Code: A-03 **Subject: APPLIED MECHANICS**
Time: 3 Hours **Max. Marks: 100**

NOTE: There are 11 Questions in all.

- **Question 1 is compulsory and carries 16 marks. Answer to Q. 1. must be written in the space provided for it in the answer book supplied.**
- **Answer any THREE Questions each from Part I and Part II.**
- **Any required data not explicitly given, may be suitably assumed and stated.**

Q.1 Choose the correct or best alternative in the following: **(2x8)**

a. The gravitational force of attraction between two bodies is F. If the mass of the bodies and the distance between them is doubled, the force would be

(A) $F/2$ **(B)** F
(C) 2F **(D)** 4F

b. For stability of a ship in water, the relative location of its centre of gravity G and metacentre M must be such that

(A) G is below M **(B)** G is above M
(C) G and M coincide **(D)** No relation required.

c. A truss member is primarily subjected to

(A) Shear force. **(B)** Bending moment.
(C) Twisting moment. **(D)** None of these.

d. The work done by gravity on a particle depends on its weight and

(A) Distance moved by the particle. **(B)** Its initial and final position.
(C) Its complete path. **(D)** Independent of its position.

e. A cylinder of mass m is rolling without slip in the x direction on a horizontal rough surface (coefficient of friction μ) with constant angular velocity. The frictional force on the sphere is

(A) μmg in the positive x direction. **(B)** μmg in the negative x direction.
(C) 0. **(D)** μm.

f. The natural frequency of a close coiled helical spring mass system is f. If the diameter of the spring wire is doubled, the natural frequency would be

(A) f. **(B)** $2f$.
(C) $4f$. **(D)** f/2.

g. For a cast iron beam the preferable section for weight saving is

(A) circular. **(B)** rectangular.
(C) I section. **(D)** T section.

h. The venturimeter in a pipe line is used to measure

(A) Velocity. **(B)** Discharge.

(C) Pressure. **(D)** Gradient.

PART I

Answer any THREE Questions. Each question carries 14 marks.

Q.2 a. Determine the simplest resultant of the forces acting on the plate shown in Fig.1. Obtain the point of action of the resultant on the plate. **(7)**

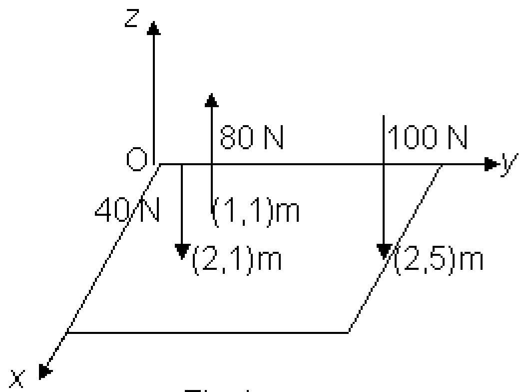

Fig.1

b. As water rises on the left side of the rectangular gate ABC Fig.2, the gate would open automatically. At what height *h* of the water level above the hinge B will this occur? Take the weight density of water is $\gamma = 10kN/m^3$. Neglect the weight of the gate. **(7)**

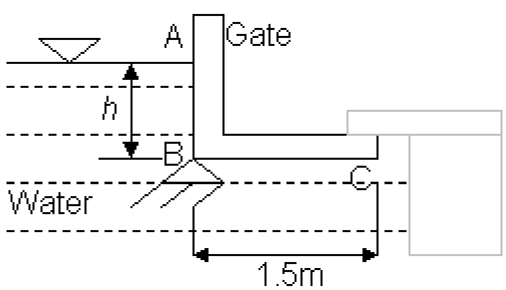

Fig.2

Q.3 A frame consists of bars ACE, BD hinged at A, B and pinned together at C Fig.3. The frictionless pulley at D weighs 2000 N. Neglecting the weights of the bars draw the free body diagrams for each component, i.e. the pulley D, the bar BD and bar ACE separately. A weight of 5000N is hanging by a string tied at E and passes over the pulley. **(14)**

