Code: A-03 **Subject: APPLIED MECHANICS**
Time: 3 Hours **June 2006**
Max. Marks: 100

NOTE: There are 9 Questions in all.

- **Question 1 is compulsory and carries 20 marks. Answer to Q. 1. A must be written in the space provided for it in the answer book supplied and nowhere else.**
- **Out of the remaining EIGHT Questions answer any FIVE Questions. Each question carries 16 marks.**
- **Any required data not explicitly given, may be suitably assumed and stated.**

Q.1 A Choose the correct or best alternative in the following: **(2x10)**

a. A shunting railway engine pulls a coach with force F. The force R applied by the coach on the engine in the opposite direction would be
(A) R < F **(B)** R = F
(C) R > F **(D)** None of these

b. A rigid body subjected to three parallel forces is in equilibrium. The forces must be
(A) equal **(B)** collinear
(C) coplaner **(D)** non coplaner

c. A truss member is treated as a
(A) two force member **(B)** three force member
(C) pinned beam **(D)** fixed beam

d. The first moment of an area about an axis through its centroid is always
(A) zero. **(B)** minimum.
(C) maximum. **(D)** none of these.

e. The position of a particle is as $x = 3t$ m, $y = (4)t - 5t^2$ m, $z = 0$ where t is the time in seconds . The magnitude of its acceleration in m/s^2 is
(A) 5. **(B)** 10
(C) 15. **(D)** 20

f. In a reciprocating engine, the instantaneous centre of rotation for the cross-head lies at
(A) the crosshead **(B)** one of the connecting rod ends
(C) one of the crank ends **(D)** none of these.

g. A uniform bar of length L and cross-sectional area A is under an axial force P. If the bar length and cross-sectional area are halved, the following would not change
(A) stress **(B)** strain
(C) elongation **(D)** young's modulus.

h. A hollow circular elastic shaft of inner radius R and outer radius $2R$ is under torsion such that the maximum shear strain in the material is γ. The shear strain at the inner radius would be
(A) 0 **(B)** $\gamma/2$
(C) γ **(D)** $\gamma/4$

i. The following term is not included for obtaining the hydraulic gradient line for pipeline flow.

(A) datum head **(B)** pressure head
(C) velocity head **(D)** none of these

j. In a free vortex of strength *K* the velocity of flow *V* at a point at a distance *R* from the centre of the vortex would be

(A) $V = K$ **(B)** $V = KR$
(C) $V = KR^2$ **(D)** K/R

Answer any FIVE Questions out of EIGHT Questions.
Each question carries 16 marks.

Q.2 a. Determine the resultant *R* of the two forces and a couple acting on the beam AB. Find the intercept of the resultant *R* on the *x* axis. **(8)**

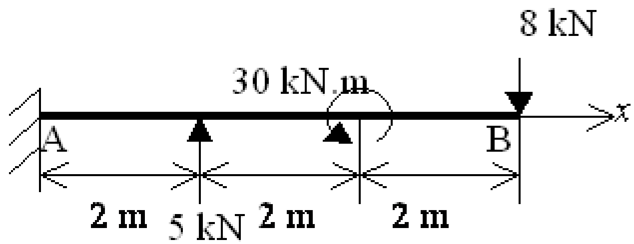

Fig.Q2a

b. The homogeneous rectangular block of weight *W*, width *b* and height *H* is placed on the rough horizontal surface. It is at impending slip when subjected to a horizontal force *P* at a height $h = H/2$. The coefficient of friction between the block and the surface is μ. Determine the location of a point C on the bottom surface of the block through which the resultant of the friction and normal reaction acts. **(8)**

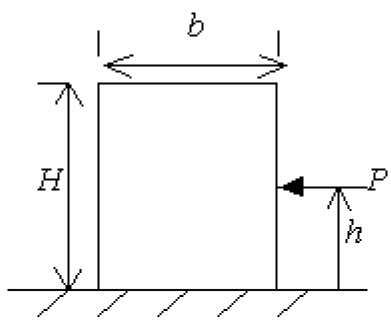

Fig.Q2b

Q.3 a. State and prove the parallel axis theorem for area moment of inertia. **(8)**

b. Calculate the moment of inertia of the area ABCDEF about the *x* axis. **(8)**

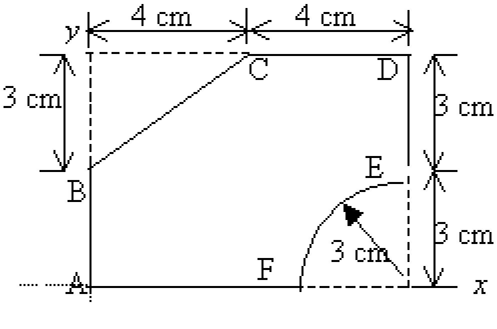

Fig.Q3b

Q.4 a. The rod OA shown is rotating in the horizontal *xy* plane such that at any instant angle $\theta = t^{3/2}$ rad. At the same time the collar C is sliding outward along OA so that OC = r = $100t^2$ mm. The time t is measured in seconds in both cases. Determine the velocity of the collar when t = 1 s. **(8)**

