unit.

4. What are servo valves ? Write their purpose in fluid power systems ?

✓ Servo valves are nothing but DC valves having infinitely variable positioning capability.

✓ The servo valves are used to control not only the direction of fluid flow, but also the amount of flow.

5. How can you classify servo valves ?

1. Mechanical type servo valve, and
2. Electrohydraulic servo valve,
 - (i) Single-stage servo valve,
 - (ii) Two-stage servo valve,
 - (iii) Jet pipe servo valve, and
 - (iv) Flapper jet servo valve.

6. Define the terms 'lap' and 'null' with respect to servo valves.

✓ **Lap** is the length relationship between the metering lands to the spool and the port openings in the sleeve or body.

✓ **Null** is the relational condition between the spool and valve port where the valve supplies no control flow at zero load pressure drop.

7. What do you mean by zero lap servo valve ?

The zero lap servo valve means that the edges of the spool lands are precisely made to line up with the metering ports in the valve sleeve.

8. Mention any four applications of hydromechanical servo valves.

Hydromechanical servo valves are employed in steering devices (such as power steering system of automobiles), test and training devices, copying devices (such as machine tools), and heavy-duty mobile equipment.

9. How does an electrohydraulic servo valve differ from the hydromechanical servo valve ?

In electrohydraulic servo valves, electrical signal is used to control the hydraulic output. But in mechanical servo valves, mechanical linkages are used for the same purpose.

10. Write few applications of electrohydraulic servo valves.

The electrohydraulic servo valves are widely employed in more sophisticated control systems such as on tape-controlled machine tools, high-speed printing presses, press brakes, etc.

11. What are the advantages of electrohydraulic servo systems over hydromechanical servo systems ?

The advantages of electrohydraulic servo systems over hydromechanical servo systems are as follows :

1. The electrohydraulic servo system can easily achieve the precision remote control of position, force, and speed of actuator.
2. They guarantee the higher flexibility of operation.
3. They ensure better control of fluid-compressibility, system-stiffness, and dynamic behaviour of load.
4. They also ensure correct ratio of force and speed that leads to higher energy conversion.

12. Differentiate between single-stage and two-stage servo valves.

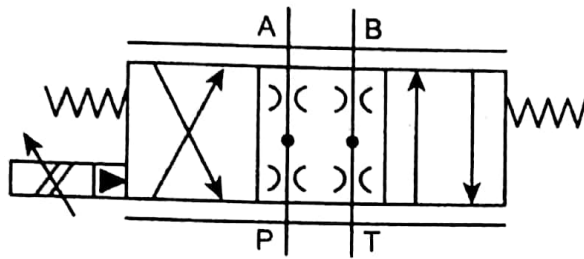
- ✓ In single-stage servo valves, the armature of the torque motor is connected directly to the valve spool, and therefore the input current will directly control the valve movement. But the two-stage configuration uses two stages—a pilot stage and a main stage—for the same purpose.
- ✓ Single-stage servo valves are limited only for small flow at low pressure, whereas two-stage servo valves can be used to handle large flow at high pressure.

13. What are proportional control valves ?

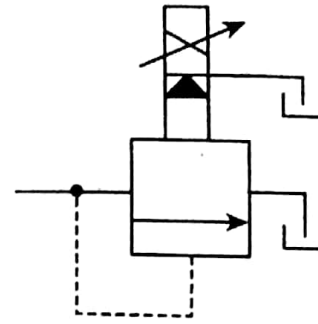
Similar to servo valves, proportional valves are also infinite variable position valves. They also use a variable force direct current solenoid to control the output from the main spool.

14. Draw the graphic symbols for the following valves :

(i) Four-way servo valve, and (ii) Proportional pressure relief valve.



(i) Graphic symbol of a four-way servo valve



(ii) Graphic symbol of a proportional pressure relief valve

CHAPTER 15 : LOGIC CONTROLS IN FLUID POWER SYSTEMS

1. What is fluidics ?

Fluidics is the technology that utilizes fluid flow phenomena in components and circuits to perform a wide variety of control functions.

2. What advantages does fluidics offer ?

1. Fluidic devices offer exceptional thermal and physical stability and ruggedness.
2. They are completely insensitive to radiation, even of extremely high loads.
3. They are not affected by severe vibration and shock.
4. They are not susceptible to wear and tear.

3. At what pressures do fluidic devices function ?

Normally fluidic devices function at pressures below 1 bar.

4. Where are fluidic control systems preferred than other control systems ?

Fluidic control systems are preferred over other control systems in areas subject to nuclear radiation, magnetic flux, temperature extremes, vibration, and mechanical shock.

5. State the 'Coanda effect'.

"When a stream of fluid meets other stream, the effect is to change its direction of flow and effect is the fluid sticks to the wall."

