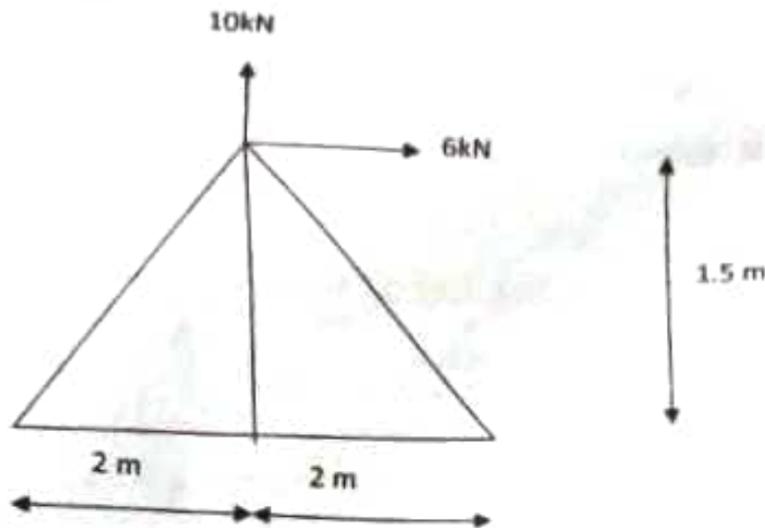


Part-I (60 marks)

Q. 1 (a)

Using the method of joints, find the forces in each member of the truss as shown in the figure below



- (b) What is wedge friction? Where it is useful? Derive the formula to calculate all the reactions and forces of the wedge (Weight W) and block, as shown in the figure given below:-



- (c) Explain the construction and working of Porter governor with neat sketch.
- (d) Explain the fundamental law of Gearing and classify different types of gear trains.

Q.2(a) Explain the Stress-strain curve of mild steel with a neat sketch in the context of true and engineering stress-strain.

- (b) Compare the permissible diameter of a steel circular shaft which is subjected to torsion considering the maximum stress theory of failures. Take Poisson's ratio as 0.3.

- (c) Find the solution of the differential equation given below

$$\frac{dy}{dx} + \frac{y}{x} = \frac{5}{(x^2 + 2)(4x^2 + 3)}$$

Given that $y = \frac{1}{2} \ln \frac{7}{6} \text{at} x = 1$.

- (d) It is estimated that 25% of emails are spam. Some software has been applied to filter these spam emails before they reach your inbox. A particular software brand claims it can detect 98% of spam emails, and the probability of a false positive (a non-spam email detected as spam) is 4%. Now if an email is detected as spam, then what is the probability that it is in fact a non-spam email?

Q.3(a) Explain the physical significance of Gradient, Divergence and Curl. Also, explain the relationship between Electric Field and Potential.

- (b) An AC circuit is composed of a serial connection of:
a resistor with resistance 50Ω ,
a coil with inductance 0.3 H
and a capacitor with capacitance $15 \mu\text{F}$.

The circuit is connected to an AC voltage source with amplitude 25 V and frequency 50 Hz . Determine the amplitude of the electric current in the circuit and a phase difference between the voltage and the current.

- (c) Write a detailed note on drinking water purification and domestic water purifiers.
(d) Write the origin, sources, adverse effects and preventive measures of air pollution.

Q.4(a) Explain the S-N curve of a ferrous material with a suitable illustration and briefly discuss its significance in the design of machine elements.

- (b) Design a flywheel for a single cylinder four stroke diesel engine, made of cast iron, whose allowable strength 20 MN/m^2 . The engine is running at a speed of 1400 r.p.m. and producing 5 kW of power. Maximum peripheral speed of the flywheel may be up to 24 m/sec . The coefficient of speed fluctuation of energy may be taken as 2.2 and the coefficient of speed fluctuation as 0.015 . The density of cast iron is 7000 kg/m^3 . (The effect of the overhang of the flywheel on the end may be neglected.)

