Name: **Enrolment No:**	UPES UNIVERSITY OF TOMORROW

UPES

End Semester Examination, May 2025

Course: Hydraulics and Pneumatics **Semester: VI**
Program: B.Tech Mechatronics **Time : 03 hrs.**
Course Code: MECH3029 **Max. Marks: 100**

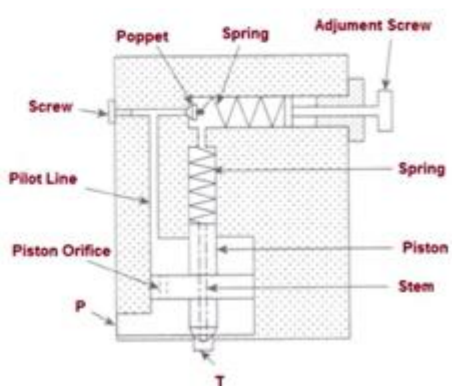
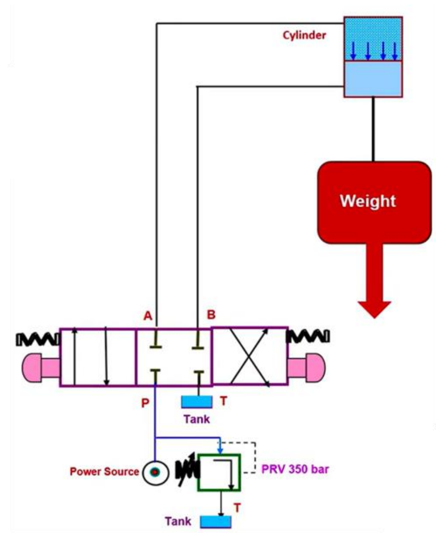
Instructions: Read all the questions carefully. Assume suitable values for parameters/variables if they are not given in any question.

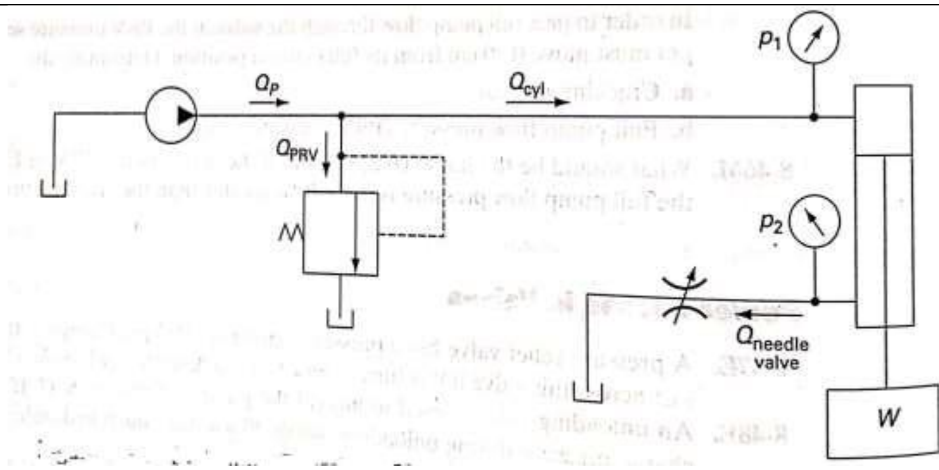
SECTION A
(5Q × 4M = 20 Marks)

S. No.		**Marks**	**CO**
Q 1	Describe the function of a hydraulic pump in a circuit. What are the two main categories of hydraulic pumps, and how do they fundamentally differ in their operation?	**4**	**CO1**
Q 2	Classify and provide a brief overview of different types of control valves used in hydraulic and pneumatic circuits.	**4**	**CO1**
Q 3	Sketch and discuss all configurations of a 4/3 spring-centred push button-operated DCV.	**4**	**CO1**
Q 4	An axial piston pump with seven pistons, each having a diameter of 0.015 m, is arranged on a piston circle with a diameter of 0.15 m. If the pump is driven at 2400 rpm and delivers a flow rate of 45.24 litres per minute, calculate the offset angle (θ) of the pump's swashplate using the relationship $S = D\ tan\theta$	**4**	**CO2**
Q 5	A hydraulic system requires a flow rate of 45 lpm. A control valve is selected that exhibits a pressure drop of 100 kPa at this flow rate when used with a fluid having a specific gravity of 0.9. What is the C_v rating of this control valve? Flow and pressure drop are related as, $Q = C_v\sqrt{\Delta P / S_g}$	**4**	**CO3**

SECTION B
(4Q × 10M = 40 Marks)

