2015

ENGINEERING MECHANICS

(MECH 1101)

Time Alloted : 3 Hours ***Full Marks : 70***

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable

GROUP - A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for the following : **[10×1=10]**

   i) The angle made by the vector $\left(\hat{i}+\hat{j}-\hat{k}\right)$ with Y-axis is

   (a) 45° (b) 60°
   (c) 65.3° (d) 54.7°

   ii) The ratio of limiting friction force 'F' and normal reaction 'N' is known as

   (a) coefficient of friction. (b) angle of friction.
   (c) angle of repose. (d) sliding friction.

   iii) Poisson's ratio is defined as

   (a) Longitudinal stress by Lateral stress.
   (b) Lateral stress by Longitudinal stress.
   (c) Longitudinal strain by Lateral strain.
   (d) Lateral strain by Longitudinal strain.

   iv) The distance of centre of gravity of a solid hemisphere of radius R from its base is

   (a) 3R/8 (b) R/2
   (c) 3R/4 (d) 2R/3

   v) Moment of inertia of a rectangular area of base 'b' and height 'h' about an axis through centroid and parallel to the base 'b' is given by

   (a) $bh^3/3$ (b) $bh^3/4$
   (c) $bh^3/8$ (d) $bh^3/12$

   vi) A rigid body in translation

   (a) can move along a straight or curved path.
   (b) can only move in a straight line.
   (c) cannot move on a circular path.
   (d) must undergo curvilinear motion.

   vii) Three forces in equilibrium must be

   (a) concurrent (b) coplanar
   (c) parallel (d) none of these

   viii) If the sum of area moments of inertia about any pair of axes lying on the area and intersecting at a fixed point is same, the angle between the axes must be

   (a) 90°
   (b) 45°
   (c) many different angles are possible
   (d) none of these

ix) While considering the free body diagram of a system of bodies as a whole, the following may not be considered:

(a) The reactions from the external supports on the bodies

(b) The reactions among the bodies from one another

(c) The normal reactions from the external supports on the bodies

(d) None of these

x) The centroid and the centre of mass of a given sphere are same. Then

(a) the density of the mass of the sphere must be uniform.

(b) the centre of mass must be at the geometric centre.

(c) both (a) and (b).

(d) none of these

GROUP - B

2. (a) The tension in the supporting cable AB shown in Figure 1 is 10 KN. Write the force which the cable exerts on the boom BC as a vector **T**. Determine the angles θ_x, θ_y and θ_z which the line of action of **T** makes with the positive x, y and z axes.

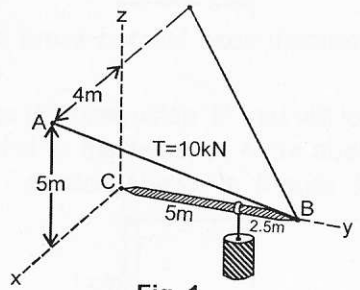

Fig. 1

(b) A force F acts from B (8, –3, 0) to D(0, 0, 6) and produces a moment of 1000 Nm about an axis directed from A (12, 0, 0) to E (0, 4, –6). Compute the magnitude of F. Co-ordinate distances are in meters.

6+6 = 12

3. (a) Given a force $\boldsymbol{F} = 10\boldsymbol{i} + 5\boldsymbol{j} + A\boldsymbol{k}$ N. If this force is to have a rectangular component of 8N along a line having unit vector $\boldsymbol{r} = 0.6\boldsymbol{i} + 0.8\boldsymbol{k}$, what should be the value of A? What is the angle between $\boldsymbol{F}$ and $\boldsymbol{r}$?

(b) A force $\boldsymbol{F}$ acts from A (4, 1, 4) to B (3, –4, 1). Moment of $\boldsymbol{F}$ about **Z**-axis is –1900 N-m. Determine the moments of the force $\boldsymbol{F}$ about **X**-axis and **Y**-axis. (Co-ordinate distances are in meter) **(2+2)+8 = 12**

GROUP - C

4. (a) A smooth right circular cylinder of radius r rests on a horizontal plane and is kept from rolling by an inclined string AC of length 2r as shown in Figure 2. A prismatic bar AB of length 3r and weight Q is hinged at point A and leans against the roller. Find the tension S that will be induced in the string AC.

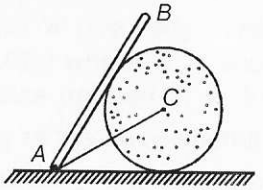

Fig. 2

(b) A horizontal beam AB is hinged to a vertical wall at A and supported at its mid-point C by a tie rod CD as shown in Figure 3. Find the tension S in the tierod and the reaction at A due to a vertical load P applied at B.

