Scheme of Evaluation and Solution

Sub:	Fluid Power Systems					Sub Code:		15ME72	Branch:
Date:	07/09/2018	Duration:	90 min's	Max Marks:	50	Sem / Sec:		7th sem A & B	

Answer any FIVE FULL Questions

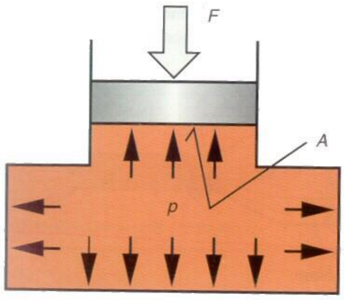
			MARKS
1 (a)	Statement of Pascal's law.	3 Marks	[10]
	Illustration with a diagram and expression for force multiplication	3 Marks	
(b)	Four differences between hydraulics and pneumatics.	4 Marks	
2 (a)	Sketch of structure of a hydraulic control system with basic components.	6 Marks	[10]
	Explanation of all components.	2 Marks	
(b)	List any four applications of hydraulic power.	2 Marks	
3 (a)	Neat sketch showing the construction and working of an external gear pump.	4 Marks	[10]
	Explanation of working of an external gear pump.	2 Marks	
(b)	Numerical on a vane pump. Expression for Volumetric displacement Eccentricity = 10 mm	4 Marks	
4 (a)	Neat sketch of double acting cylinder and graphical symbol.	5 Marks	[10]
	Explanation of double acting cylinder.	3 Marks	
	List the application of hydraulic cylinders.	2 Marks	
5 (a)	Derivation of expressions for the power developed by a double acting cylinder. V_{ext}=Pin * V_{ret}=Pin *	8 Marks	[10]
(b)	Numerical on Extension and retraction speed of a double acting cylinder. V_{ext}= V_{ret}=	2 Marks	
6	Numerical on Hydraulic pump 1. Pump delivery in LPM. 2. The input power required in kW. 3. The drive torque at the pump shaft.	4+4+2 Marks	[10]
7.	Numerical on a hydraulic motor 1. Volumetric efficiency 2. Mechanical efficiency 3. Overall efficiency	4+4+2 Marks	[10]

Solution

Answer any FIVE FULL Questions

1 (a) State Pascal’s law. Illustrate with a neat sketch.

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



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

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

$$p = f/a$$

The force on the base is:

$$F = p \times A$$

from which F can be derived as:

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

Expression shows an enclosed fluid may be used to magnify a force.

(b) Differentiate hydraulics and pneumatics.

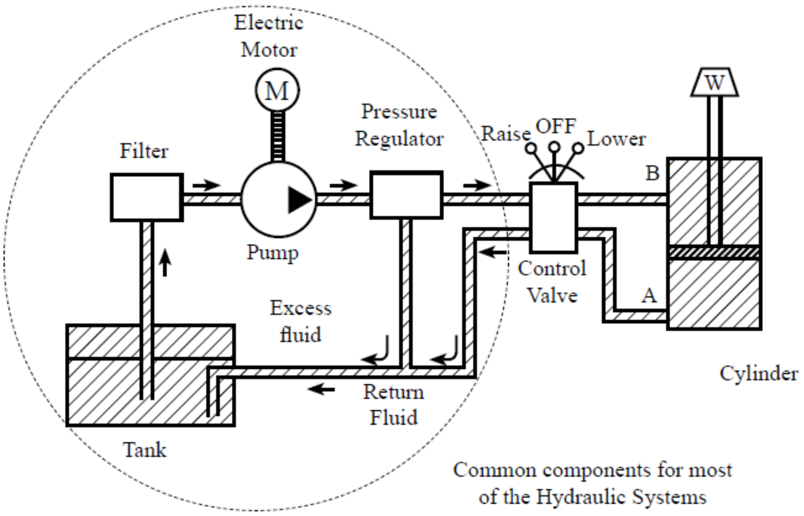
	Hydraulic	Pneumatic
Energy storage	Electric motor or diesel driven	Electric motor or diesel driven
Energy storage	Limited (accumulator)	Good (reservoir)
Distribution system	Limited, basically local facility	Good, can be treated as a plant wide service
Rotary actuators	Low speed, good control, can be stalled	Wide speed range. Accurate speed control difficult
Linear actuators	Cylinders very high force	Cylinders medium force

2 Sketch and explain the structure of a hydraulic control system.

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

There are eight basic components required in a hydraulic system.

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



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

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

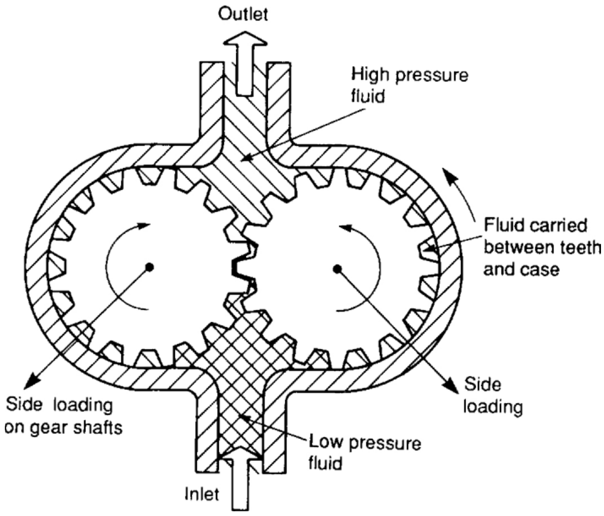
List any four applications of hydraulic power.

