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Paper Code : ME-101

ENGINEERING MECHANICS

Time Allotted : 3 Hours | *Full Marks* : 70

The figures in the margin indicate full marks.

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

GROUP – A

(Multiple Choice Type Questions)

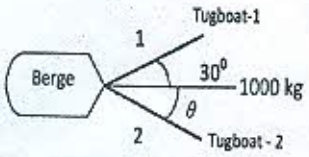
1. Choose the correct alternatives for any ten of the following : $10 \times 1 = 10$

   i) Volumetric strain of a rectangular body subjected to an axial force, in term on terms of linear strain ε and Poisson's ratio $\sqrt{}$ is given by

   a) $\varepsilon (1 + 2\sqrt{})$ b) $\varepsilon (1-2\sqrt{})$

   c) $\varepsilon (1 + \sqrt{})$ d) $\varepsilon (1-\sqrt{})$.

ii) A berge is pulled by two tugboats as shown in figure. What will be the value of θ so that the tension in the rope 2 is minimum ?



a) 30° b) 60°

c) 45° d) 0°.

iii) Given $\vec{F}_1 = 7\hat{j} + 5k$ and $\vec{F}_2 = 3\hat{i} + 4\hat{k}$. The magnitude of the scalar product of these vectors is

a) 21 b) 12

c) 20 d) 15.

iv) Under static condition, when the motion is impending, the friction force F is the

a) $F = \mu_s N$ b) $F > \mu_s N$

c) $F < \mu_s N$ d) unpredictable.

v) A body of weight 40 N is placed on a horizontal plane having $\mu = 0.4$. A pull force of P is applied at an angle θ with the horizontal. The minimum value of P will be

a) 10.86 N b) 12.37 N

c) 14.85 N d) 20 N.

vi) The moment of inertia of a semicircle of radius R about its centroidal axis x-x is

a) $0.22\ R^4$. b) $0.055\ R^4$.

c) $0.11\ R^4$ d) none of these.

vii) The velocity-time relationship of a moving particle is given by the equation $\dot{x} = (1/2)ct^2$, where $c = 2.4$ m/s^2. Determine the displacement of the particle at the instant t = 3 seconds, if there is no initial displacement.

a) 10.8 m b) 9 m

c) 12.7 m d) 3.6 m.

viii) When a body slides down an inclined surface (angle of inclination = θ), the acceleration f of the body is given by

a) $f = g$ b) $f = g \sin\theta$

c) $f = g \cos\theta$ d) $f = \tan\theta$.

ix) If moment of the body is doubled, its kinetic energy will

a) get doubled b) get halved

c) get quadrupled d) remain same.

x) If i and j are two Cartesian unit vectors then

a) $i.j = 0$ b) $i.j = 1$

c) $i.j = 2$ d) none of these.

xi) M.I. of circular area whose diameter is d about an axis perpendicular to the area passing through its centre is given by

a) $\pi d^4/64$ b) $\pi d^4/32$

c) $\pi d^4/12$ d) $\pi d^4/16$.

xii) Null vector is known as

a) negative vector b) unit vector

c) zero vector d) all of these.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. $3 \times 5 = 15$

2. A force given by $F = 3i + 2j - 4k$ is applied at the point P (1, –1, 2). Find the moment of the force F about the point O (2, –1, 3) & about origin.

3. A simply supported beam AB of span 4m is carrying point loads of 5kN, 2kN & 3kN at 1m, 2m & 3m from the left supported at A. Calculate the reactions at the supports A & B.

4. A particle travels along a straight line with a velocity $v_p = \frac{a}{b + x_p}$. Determine the acceleration when x_p = 2m. Given that $a = 6\text{m}^2/\text{s}$ and b = 3m.

5. Determine the tensile force in cables AB and BC as shown in Fig. 1. Assume the pulleys to be frictionless.

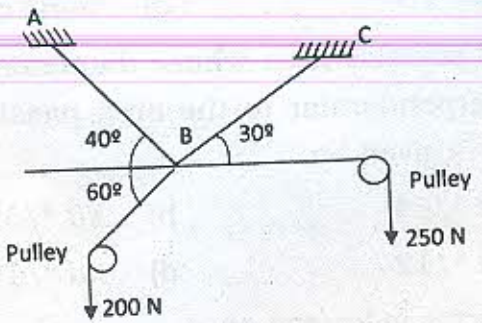


Fig.-1

6. A weight Q = 12 N rests in a right-angled trough, as shown in Fig. 2. Determine the forces exerted on the sides of the trough at *D* and *E* if all surfaces are perfectly smooth.

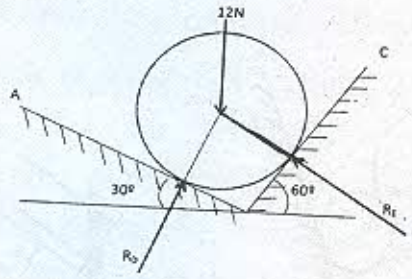


Fig.-2

7. A roller of radius 50 cm and weight 4000 N is to be pulled over rectangular block of height 30 cm as shown in figure 3. A force *P* is applied tangentially at point *C* through a string wound the circumference of the roller. Find the magnitude of force *P* required just to turn the wheel over the corner of rectangular block. Also determine the magnitude and direction of reaction at *A* and *B*. All surfaces are assumed to be smooth.

