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. Which of the following quantities does not follow the parallelogram law of addition?

(A) Force **(B)** Velocity
(C) Linear Momentum **(D)** None of these

b. A projectile is launched with a velocity v at an angle θ to the horizontal. The radius of curvature at the top of its trajectory would be

(A) $(v\cos\theta)^2/g$ **(B)** $(v\sin\theta)^2/g$
(C) v^2/g **(D** $v^2\cos\theta/g$

c. A body rebounds after impacting a fixed smooth surface. If the impact is perfectly elastic, the following is conserved

(A) Momentum. **(B)** Kinetic energy.
(C) Momentum and Kinetic energy. **(D)** Velocity.

d. A particle of mass *m* is executing simple harmonic motion with circular frequency ω and amplitude *A*. The maximum force on the particle is

(A) mA **(B)** $mA\omega$
(C) $mA\omega^2$ **(D)** $m\omega^2$

e. In a standard uniaxial tension test on a specimen of diameter *d* and gauge length *L*, the yield stress would depend on

(A) material. **(B)** diameter *d*.
(C) gauge length *L*. **(D)** type of machine used.

f. A simply supported beam of span *L* is subjected to a concentrated load at a distance *L/3* from the left support. The maximum curvature of the beam would be at

(A) the centre. **(B)** left support.
(C) right support. **(D)** the point of loading.

g. The Froude number depends on the ratio of inertia force to

(A) Pressure force. **(B)** Viscous force.

(C) Gravity force. **(D)** sum of pressure force and gravity force.

h. In flow through a pipeline, the hydraulic gradient line, with respect to the energy gradient line, is always

(A) the same. **(B)** below.
(C) above. **(D)** none of these.

PART I

Answer any THREE Questions. Each question carries 14 marks.

Q.2 a. Determine the resultant force vector F_R of the loads shown in Fig.1 on the beam OA and give its intercept x_R with the x axis. **(6)**

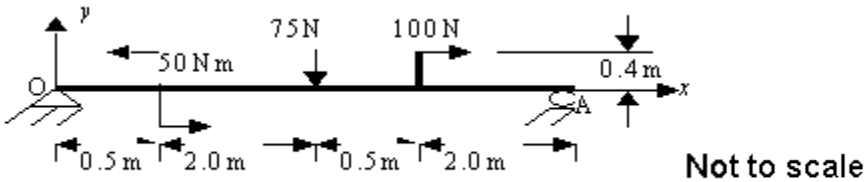

Fig. 1

b.

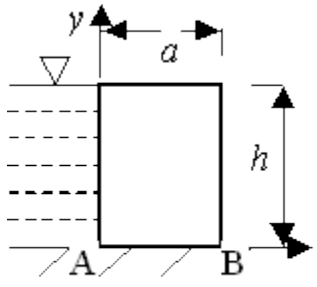

Fig. 2

A dam of rectangular section of height *h* and width *a* rests on a horizontal foundation shown in Fig.2. The weight density of water is υ and that of dam material as υ_1. Find the shear and normal forces exerted by the foundation on the dam. Determine the distance of the normal force from the end A. **(8)**

Q.3 a. Find the forces in the members BF and BC using method of sections in the truss shown in Fig.3. **(7)**

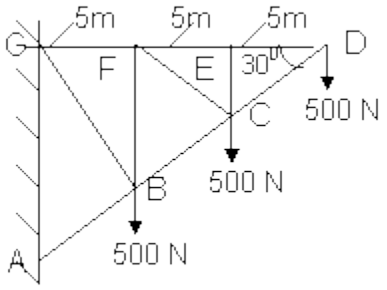

Fig.3

b. A light collar of a bracket has to support a load *P* as shown in Fig.4 with the coefficient of friction μ between the column and the collar. Show that for equilibrium of the collar at impending slip $x = a/2\mu$, the collar is in contact with the column only at A and B.

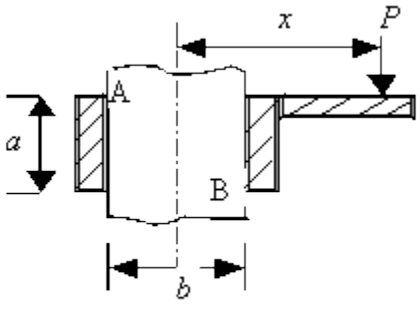

Fig. 4

(7)

Q.4 Determine the location of the centroid for the channel section shown in Fig.5. Also find the polar moment of area of the section about its centroidal axis. **(14)**

