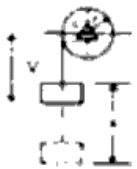
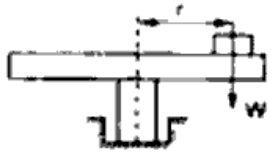
9 (a) Determine the velocity v of the falling weight W of the system as shown in figure, as a function of displacement from the initial position of rest. Assume weight of the cylinder as $2W$

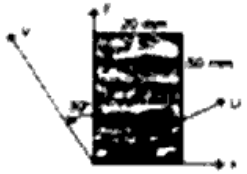


(b) Prove that the volumetric strain of a rectangular bar is the algebraic sum of strains of length, width and height

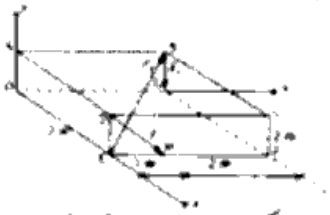
(c) A small block of weight W rests on a horizontal turntable at a distance r from the axis of rotation as shown in figure. If the coefficient of friction between the block and surface of the turntable is μ, find the maximum uniform speed that the block can have due to rotation of the turntable without slipping off



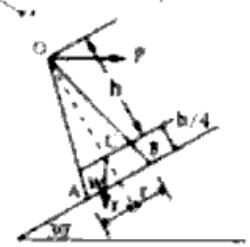
10 (a) For a rectangle shown in Figure, compute I_{uu}, I_{vv} and I_{uv} with respect to u-v axes inclined to x-y axes by 30°. Determine principal axes and second moment of area about the principal axes



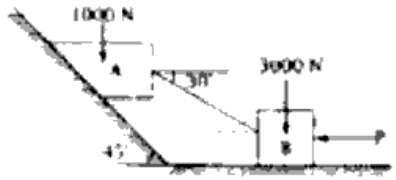
(b) The forces F_1, F_2 and F_3 act on the box as shown in Figure 10. The magnitude of the given forces are 19 N, 23 N and 46 N respectively. Determine the resultant of the forces and its magnitude



11 (a) A solid right circular cone of altitude h = 12 cm and radius r = 3 cm has its cg C on its geometric axis at a distance h/4 above the base. This cone rests on the inclined plane AB which makes an angle of 30° with the horizontal and for which the angle of friction is 0.5. A horizontal force P is applied to the vertex O of the cone and acts in the vertical plane of the figure. Find the maximum and minimum values of P consistent with equilibrium of the cone of weight W = 10 kgf



(b) A block A weighing 1000 N rests on a rough inclined plane whose inclination to the horizontal is 45°. The block is connected to another block B weighing 3000 N resting on a rough horizontal plane, by a weightless rigid bar inclined at an angle 30° to the horizontal as shown in figure. Find the horizontal force that has to be applied on the block B to just move the block A up the slope. Assume coefficients of friction for all contact surfaces is 0.26



ME-101

ENGINEERING MECHANICS

Time Allotted: 3 Hours | Full Marks: 70

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

GROUP A
(Multiple Choice Type Questions)

1 Answer any ten questions 10×1 = 10

(i) The work done against any conservative forces is stored in the body in the form of

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

(ii) The magnitude of two forces, which when acting at right angle produce resultant force of $\sqrt{10}$ kg and when acting at 60° produce resultant of $\sqrt{13}$ kg. These forces are

(A) 2 and $\sqrt{6}$ kg (B) 3 and 1 (C) $\sqrt{5}$ and $\sqrt{5}$ (D) 2 and 5

(iii) If three forces acting in one plane upon a rigid body, keep it in equilibrium, then they must either

(A) meet in a point (B) be all parallel
(C) at least two of them must meet (D) all the above are correct

(iv) A projectile is fired at an angle θ to the vertical. Its horizontal range will be maximum when θ is

(A) 0° (B) 30° (C) 45° (D) 60°

(v) Varignon's theorem is related with

(A) moment of force(s) (B) friction
(C) deformation characteristics of rigid bodies (D) none of the above

(vi) Strain energy is the

(A) maximum energy which can be stored in a body
(B) energy stored in a body when stressed to the elastic limit
(C) energy stored in a body when stressed to the breaking point
(D) none of these