6. Name four fluidic devices.

1. Bistable flip-flop,
2. Flip-flop with start-up preference,
3. SRT flip-flop,
4. OR/NOR gate.

7. What is a bistable flip-flop ?

A bistable flip-flop provides controlled assurance as to which of the two output ports will deliver the power stream. It is normally used as a memory device.

8. What is a monostable device ?

A monostable device is required to perform monostable function which is analogous to spring return function. In this device, when the control signal is removed, the device will switch back to the favoured output.

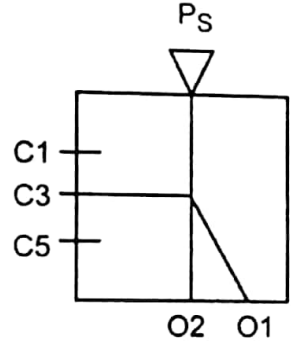
9. When do you use a flip-flop with start-up preference ?

A flip-flop with start-up preference is used in applications where a specific output is required when the power supply is first turned ON and all controls are OFF.

10. What is the use of truth table in logic devices ?

A truth table helps to describe the functioning of that particular logic device.

11. Give the symbol and truth table for fluidic OR/NOR gate.



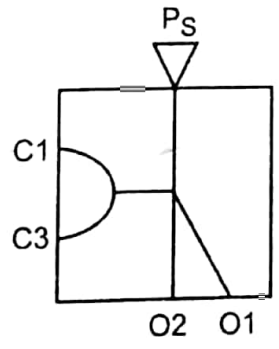
Symbol

		OR	NOR
C1	C3	O1	O2
0	0	0	1
1	0	1	0
0	1	1	0
1	1	1	0

Truth table

OR/NOR gate

12. Give the symbol and truth table for the fluidic AND/NAND gate.



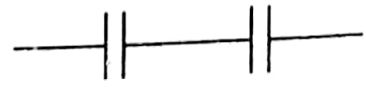
Symbol

		AND	NAND
C1	C3	O1	O2
0	0	0	1
1	0	0	1
0	1	0	1
1	1	1	0

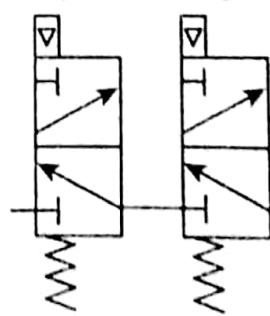
Truth table

AND/NAND gate

13. Draw the equivalent electrical and pneumatic symbols for AND gate function.



(a) Electrical equivalent



(b) Pneumatic equivalent

14. What is Boolean algebra ? Write its two functions relative to fluid power systems.

- ✓ Boolean algebra is an 'algebra of logic'. This is the algebra of proportions where only two possibilities – true or false – are allowed.
- ✓ Boolean algebra provides the following two functions :
 1. It provides a means by which a logic circuit can be reduced to its simplest form.
 2. It allows for the quick synthesis of a circuit that is to perform desired logic operations.

15. What is a fluid sensor ?

A fluid sensor is a device that senses a change in some parameter and as a result causes a related change in another parameter that can be recognized and interpreted.

16. Name four fluid sensors that are used in fluid power systems.

1. Back-pressure sensor,
2. Cone-jet proximity sensor,
3. Interruptible-jet sensor, and
4. Contact sensing.

17. What is meant by the term 'contact sensing' ?

Contact sensing is nothing but the sensing of objects by physical contact. It can be achieved by using a device called a limit valve or limit switch.

18. What are moving-part logic devices ?

Moving-part logic (MPL) devices are miniature valve-type devices that perform switching operations in fluid logic systems by the action of internal moving parts.

19. Name three ways in which MPL devices can be actuated.

The MPL devices can be actuated by means of (i) mechanical displacement, (ii) electric voltage, or (iii) Fluid pressure.

20. What are the distinctive features that differentiates MPL devices from fluidic devices.

1. Very small in size and hence occupies less space.
2. Very fast response time.
3. Can be readily interfaced with electric and electronic circuits.
4. Longer life of elements.

21. Name few applications of MPL devices.

The MPL devices are well-suited for a wide range of applications in biomedical, environmental test equipment, textile machines, packaging machinery, computerised industrial automation, and portable systems.

22. What is a PLC ?

A programmable logic controller (PLC) is a user-friendly electronic computer designed to perform logic functions such as AND, OR, or NOT for controlling the operation of industrial equipment and processes.

23. How does a PLC differ from a general-purpose computer ?

1. PLCs are rugged and designed to withstand vibrations, temperature, humidity, and noise.
2. The interfacing for inputs and outputs is inside the controller.
3. They are easily programmed and have an easily understood programming language. Programming is primarily concerned with logic and switching operations.