- (c) A vibrating system has the following constants:

Weight of mass (W) = 19.62 kg , Spring stiffness (K) = 8 kg/cm , Damping coefficient (C) = $.08 \text{ kg-s/cm}$

Determine:

- (i) Damping factor
- (ii) Natural frequency of damped oscillations
- (d) A single degree of freedom system is subjected to a n external harmonic force $F(t) = F_0 \sin \omega_0 t$. Define magnification factor and plot it as a function of damping factor as it varies with respect to frequency ratio.

Part-II (60 marks)

Q.5 (a) Explain the working of practical NH_3 water vapour absorption refrigeration system with a neat sketch.

(b) 28 tonnes of ice from and at $0^\circ C$ is produced per day in an ammonia refrigerator. The temperature range in the compressor is from $25^\circ C$ to $-15^\circ C$. The vapour is dry and saturated at the end of compression, and an expansion valve is used. Assuming a coefficient of performance of 62% of the theoretical, calculate the power required to drive the compressor.

Temp. ($^\circ C$)	Enthalpy (kJ/kg)		Entropy of liquid (kJ/kg K)	Entropy of vapour (kJ/kg K)
	Liquid	Vapour		
25	100.04	1319.22	.3473	4.4852
-15	-54.56	1304.99	-2.1338	5.0585

(c) A reversible heat engine operates between two reservoirs at temperatures of $600^\circ C$ and $40^\circ C$. The engine drives a reversible refrigerator, which operates between reservoirs at temperatures of $40^\circ C$ and $-20^\circ C$. The heat transfer to the heat engine is 2000 kJ and the net work output of the combined engine refrigerator plant is 360 kJ. Evaluate the heat transfer to the refrigerant and the net heat transfer to the reservoir at $40^\circ C$.

(d) Explain the construction and working of the Cochran boiler with a neat sketch.

Q.6 (a) Explain Francis and Kaplan turbines' working and design principles.

(b) Draw and explain the velocity diagram for moving Blades of an impulse Turbine.

(c) Water flows through a pipe 25 mm in diameter at a velocity of 6 m/s. Determine whether the flow is laminar or turbulent. Assume that the dynamic viscosity of water is $1.30 \times 10^{-3} \text{ kg/m/s}$ and its density is 1000 kg/m^3 . If oil of specific gravity 0.9 and dynamic viscosity $9.6 \times 10^{-2} \text{ kg/m/s}$ is pumped through the same pipe, what type of flow will occur?

- (d) The drag D of a sphere is influenced by, sphere diameter d , flow velocity U , fluid density ρ and fluid viscosity μ . Obtain π_1, π_2 by Buckingham's pi method, with density, velocity and diameter as repeating variables.

Q.7 (a) Solve the following LPP.

$$\text{Max } Z = 3X_1 + X_2$$

Subjected to

$$2X_1 + X_2 \leq 18$$

$$X_1 + X_2 \leq 8$$

with X_1, X_2 non - negative

- (b) Write a detailed note on the effectiveness of TQM principles in the present era.
- (c) Weekly consumption of an item is 1000 units and price per unit is 30 rupees. Inventory carrying cost is 20 percent and ordering cost is 100 rupees per order; lead time of 1 week's stock. Assuming ROL system, calculate the following:
- (i) Reorder quantity (ii) Reorder level
- (iii) Minimum inventory level (iv) Maximum inventory level
- (v) Average inventory
- (d) Explain Steering system of an automobile with a neat sketch.

Q.8(a) Draw a Time-Temperature-Transformation (TTT) diagram and label its various features.

- (b) Enlist the requirement that govern the selection of actuator sizing for a motion axis in a mechatronics equipment, Will the requirements remain same for different types of actuators? Explain.
- (c) An infinite slab of thickness "L" (m) is having thermal conductivity "K" (W/mK). It generates heat at a uniform rate of "q" (W/M³). One of the sides of the slab is perfectly insulated and the other side is maintained at a constant temperature of "T_w" (°C). Deduce an expression for the temperature distribution within the slab.
- (d) In a parallel flow heat exchanger, engine oil enters a heat exchanger at 150 °C and leaves at 80 °C. The cooling water enters at 30 °C and leaves at 65 °C. If the fluid flow rates and the inlet conditions are unchanged, find the exit temperature of each stream in the counter flow exchanger.