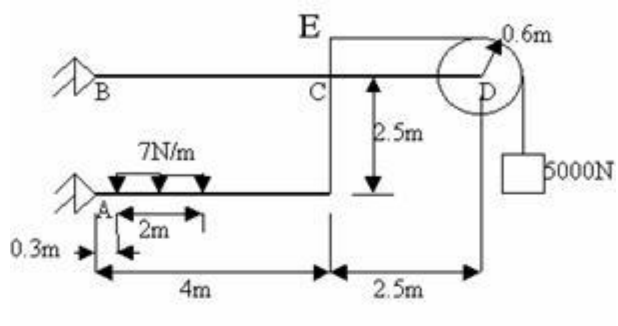

Fig.3

Q.4 a. Determine the location of the centroid of the shaded area shown in Fig.4. Take the distance of the centroid of a semicircular area of radius r from its centre as $0.424r$. **(7)**

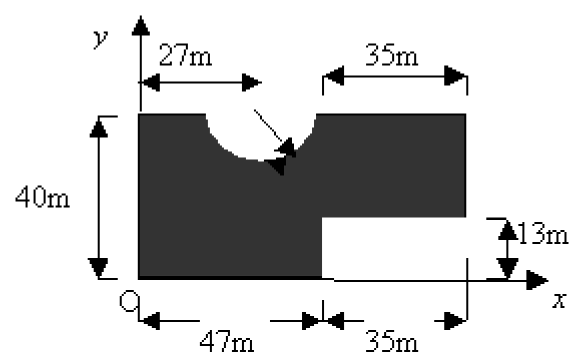

Fig.4

b. Starting from the definition, derive an expression for the moment of inertia of a thin disc of mass M and radius R about its diameter through the centroid. **(7)**

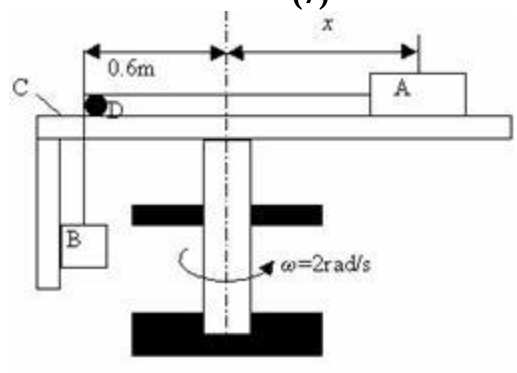

Fig 5

Q.5 A platform C rotates at ω = 2 rad/s as shown in Fig 5. A body A of mass 50 kg rests on the platform. It is connected by a flexible weightless string, passing over a smooth pulley D which is fixed to the platform, to a mass B of 25 kg. The mass B is prevented from swinging out by the vertical part of the platform. For what range of values of x will the bodies A and B remain stationary relative to the platform? Take the coefficient of friction for all surfaces as μ = 0.4. **(14)**

Q.6 A cylinder C is rotating at 1750 rpm when the light hand brake system is applied using force F = (10t+300) N with t in seconds. The belt is fixed at A and E after passing over the cylinder. If the cylinder has a radius of gyration of 20cm and a mass of 500 kg, how much time is required to stop the rotation. Take the coefficient of friction between the belt and cylinder as μ = 0.3. **(14)**

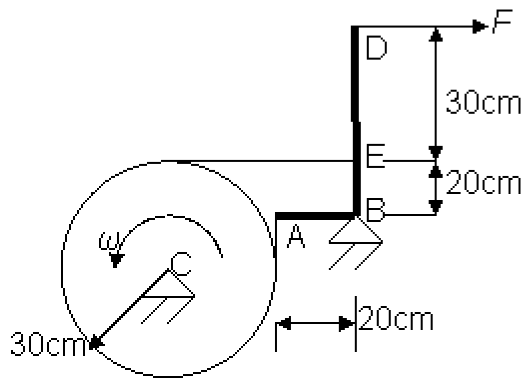

Fig.6

PART II

Answer any THREE Questions. Each question carries 14 marks.