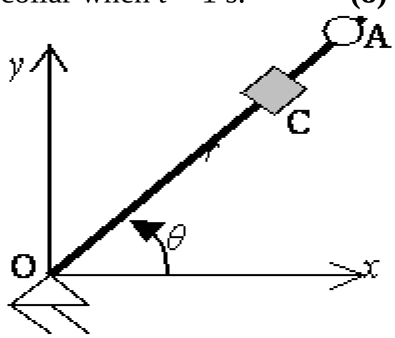

Fig.Q4a

b. A rigid pile has a mass of 800 kg and is driven into the ground using a hammer of mass 300 kg. The hammer falls from rest from a height of 0.5 m and strikes the top of the pile. If the impact is perfectly plastic, determine the impulse which the hammer imparts on the pile. **(8)**

Q.5 a. A rod AB, in contact with a vertical wall and horizontal floor shown, is sliding down in a vertical plane. At an instant when the rod is at an angle $\theta = \tan^{-1} = 3/4$ with the wall, the velocity of end A is 3 m/s downward. Determine the velocity of point B at this instant. **(8)**

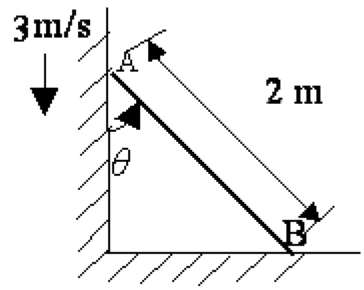

Fig.Q5a

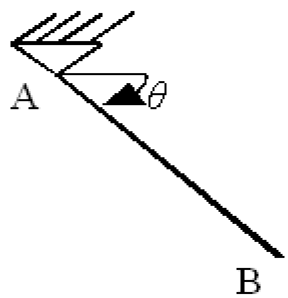

Fig.Q5b

b. The thin uniform rod AB of length 1.5 m has a mass of 20 kg. It is released from rest when angle $\theta = 0^0$. Determine the horizontal and vertical components of reaction at the pin at A on the rod at the instant when $\theta = 90^0$. **(8)**

Q.6 a. An elastic stepped bar ABC consists of part AB of length L_1 of cross-sectional area A_1 and part BC of length L_2 of cross-sectional area A_2. The bar is fixed at both ends and subjected to a point load P at the step as shown. Determine the reactions from the wall at A and C. The Young's modulus of the material is E. **(8)**

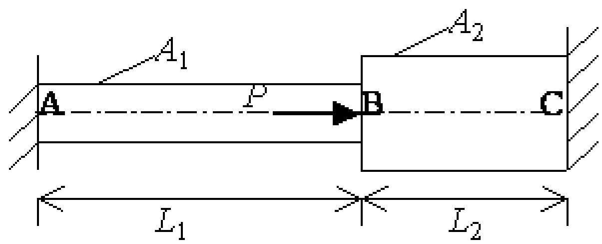

Fig.Q6a

b. Derive the torsion formula $T/J = G\theta/L = \tau_{max}/R$ for an elastic circular shaft. **(8)**

Q.7 Draw the shear force and bending moment diagrams for the beam loaded as shown. Determine the maximum S.F. and B.M. and their locations. Also find the point of contraflexure. If the beam has a rectangular cross-section with width 3 cm and depth 4 cm, determine the maximum bending stress in the beam. **(16)**

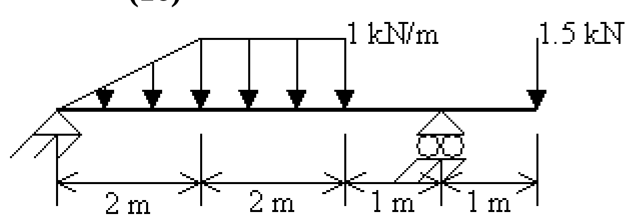

Fig.Q7a

Q.8 a. A ship weighs 5000 kgf and has a cross-section at the waterline as shown. The centre of buoyancy B is 1.5 m below the free surface and the centre of gravity G is

0.6 m above the free surface. Determine the metacentric height. **(8)**

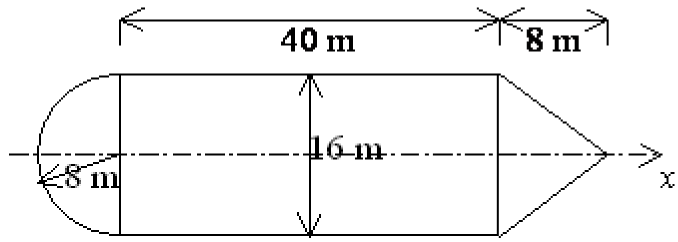

Fig.Q8a

b. The velocity potential for a two dimensional flow field is given by $\varphi = 2x^3y - xy^3$. Calculate the velocity field and obtain the stream function. **(8)**

Q.9 a. A horizontal pipe of 0.6 m diameter and 1.5 km long is discharging water under a head of 30 m at the inlet. To increase the discharge, a pipe of the same diameter is introduced in parallel to the first in the second half of its length. Neglecting minor losses, find the increase in discharge if the friction factor f = 0.04. **(8)**

b. A centrifugal pump1.3 m in diameter delivers 3.5 m^3/min of water at a tip speed of 10 m/s and a flow velocity of 1.6 m/s. The outlet blade angle is 30^0 to the tangent at the impeller periphery. Assuming zero whirl at inlet and zero slip, calculate the torque delivered by the impeller. **(8)**