Q 6	A fixed displacement hydraulic motor is driven by a pump that delivers a constant flow rate of oil. The motor initially operates with a pressure drop of 100 bars and achieves a certain output speed and torque. By what factor would the motor's output speed and theoretical torque change under the following	**10**	**CO2**

	independent scenarios: **(a)** The pressure drop across the motor is increased by 50%. **(b)** The displacement volume of the hydraulic motor is doubled while the pressure drop remains constant. **(c)** The pump's flow rate is halved, and the pressure drop across the motor remains constant (assume the system adjusts to maintain this pressure).		
Q 7	**Do either (a) or (b) part.** Identify all the components of the shown hydraulic circuit and describe the operations in different configurations of the direction control valve (DCV). **(a)** (i) Comment on the construction and functioning of Puppet and Spool-type valves in terms of ease of manufacturing and efficiency. (ii) Explain the working principle of the valve shown below.  **(b)** Analyse and modify the shown circuit for smooth operations  	**10**	**CO3**
Q 8	The system in Figure below has a hydraulic cylinder with a suspended load W. The cylinder piston and rod diameters are 50 mm and 25 mm, respectively. The pressure relief valve setting is 50 bars. Determine the pressure P_2 for a constant cylinder speed if (a) $W = 1000$ N (b) $W = 0$.	**10**	**CO3**



Q No.	Question	Marks	CO
Q 9	A pilot-operated pressure relief valve controls the pressure in a hydraulic system. The pilot poppet has an effective area of 3.50 cm^2 exposed to the pilot pressure, which is a direct representation of the main system pressure. The pilot spring has a spring constant of 4000 N/cm and is initially compressed by 0.60 cm. The main poppet has a seating diameter of 2.5 cm. To allow the main valve to pass full pump flow, the pilot poppet must lift 0.25 cm, which results in a pressure drop across the pilot orifice that is proportional to the flow rate through it. Assume that at full pump flow, the pressure at the pilot poppet increases by 15% above the pressure at which the pilot poppet just starts to lift (cracking pressure). Determine: **(a)** The cracking pressure of the pilot valve (the pressure at which the pilot poppet just begins to lift). **(b)** The pressure at the main valve inlet required to achieve the cracking of the main valve (consider the force balance on the main poppet). Assume a small backpressure of 2 bars exists on the outlet side of the main valve.	**10**	**CO3**

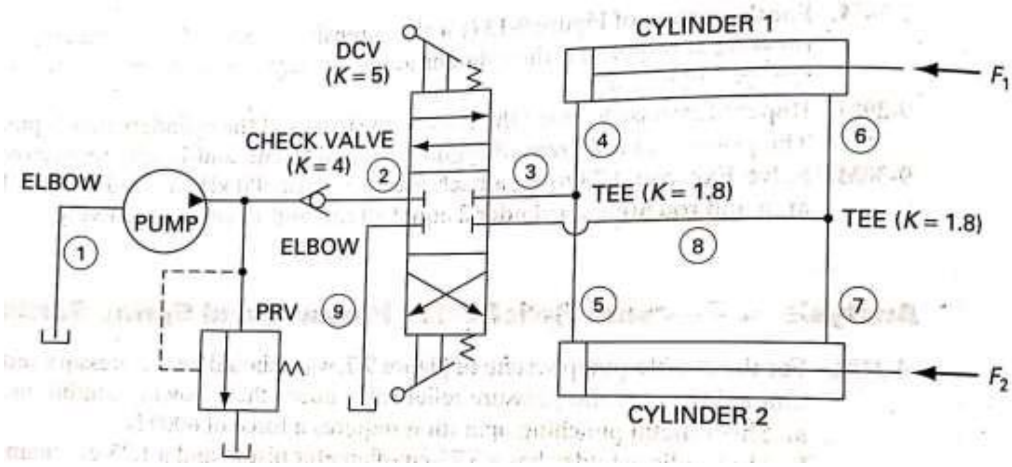
SECTION-C
(2Q × 20M = 40 Marks)

Q 10 (**20** marks, **CO4**)

For the fluid power system shown in Figure, determine the external load (F_1 and F_2) each hydraulic cylinder can sustain while moving in the extending direction. Take frictional pressure losses into account. The pump produces a pressure increase of 80 bars from the inlet port to the discharge port and a flow rate of 0.25 liters/sec. The following data are applicable. Oil density = 850 kg/m^3
Cylinder piston diameter = 5 cm, Cylinder rod diameter = 2 cm

Pipe lengths and inside diameters are given as follows;

Pipe No.	Length(mm)	Dia(mm)	Pipe No.	Length(mm)	Dia(mm)
1	6	2	6	10	1
2	30	1.25	7	10	1
3	20	1.25	8	40	1.25
4	10	1.0	9	40	1.25
5	10	1.0			



(b) A hydraulic vane motor with a variable displacement has a maximum displacement of 100 cm³/rev. It operates in a system where the pump delivers a constant hydraulic power of 15 kW. The pressure at the motor inlet is 100 bars. If the motor's volumetric efficiency is 94% and its mechanical efficiency is 86%, determine the required displacement setting of the motor (in cm³/rev) to achieve a rotational speed of 1000 rpm and the actual torque delivered at this condition.