24. List any four advantages that PLCs provide over electromechanical relay control systems.

1. PLCs are more reliable and faster in operation.
2. They are smaller in size and can be more readily expanded.
3. They require less electrical power.
4. They have very few hardware failure when compared to electromechanical relays.

25. List three major units of a PLC.

1. Central processing unit (CPU).
2. Programmer/monitor (PM), and
3. Input/output module (I/O).

26. What is the function of the CPU in a PLC ?

The CPU (i) receives input data from various sensing devices, (ii) executes the stored program, and (iii) delivers corresponding output signals to various load control devices.

27. What is the purpose of the I/O module in a PLC ?

The purpose of the I/O module is to transform the various signals received from or sent to the fluid power interface devices.

CHAPTER 16 : FLUID POWER CIRCUITS : FAILURE AND TROUBLESHOOTING

1. List four basic requirements on which the life of the fluid power systems depend ?

The four basic requirements are :

- (i) Properly installed equipments,
- (ii) Properly trained personnel,
- (iii) Planned preventive maintenance, and
- (iv) Efficient troubleshooting.

2. List any four common types of faults that can be found in hydraulic systems.

1. Reduced speed of travel of machine tool elements.
2. Slow response to control.
3. Excessive loss of system pressure.
4. Excessive leakage in the system.

3. List any four common causes of hydraulic system breakdown.

1. Inadequate supply of oil in the reservoir.
2. Clogged or dirty oil filters.
3. Leaking seals.
4. Loose inlet lines that cause the pump to take in air.

4. What does the term troubleshooting refer to ?

The term troubleshooting refers to an organised and systematic study of the problem and a logical approach to the difficulty faced in a system.

5. What is the purpose of a tree-branching chart ?

A tree-branching chart is a fault finding chart which can be used to simplify the complex fault finding process in a fluid power circuit. This chart helps the maintenance personnel in developing a logical and rapid approach to fault diagnosis.

6. List any four common types of pump faults.

1. Pump may deliver insufficient or no oil.
2. Pump may make more noise.
3. Pump may develop unstable or zero pressure.
4. Pump oil may get overheated.

7. If a pump is delivering insufficient or no oil, what are all the possible causes and also give remedies for them.

Probable Causes	Remedies
1. Wrong direction of shaft.	Must be reversed immediately to prevent seizure.
2. Pump shaft turning too slowly to prime itself.	Check minimum speed recommendation and momentarily increase rpm, to rectify.
3. Clogged strainer or suction pipeline.	Clean strainer or suction pipeline. Remove foreign matter.
4. Air leak in suction line.	Add oil and check oil level in reservoir. Check for leaks and repair.

8. List any four causes for a pump making more noise.

1. Misalignment of pump and prime mover.
2. Strainer capacity insufficient.
3. Air remains in pump casing.
4. Small size of suction pump.

9. *List any two types of faults that can be found in each of the following hydraulic valves : (a) Directional control valve, and (ii) Flow control valve.*

Faults in a DC valve may be :

1. Faulty or incomplete shifting, or
2. Cylinder creeping or drifting.

Faults in a flow control valve may be :

1. Variation in feed, or
2. External leakage.

10. *If a hydraulic motor does not provide the proper speed and torque, what could be the possible causes for it ?*

Probable causes are :

1. System overload, relief valve adjustment not set high enough.
2. Relief valve sticking open.
3. Free recirculation of oil to reservoir.
4. Pump not delivering sufficient volume or pressure.

11. *What will you do to reduce/prevent excessive heating of oil in a hydraulic system ?*

Remedial actions are :

1. Follow manufacturer's instructions while trying to reassemble.
2. Use artificial cooling.
3. Provide large reservoir or install cooler.
4. Check and repair the leaking check valves and relief valves in the pump.

12. *List any two types of faults that can be found in each of the components of a FRC unit.*

Faults in a filter :

1. Excessive pressure drop through filter.
2. Contaminants carried through the filter.

Faults in a regulator :

1. Air often escaping from vent hole.
2. Chatter and vibration.

Faults in a lubricator :

1. Oil not delivered from the lubricator.
2. Delayed oil delivery.

13. *If an air cylinder produces erratic cylinder action, identify the probable causes and also give remedies for them.*

Probable Causes	Remedies
1. Valve sticking or binding.	(a) Check for dirt or gummy deposits. (b) Check for worn parts.
2. Cylinder sticking or binding.	(a) Check for overtightened packing on rod seal or piston. (b) Check for misalignment or worn parts.

14. *List the probable causes for the problem of leakage of compressed air in pneumatic systems.*

1. Loose joints, fittings or glands.
2. Ruptured pipes and hoses.