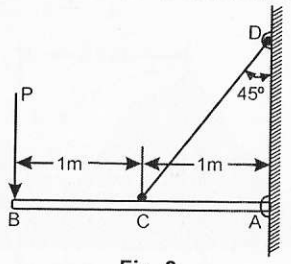

Fig. 3

6+6 = 12

5. (a) A particle rests on the surface of a hollow sphere of radius R. If the angle of friction is given as θ, find the maximum height (from the bottom of the sphere) at which the particle can rest.

(b) A roller of radius r = 12 cm and weight Q = 500 N is to be rolled over a curb of height h = 6 cm by a horizontal force P applied to the end of a string wound around the circumference of the roller. Find the magnitude of P required to start the roller over the curb. There is sufficient friction between the roller surface and the edge of the curb to prevent slip at A.

Also, find the coefficient of static friction required at A.

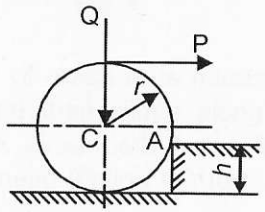

Fig. 4 **6+(2+4) = 12**

Group - D

6. (a) State and prove parallel axes theorem for area moment of inertia.

(b) Determine the dimension 'b' that will locate the centroidal axis parallel to the base, at 4 cm above the base of the inverted T-section shown in Figure 5.

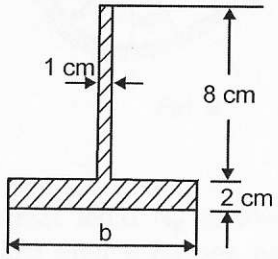

Fig. 5 **(2+4)+6 = 12**

7. (a) A brass bar having a cross sectional area of 1000 mm^2 is subjected to axial forces as shown in Figure 6. Find the total change in length of the bar and state the nature of deformation. Take E = 1.05×10^5 N/mm^2. Also, calculate stress in the segment BC.

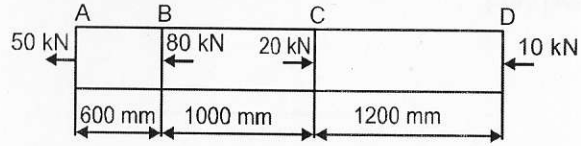

Fig. 6

(b) Define and explain the following (*any two*)

ductility, factor of safety, radius of gyration (for area moment of inertia) **(4+4)+(2×2) = 12**

GROUP - E

8. (a) The acceleration 'a' of a body starting from rest is given by $a = (4 - 0.02s)$ where 'a' is acceleration in m/s^2 and 's' is the distance traveled in m. Find

(i) the velocity of the body when it has traveled 100 m.

(ii) distance traveled when the body is again at rest.

(b) A long range artillery rifle at A is aimed at an angle of 45° with the horizontal, and its shell is just able to clear the mountain top at the highest point of its trajectory. The point A is at 600 m above horizontal sea level (Figure 7).

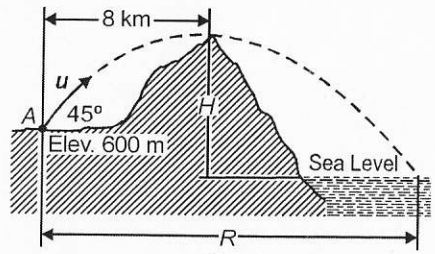

Fig. 7

Determine the magnitude **u** of the muzzle velocity, the height **H** of the mountain above sea level and the range **R** of the rifle. **(2+3)+7 = 12**

9. (a) If the coefficients of static and kinetic friction between the 20 kg block ***A*** and 100 kg cart ***B*** are both essentially equal to 0.5 (refer Figure 8), determine the acceleration of block ***A*** and cart ***B*** for (i) **P** = 60 N and (ii) **P** = 40 N.

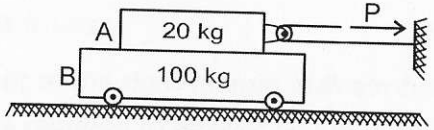

Fig. 8

(b) The small slider of mass *m* is released from rest while in position ***A*** and then slides along the vertical-plane track. The track is smooth from ***A*** to ***D*** and rough (coefficient of kinetic friction μ_k) from point ***D*** on. (refer Figure 9).

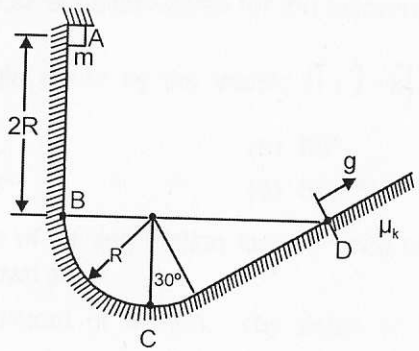

Fig. 9

Determine

(i) the normal force N_B exerted by the track on the slider just after it passes point ***B***.

(ii) the normal force N_C exerted by the track on the slider as it passes the bottom point ***C***, and

(iii) the distance *s* travelled along the incline past point ***D*** before the slider stops.

(4+2)+6 = 12