(vii) The C.G. of a solid hemisphere lies on the central radius

(A) at distance 3r/2 from the plane base (B) at distance 3r/4 from plane base

(C) at distance 3r/8 from the plane base (D) at distance 3r/8 from plane base

(viii) If i and j are two Cartesian unit vectors then

(A) i.j = 1 (B) i.j = 0 (C) i.j = 2 (D) none of these

(ix) An elevator weighing 980 N attains an upward velocity of 1m/s in 3 s following a uniform acceleration. The tension in the cable that supports the elevator is

(A) 1000 N (B) 1080 N (C) 880 N (D) 1150 N

(x) If momentum of a body is doubled, its kinetic energy will

(A) get doubled (B) get halved (C) remain same (D) get quadrupled

(xi) The condition of equilibrium of co-planar non-concurrent forces are

(A) $\sum F_x = 0, \sum F_y = 0$ (B) $\sum F_x = 0, \sum F_y = 0, \sum M = 0$

(C) $\sum F_y = 0, \sum M = 0$ (D) $\sum F_x = 0, \sum M = 0$

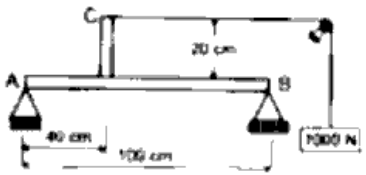
(xii) The equation of motion of a particle is $S = 2t^3 - t^2 + 2$ where S is the displacement in metres and t is time in seconds. The acceleration of the particle after 1 second will be

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

GROUP B
(Short Answer Type Questions)

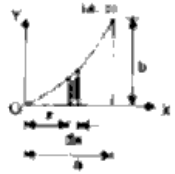
Answer any three questions 3×5 = 15

2. A string is connected at point C of a structure AB passing through a frictionless pulley and at the free end of the string a weight is suspended as shown in Figure. Determine the reaction forces developed at point A and B. Neglect the mass of the structure AB. 5



3. What is meant by toughness? What is meant by resilience? Draw a stress-strain diagram of a mild steel specimen and show region of modulus of toughness and modulus of resilience. 1+1+3

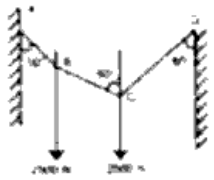
4. By integration determine the co-ordinate of the centroid of the plane area under the curve $y = kx^2$ and x axis, between (0, 0) and (a, b) of the given Figure. 5



5. Given a force $F = 10i - 5j - Ak$ N. If this force is to have a rectangular component of 8 N along a line having unit vector $r = 0.6i - 0.8k$, what should be the value of A? What is the angle between F and r? 2+3

6. (a) State Lami's theorem. 1+4

(b) Two equal loads of 2500 N are supported by a flexible string ABCD at points B and D as shown in the figure. Find the tensions in the portions AB, BC, CD of the string.

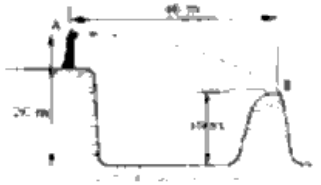


GROUP C
(Long Answer Type Questions)

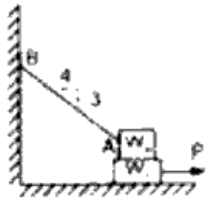
Answer any three questions 3×15 = 45

7. (a) A force of 200 N is directed along the line drawn from the point P(5,2,4) to the point Q(3, 5,6). Determine the moment of this force about a point A(4,3,2). The distances are in meters. 7

(b) Reference to Figure, with what minimum horizontal velocity u can a boy throw a rock at A and have it just clear the obstruction at B? 8



8. (a) A block of weight W_1 = 200 kgf rests on a horizontal surface and supports on top of it another block of weight W_2 = 50 kgf. The block W_2 is attached to a vertical wall by the inclined string AB. Find the magnitude of the horizontal force P applied to the lower block as shown in Figure, which will be necessary to cause slipping to impend the coefficient of static friction for all contiguous surfaces which is $\mu = 0.3$. 8



(b) A steel rod ABCD of stepped section is loaded as shown in figure. The loads are assumed to act along the centre line of the rod. Estimate the displacement of D relative to A. Assume $E = 2 \times 10^5$ N/mm^2. 7