(b) 1. Fluid power systems find application in automobile industries, such as Power steering, power brakes, suspension systems, hydrostatic transmission.

2. Agriculture equipments such as tractors, mowers, ploughs, chemical and water sprayers, fertilizer spreaders, harvesters.
3. Construction equipments such as excavators, lifts, bucket loaders, crawlers.
4. Amusement park entertainment rides such as roller coasters.

3 (a) With a neat sketch, explain the construction and working of an external gear pump.

External gear pumps are the most popular hydraulic pumps in low-pressure ranges due to their long operating life, high efficiency and low cost. These are simplest and most robust positive displacement pump, having just two moving parts, is the gear pump. Its parts are non-reciprocating, move at constant speed and experience a uniform force. Internal construction, shown in Figure



It consists of a pump housing in which a pair of precisely machined meshing gears runs with minimal radial and axial clearance. One of the gears, called a driver, is driven by a prime mover. The driver drives another gear called a follower. As the teeth of the two gears separate, the fluid from the pump inlet gets trapped between the rotating gear cavities and pump housing. The trapped fluid is then carried around the periphery of the pump casing delivered to outlet port. The teeth of precisely meshed gears provide almost a perfect seal between the pump inlet and the pump outlet.

(b) A vane pump has a rotor diameter of 65 mm, a cam ring diameter of 80 mm and a vane width of 50 mm. What must be eccentricity for it to have a volumetric displacement of 115cm^3?

Given data:

Rotor diameter D_R= 65 mm

Cam ring diameter D_C= 80 mm

Vane width, L = 50 mm.

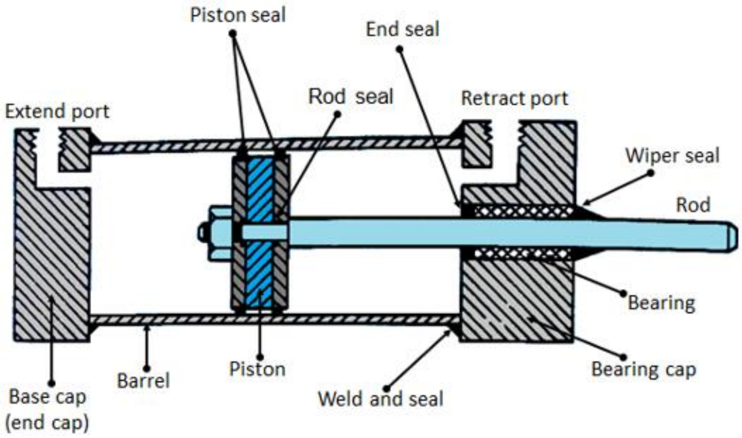
Volumetric displacement V_D= 115cm^3

For a vane pump volumetric displacement is given by $V_D = \frac{\pi}{2}(D_C + D_R)eL$

Eccentricity, e = 10mm

4 (a) Explain with a neat sketch, the working of double acting cylinder.

The main parts of a hydraulic double acting cylinder are: piston, piston rod, cylinder tube, and end caps. These are shown in Figure. The piston rod is connected to piston head and the other end extends out of the cylinder. The piston divides the cylinder into two chambers namely the rod end side and piston end side. The seals prevent the leakage of oil between these two chambers. The cylindrical tube is fitted with end caps. The pressurized oil, air enters the cylinder chamber through the ports provided. In the rod end cover plate, a wiper seal is provided to prevent the leakage of oil and entry of the contaminants into the cylinder. The combination of wiper seal, bearing and sealing ring is called as cartridge assembly. The end caps may be attached to the tube by threaded connection, welded connection or tie rod connection. The piston seal prevents metal to metal contact and wear of piston head and the tube. These seals are replaceable. End cushioning is also provided to prevent the impact with end caps.

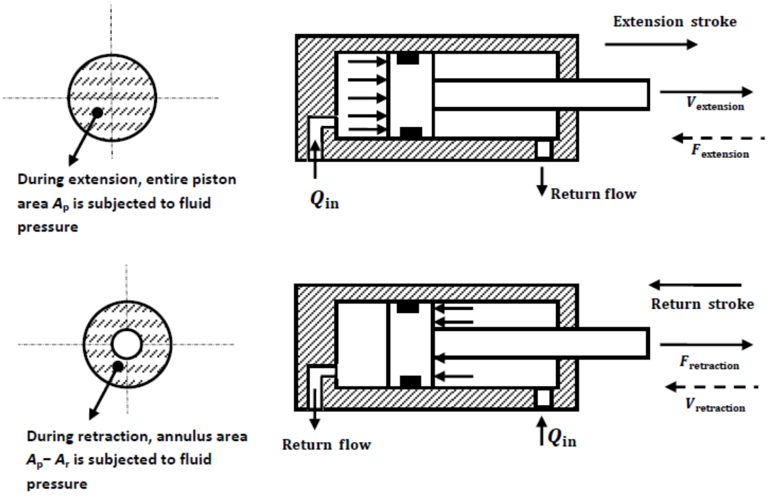


(b) List the application of hydraulic cylinders.