Q.7 a. Determine the elongation of the steel rod AD of variable cross-sections shown in Fig. 7 and subjected to the loads P_1 =100 kN at A, P_2 =200 kN at B, P_3 =250 kN at C and P_4 =50 kN at D as shown. The cross-sectional areas of the bar segments AB, and CD are 10 cm^2 each whereas the cross sectional of the segment BC is 20 cm^2. Take Young's modulus for steel E = 200 GPa. **(6)**

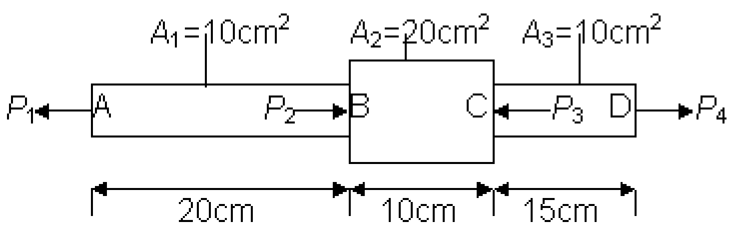

Fig.7

b. A thin steel cylinderical pressure vessel of mean radius R length ℓ and thickness t, is full of water at atmospheric pressure. An additional volume ΔV of water is pumped into the vessel. Assuming water to be incompressible, determine the pressure p developed in the vessel. **(8)**

Q.8 a. Derive the differential relation between the loading, shear force and bending moment in a beam. **(6)**

b. A cantilever beam of length L and flexural rigidity EI is subjected to a uniformly distributed load w per unit length. A concentrated vertical upward force R is applied at the free end so that there is no deflection at the free end. Determine the force R. **(8)**

Q.9 a. A hollow steel shaft has to transmit 448 kW at 120 rpm. The ratio of inside diameter to outside diameter is 3/5. The shear stress must not exceed 62 MPa and angle of twist is limited to 1^0 over a 2.5 m length. Calculate the necessary outside diameter of the shaft. G= 82.7 GPa. **(7)**

b. A centrifugal pump works against a head of 30 m and discharges 0.25 m^3/s while running at 1000 rpm. The velocity of flow at the outlet is 3m/s and vane angle at outlet is 30^0. Determine the diameter and width of the impeller at outlet if the hydraulic efficiency is 80%. **(7)**

Q.10 a. The flow through a plane converging channel is idealized as a two dimensional incompressible flow in the *xy* plane. The velocity field on the horizontal centreline (along *x* axis) is given by $u = U(1 + x/L)$, $v = w = 0$, where U is the velocity at the end $x = 0$ and L is the length of the channel Find the acceleration of a particle on the centreline. **(7)**

b. A reducing bend in a pipeline turns the direction of flow through 90^0 in the horizontal plane. At the inlet to the bend, the absolute pressure is 221 kPa and the cross

b. A reducing bend in a pipeline turns the direction of flow through 90^0 in the horizontal plane. At the inlet to the bend, the absolute pressure is 221 kPa and the cross sectional area is 0.01 m^2. At the outlet, the cross sectional area is 0.0025 m^2 and the velocity is 16 m/s. The pressure at the outlet is atmospheric. Determine the reaction force on the bend in the horizontal plane due to water flow. Take the density of water as 999 kg/m^3 and atmospheric pressure as 101 kPa. **(7)**

Q.11 a. Show that the velocity field $u = - Cy/(x^2 + y^2)$, $v = Cx/ (x^2 + y^2)$, $w = 0$; is a possible two dimensional incompressible flow. Obtain the equation for the streamlines. Check if the flow is irrotational. **(7)**

b. The drag force F on a sphere depends on the relative velocity V, the sphere diameter D, the fluid density ρ and fluid viscosity μ.. Obtain a set of dimensionless groups that can be used to correlate data. **(7)**