MAULANA ABUL KALAM AZAD UNIVERSITY OF TECHNOLOGY, WEST BENGAL

ME-101

ENGINEERING MECHANICS

Time Allotted: 3 Hours | Full Marks: 7

The questions are of equal value.
The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable
All symbols are of usual significance

GROUP A
(Multiple Choice Type Questions)

1. Answer *all* questions. $10\times1 = 1$

(i) A number of forces acting at a point will be in equilibrium if

(A) their total sum is zero
(B) two resolved parts in two directions at right angles are equal
(C) sum of resolved parts in any two perpendicular directions are both zero
(D) all of them are inclined equally
(E) none of these

(ii) Given $\vec{F}_1 = 5\hat{j} + 4\hat{k}$ and $\vec{F}_2 = 3\hat{i} + 6\hat{k}$. The magnitude of the scalar product of these vectors is

(A) 15 (B) 12 (C) 24 (D) 30

(iii) The work done against any conservative force is stored in the body in the form of

(A) energy (B) potential energy
(C) elastic energy (D) strain energy

(iv) Equation of motion of a particle is $S = 2t^3 - t^2 - 2$, where S is displacement in meter and t is in sec. Acceleration of the particle after 1 sec will be

(A) 8 m/sec^2 (B) 9 m/sec^2 (C) 10 m/sec^2 (D) 5 m/sec^2

(v) The values of $\hat{i}\cdot\hat{i}$ and $\hat{i}\times\hat{i}$ are

(A) 1 and 0 (B) 1 and 1 (C) 0 and 0 (D) 0 and 1

(vi) A body is resting on a plane inclined at angle of 30° to horizontal. What force would be required to slide it down, if the coefficient of friction between body and plane is 0.3

(A) zero (B) 1 kg
(C) 5 kg (D) would depend on weight of body

(vii) Null vector is known as

(A) negative vector (B) unit vector
(C) zero vector (D) all of these

(viii) Relative velocity of $\vec{A}$ with respect to $\vec{B}$ is defined as

(A) $\vec{V}_{AB} = \vec{V}_B - \vec{V}_A$ (B) $\vec{V}_{AB} = \vec{V}_A - \vec{V}_B$
(C) $\vec{V}_{AB} = \vec{V}_B + \vec{V}_A$ (D) None of these

(ix) Frictional force has the following relation with the normal reaction between the two connecting surfaces

(A) $F = \mu N$ (B) $F = \mu^2 N$ (C) $F = \mu/N$ (D) None of these

(x) Three forces $\sqrt{3}p$, p and $2p$ acting on a particle are in equilibrium. If the angle between the first and second be 90°, the angle between the second and the third will be

(A) 30° (B) 60° (C) 120° (D) 150°

GROUP B
(Short Answer Type Questions)

Answer any *three* questions. 3×5 = 15

2. A ball of weight Q = 120N rests in trough ABC, as shown in Fig. A. Determine the forces exerted on the sides, on the vertical face at D and on the inclined face at E, if all the surfaces are perfectly smooth. 5

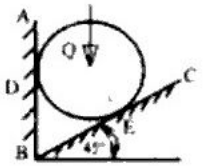

Fig A

3. The line of action of the 500-N force runs through the points A(–7, –2) and B(8, 6) as shown in Fig. B. Find the 'x' and 'y' scalar components of force F. 5

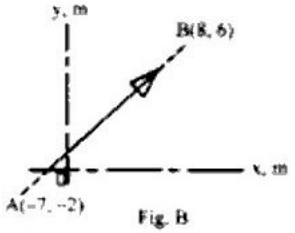

Fig. B

4. The acceleration of a particle is given by '$a = 4t - 30$', where 'a' is in m/sec^2 and t is in seconds. Determine the velocity and displacement as functions of time. The initial displacement at $t = 0$ is $s_0 = -5$m and initial velocity is $v_0 = 3$m/s. 5

5. 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) and about origin. 3+2

6. Two blocks of weights P and Q are connected by a flexible but inextensible cord and supported as shown in Fig. C. If the co-efficient of friction between 5

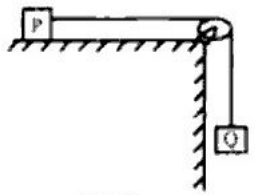

Fig. C

the block P and the horizontal surface is μ (mu) and all other friction is negligible, find (a) the acceleration of the system and (b) the tensile force S in the cord. The following numerical data are given P = 53.4 N; Q = 26.7 N $\mu = \frac{1}{3}$.