1. CNC Machines
2. Earth movers
3. Hydraulic Brakes
4. Landing gears of an aircraft

5 (a) Derive an expression for the power developed by a double acting cylinder.

The output force (F) and piston velocity (v) of double-acting cylinders are not the same for extension and retraction strokes.



Power developed by a hydraulic cylinder (both in extension and retraction) is

Power Force ×Velocity = F × V

In metric units, the kW power developed for either extension or retraction stroke is

$$\text{Power (kW)} = v_p\,(\text{m/s}) \times F\ (\text{kN})$$
$$= Q_{in}\,(\text{m}^3/\text{s}) \times p\ (\text{kPa})$$

Power during extension is

$$P_{ext} = F_{ext} \times v_{ext} = p \times A_p \times \frac{Q_{in}}{A_p} = p \times Q_{in}$$

Power during retraction is

$$P_{ret} = F_{ret} \times v_{ret}$$
$$= p \times (A_p - A_r) \times \frac{Q_{in}}{A_p - A_r}$$
$$= p \times Q_{in}$$

Power developed during extension and retraction is same.

(b) An 8cm dia hydraulic cylinder has 4cm dia rod. If the cylinder receives the flow at 100LPM and 12 MPa. Find Extension and retraction speed.

Solution:

Let us first convert the flow in LPM to m^3/s before we calculate forward velocity Q_{in}=100 LPM = 100/(1000 × 60) =1/600 m^3/s

Now

D_C = Diameter of cylinder = 8 cm = 8×10^{-2} m

d_r = Diameter of piston rod = 4 cm = 4×10^{-2} m

p = 12 MPa = 12×10^6 N/m² or Pa

(a) Forward velocity is given by

$$v_{ext} = \frac{Q_{in}}{A_p} = \frac{1/600}{\pi d^2/4} = 0.3315 \text{ m/s}$$

Return velocity is given by

$$v_{ret} = \frac{Q_{in}}{(A_p - A_r)} = \frac{\frac{1}{600}}{\frac{\pi(d_C^2 - d_r^2)}{4}} = 0.442 \text{ m/s}$$

6 A pump having a displacement of 15 cm³ is driven at 1400 rpm and operates against a maximum pressure of 170 bar. The volumetric efficiency is 0.9 and the overall efficiency is 0.83. Find:

a. Pump delivery in LPM.
b. The input power required in kW.
c. The drive torque at the pump shaft.

Given data:

$V_D =$ 15 cm³

N = 1440 rpm

P = 170 bar

η_V = 0.9

η_o = 0.8

Theoretical discharge is given by $Q_T = V_D \times N$.

$$15 \times 10^{-6} \times 1440 = 0.0216 \text{ m}^3\text{/min}$$

$$Q_A = \eta_V \times Q_T$$

$$\mathbf{Q_A = 0.01944 \text{ m}^3\text{/min}}$$

The theoretical torque (T T) is determined as follows:

$$T_T = \frac{V_D \times N}{2\pi}$$

$$T_T = 40.84 \text{ N-m}$$

$$T_A = \frac{T_T}{\eta_m}$$

$$\mathbf{T_A = 44.0 \text{ N-m}}$$

$$\text{Input Power} = 2\pi N T_A/60$$

P = 6.6 kW

7. A hydraulic motor has a displacement of 164cm³/rev and operates with a pressure of 70 bar and a speed of 2000rpm. If the flow rate consumed by the motor is 6 LPS and the actual torque delivered by the motor is 150N-m. Find: i) Volumetric efficiency ii) Mechanical efficiency iii) Overall efficiency.

Given data:

$V_D =$ 164 cm³

N = 2000 rpm

P = 70 bar

$Q_A = 6\ LPS$

T_A = 150 N-m

Theoretical discharge is given by $Q_T = V_D \times N$.

$$Q_T = 0.0047 \text{ m}^3/\text{s}$$

$$Volumetric\ efficiency\ (\eta_V) = \frac{Q_A}{Q_T}$$

$$\boldsymbol{\eta_V} \textbf{=91.16 \%}$$

The theoretical torque (T T) is determined as follows:

$$T_T = \frac{V_D \times N}{2\pi}$$

$$T_T = 182.7 \text{ N-m}$$

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

$$\boldsymbol{\eta_m} \textbf{= 82.09 \%}$$

$$Overall\ \ efficiency\ (\eta_o) = \eta_v \times \eta_m$$

$$\boldsymbol{\eta_o} \textbf{= 74.84\%}$$