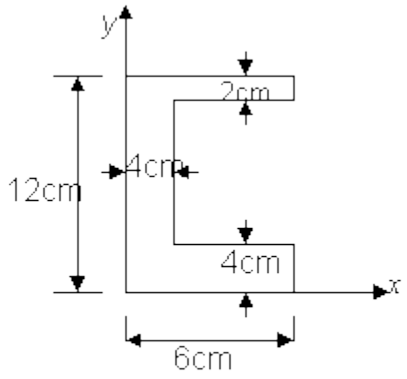

Fig.5

Not to scale

Q.5 a. A particle is moving in a circular path of radius 4 m in the *xy* plane with centre at the origin. At a point P (0, - 4) on the path, its speed is 4 m/s in the positive x direction and is increasing at the rate of 3 m/s^2. Find its acceleration. **(6)**

b. A bumper is designed to protect a 1100 kg car from damage when it hits a rigid wall at speeds up to 8 km/h. Assuming a perfectly plastic impact, determine the energy absorbed by the bumper during the impact. Determine the maximum speed at which this car can hit another 1100 kg car without incurring any damage if the other car is similarly protected and is at rest with the brakes released. **(8)**

Q.6 a. A disc C mounted on a bent rod rotates as shown in Fig.6 with constant angular speed $\omega_1 = 10$ rad/s relative to the bent rod ABC. The bent rod itself rotates at a constant angular speed of $\omega_2 = 5$ rad/s about the Z axis. Determine the angular velocity and angular acceleration of the disc with respect to the ground reference

XYZ at this instant when BC is parallel to the Y axis **(6)**

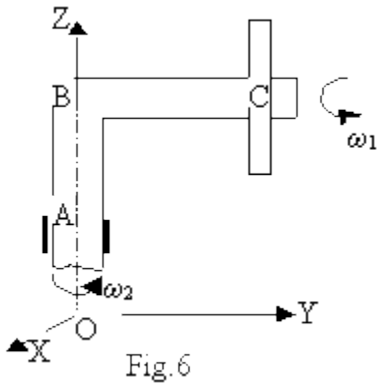

Fig.6

b. A uniform rod AB of weight *W* and length *L*, is supported by a pin connection at A and a wire at B as shown in Fig.7. Determine the angular acceleration of the rod and the acceleration of its centre of mass C at the instant the wire breaks. Also find the reaction force of the pin A at the instant the wire breaks. **(8)**

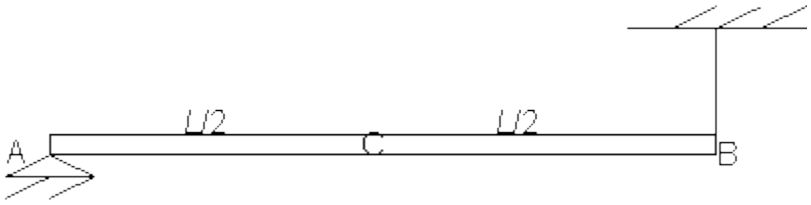

Fig.7

PART II

Answer any THREE Questions. Each question carries 14 marks.

Q.7 a. A rod of length *L* and cross-sectional area *A* is subjected to tensile axial forces *P* at the ends. Determine the normal and shear stresses on a plane inclined at an angle of 45° to bar cross-section. **(7)**

b. A thin cylindrical pressure vessel with closed ends, mean diameter *d* =2000 mm and wall thickness t = 10 mm, is subjected to an internal pressure *p* = 0.8 Mpa. Determine the change in diameter of the cylinder. Take Young's modulus *E* = 200 Gpa and Poisson's ratio $\upsilon = 0.25$. **(7)**

Q.8 A simply supported beam is loaded as shown in Fig.8. Determine the support reactions. Draw the S.F. and B.M. diagrams for the beam and determine the critical values. **(14)**

Q.9 a. A solid circular shaft is connected to the drive shaft of an electric motor with a flanged coupling. The drive is taken by 8 bolts, each 12.5 mm in diameter on a pitch circle diameter of 230 mm. Find the shaft diameter if the maximum shear stress in the shaft is equal to that in the bolts. **(6)**

b. The mean bucket speed of a Pelton turbine is 15 m/s. The rate of flow of water supplied by the jet under a head of 42 m is /s. If the jet is deflected by the buckets at an angle of  , find the power and efficiency of the turbine. Take the coefficient of velocity  =0.985. **(8)**

Q.10 a. A venturimeter with 7 cm throat diameter is fitted in a 15 cm diameter vertical pipeline with upward discharge. The absolute pressure at 6 m below the throat is 5 atm. while the pressure at the throat is such that it supports a column of 20 cm of water gauge. Estimate the discharge through the pipe.
(7)

b. A one-sixth scale model of an automobile is to be tested in a wind tunnel at a speed corresponding to the prototype speed of 60 km/h. If only the inertial and viscous forces are important, determine the wind speed at which the model must be tested. If the model drag at that speed is 510 N, find the prototype drag.
(7)

Q.11 a. The stream function represents 2D incompressible, irrotational flow around a circular cylinder of radius R. Determine the velocity field and obtain the stagnation points. Find the pressure distribution over the surface of this cylinder. **(7)**

b. Derive the velocity distribution for a fully developed incompressible laminar flow through a horizontal pipe. **(7)**