7. In Fig. D, a lever is attached to a spindle by means of a square key 6 mm × 6 mm by 2.5 cm long. If the average shear stress in the key is not to exceed 700 N/Cm^2, what is the safe value of the load P applied to the end of the lever? 5

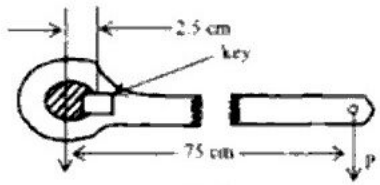

Fig. D

GROUP C
(Long Answer Type Questions)

Answer any *three* questions. 3×15 = 45

8. (a) A force F of 100 kN is applied at the origin O of the axes x-y-z. The line of action of F passes through a point A whose coordinates are 3 m, 4 m and 5 m. Find (i) x, y and z scalar components of F, (ii) the projection F_{XY} of F on the x-y plane and (iii) the projection F_{OB} of F along the line OB. 2.5+2.5+2

(b) Weight W and 2W are supported in a vertical plane by a string and pulleys arranged as shown in Fig. E. Find the magnitude of an additional weight Q applied on the left which will give a downward acceleration $a = 0.1\ g$ to the weight W. Neglect friction and inertia of pulleys. 8

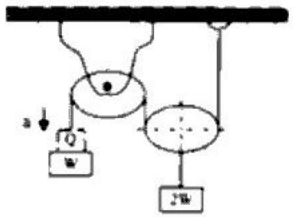

Fig. E

9. (a) Given initial velocity v_0 and angle of projection θ of a projectile. Find the equation that defines y as a function of x. Eliminate time from the kinematic equation. 5

(b) 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 Fig. F. Determine

(i) The velocity of rebound at 'A'

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

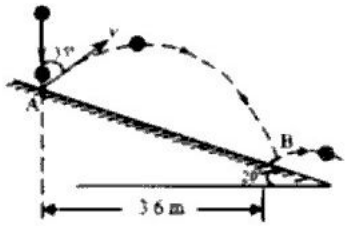

Fig. F

10.(a) Determine the centroid of the area shown in the Fig. G with respect to the axis shown.

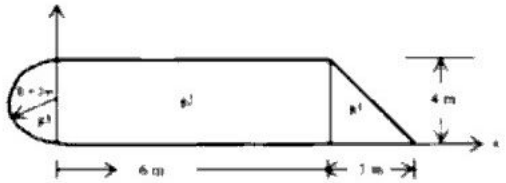

Fig. G

(b) Find the centroid of the unequal angle 200 * 150 * 12 mm, shown in Fig. H

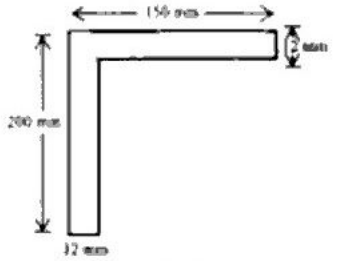

Fig. H

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11.(a) A cable supporting a 6 m high vertical post. The post is anchored to the ground as shown in Fig. I. If the tensile force in the cable is 15 kN, find its moment about z-axis passing through the base of the post. 7

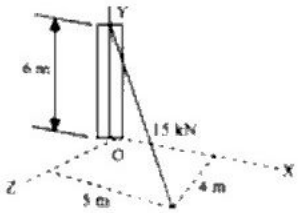

Fig. I

(b) Three flat blocks are positioned on the 30° incline as shown in Fig. J and a force P parallel to the incline is applied to the middle block. The upper block is prevented from moving by a wire which attaches it to the fixed support. The coefficient of static friction for each of the three pairs of mating surfaces is shown. Determine the maximum value of P which may have before any slipping takes place. 8

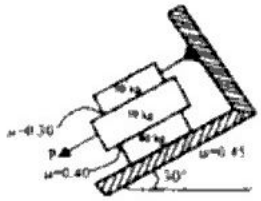

Fig. J

12.(a) A body having mass 5 kg is released at point A from rest, down the incline shown in the Fig. K. Find the velocity when the body will reach to position B, using work energy principle. 6

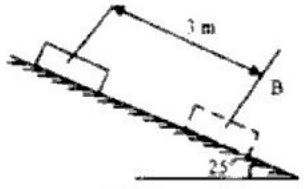

Fig. K

(b) A right circular cylindrical tank containing water spins about its vertical geometric axis oo' at such speed that the free water surface is a paraboloid ACB, as shown in Fig. L. What will be the depth of water in the tank when it comes to rest?

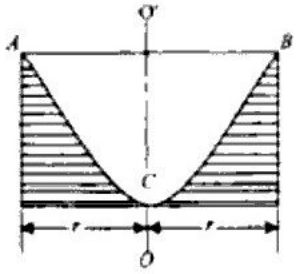

Fig. L