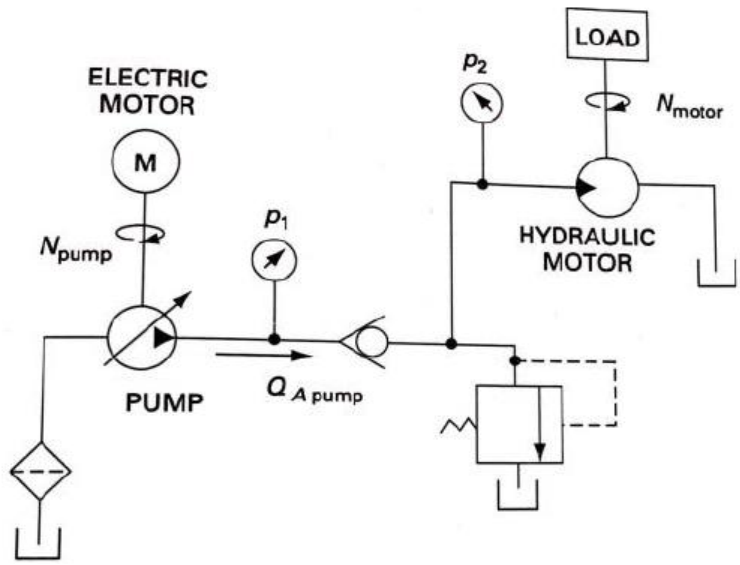
(12+8 Marks)

OR

The system shown in the Figure contains a pump delivering high-pressure oil (specific gravity SG = 0.88, kinematic viscosity v = 30 mm^2/s) to a hydraulic motor, which drives an external load with a torque requirement that varies with the motor speed as $T_L = 500 + 0.5 \times N_m^2$ Nm, where Nm is the motor speed in rpm. The following data are given:

Pump	**Hydraulic Motor**
η_v = 92%	η_v = 90%
η_m = 94%	η_m = 92%
V_D =150 cm^3	V_D =100 cm^3
N =1000 rpm	Inlet pressure p_2 required to drive load = 150 bar
Inlet Pressure = -1.5 bar	Motor discharge pressure = 2 bar

The hydraulic motor is located 20 cm above the pump. The connecting lines have an internal diameter of 20 mm and a total length of 5 meters. Consider the pressure drop due to frictional losses in the lines using the Darcy-Weisbach equation, assuming a turbulent flow regime with a Moody friction factor, f = 0.025. Account for the pressure head difference due to the elevation change between the pump and the motor. Determine the (a) Actual pump flow rate delivered to the motor. (b) Pump discharge pressure required to drive the load.

	(c) Overall efficiency of the system (ratio of power delivered to the load to the power input to the pump shaft). The Darcy-Weisbach equation $(\Delta p_{line} = f \frac{L}{D} \frac{\rho v^2}{2})$  		
Q 11	Design a suitable double pump hydraulic circuit to power a hydraulic cylinder for a two-stage operation: rapid advance followed by a slower, high-force pressing operation. Determine the required pressure settings for both the unloading valve and the pressure relief valve based on the following specifications and operational requirements: **(a)** The rapid advance at the beginning of the extending stroke requires overcoming an initial resistance of 3000 N. **(b)** The double-acting hydraulic cylinder has an 80 mm diameter piston and a 40 mm diameter rod. **(c)** During the rapid extension phase (when both high-flow and low-flow pumps are contributing), the frictional pressure loss in the line from the high-flow pump to the blank end (piston side) of the cylinder is 3 bars. Simultaneously, the frictional pressure loss in the return line from the rod end of the cylinder to the oil tank is 6 bars. **(d)** The pressing operation during the extending stroke (after the rapid advance) requires a force of 20000 N. Assume this occurs after the high-flow pump is unloaded. **(e)** Assume that both the unloading valve and the pressure relief valve pressure settings should be 30% higher than the maximum pressure required to overcome the frictional pressure losses and the cylinder operational loads during the relevant phases.	**20**	**CO4**