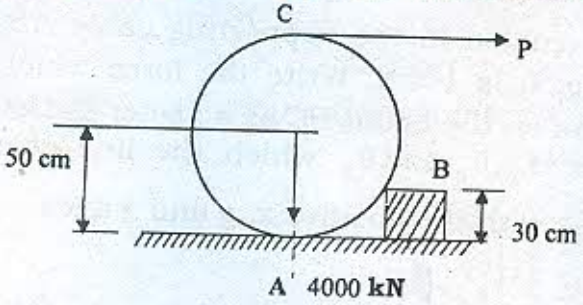


Fig.-3

GROUP – C
(Long Answer Type Questions)

Answer any *three* of the following. 3 × 15 = 45

8. a) Two cylinders are supported in a right-angled wedge support as shown in figure 4. The side OL

makes 30° angle with horizontal. The diameters of the cylinders *A* and *B* are 250mm and 500mm, and their weights being 100N and 400N, respectively. Determine the reactions *R* between all contact points. 8

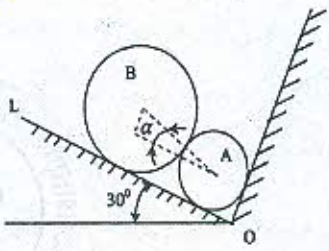


Fig.-4

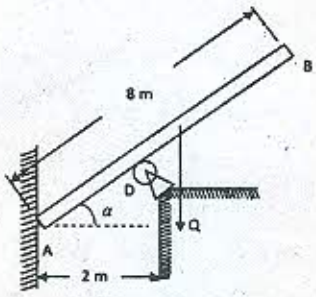


Fig.-5

b) A heavy prismatic bar *AB* of weight '*Q*' and length $2l$ rests on a very small frictionless roller at *D* and against a smooth vertical wall at *A*, as shown in figure 5. Determine the angle α that the bar must make with the horizontal in the condition of equilibrium. 7

9. a) The tension in the supporting cable *AB*, as shown in fig. 6 is 10kN. Write the force which the cable exerts on the boom *BC* as a vector *T*. Determine the angle θ_x, θ_y and θ_z which the line of action of *T* forms with the positive *x*, *y* and *z* axes. 8

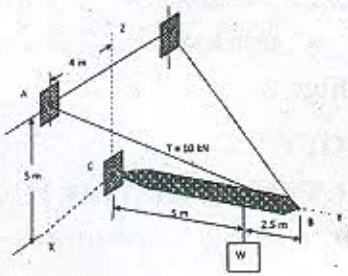


Fig.-6

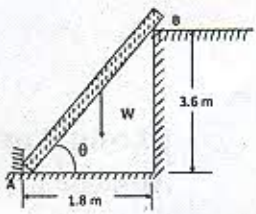


Fig.-7

b) A 667.5 N man stands on the middle rung of a 222.5 N ladder as shown in figure 7. Assuming the end B rests on the corner of a wall and a stop at A to prevent slipping, find the reactions at A and B. 7

10. a) A block of weight W, height $2h$ and width $2c$ rests on a flat car which moves horizontally with constant acceleration a, as shown in Fig. 8. Determine (a) the value of the acceleration a at which slipping of the block on the car will impend if the coefficient of friction is μ and (b) the value of the acceleration at which tipping of the block about the edge A will impend, assuming sufficient friction to prevent slipping. 7

b) A solid right circular cylinder of weight $W = 50$ N and cross-sectional area $A = 100$ cm^2 is suspended by a spring of constant $k = 2$N/cm and hangs partially submerged in water (w = 9810N/m^3), as shown in Fig. 9. Calculate the period τ for small vertical oscillations. Neglect inertia of water. 8

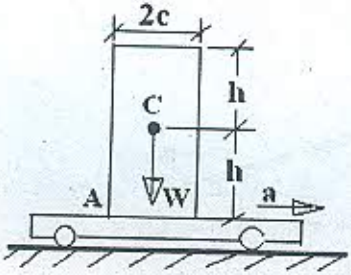


Fig.-8

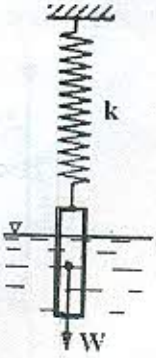


Fig.-9

11. a) An I-section has the following dimensions in mm units.

Bottom flange = 100 × 20

Top flange = 60 × 20

Web = 100 × 20

Determine the moment of inertia of the I-section about centroidal *x-x* axis passing through its centroid & parallel to base. 9

b) Draw the stress-strain diagram of a **mild steel** specimen by showing all the salient points on it. 6

12. A ball is dropped vertically on to a 20° inclined **plane at** 'A'. The direction of rebound forms an angle of 35° **with** vertical. Knowing that the ball strikes the inclined plane at 'B' as shown in figure 10. Determine :

i) The velocity of rebound at 'A'

ii) The time required for the ball to travel from 'A' to 'B'

iii) What do you mean by Free body diagram ? Explain with suitable example. 5 + 5 + 5

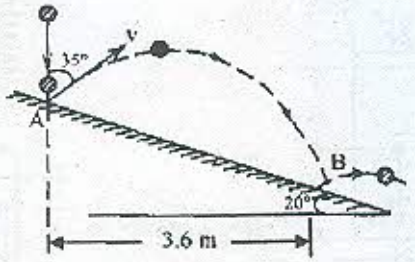


Fig.-10