B.Tech/1st/All Sections
Engineering Mechanics

Full Marks : 70

Time : 3 hours

Answer **six** questions including **Q. No. 1**, which is compulsory

The figures in the right-hand margin indicate marks

1. Answer the following : 2×10

(*a*) State and explain the necessary conditions for three non-parallel forces in equilibrium.

(*b*) State and prove the theorem of Varignon.

(*c*) What do you mean by FBD ? Draw the FBD^s for the identical spheres *A* and *B*, kept in a horizontal channel as shown in Fig. 1.

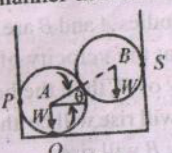

*Fig.*1

(*Turn Over*)

(*d*) Find the second moment of area of the annular area about an axis (YY) parallel to the centroidal y-axis.(Fig.2

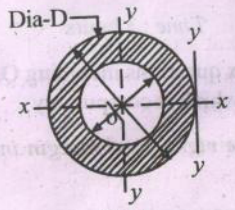

Fig.2

(*e*) State and explain, with a suitable example, the principle of virtual work.

(*f*) How do you differentiate between a truss and a frame ? Why the joints in a truss, are assumed to be frictionless hinged joints ?

(*g*) If two bodies *A* and *B* are projected upwards such that the velocity of *A* is double the velocity of *B*, then the height to which the body *A* will rise will be the height to which the body *B* will rise.

(*h*) Show that the differential change in kinetic-energy of a moving particle is equal to the work done by the acting force on the corresponding infinitesimal displacement.

(*i*) Show that the differential change in momentum of a particle during a small element of time 'dt' is equal to the impulse of the acting force during the same time. What is the unit of impulse ?

(*j*) A particle of weight 'W' attached to a string of length '*l*' whirls in a horizontal circular path with uniform speed '*v*'. Find the tensile force 'T' in the string.

2. (*a*) Three equal inextensible strings of negligible weight are knotted together to form an equilateral triangle *ABC* and a weight *W* is suspended from *A*. If the triangle and weight to be supported with BC horizontal by means of two strings at *B* and *C* as shown in *Fig.*3,

each at an angle of $\alpha = 135^\circ$ with BC, find the tension in the string BC. 5

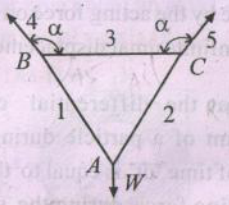

Fig.3

(*b*) Two blocks of weights W_1 and W_2 rest on a rough inclined plane and are connected by a short piece of string as shown in *Fig.*4. If the coefficients of friction are $\mu_1 = 0{\cdot}2$ and $\mu_2 = 0{\cdot}3$, respectively, find the angle of inclination of the plane for which sliding will impend. Assume $W_1 = W_2 = 22{\cdot}25$ N. 5

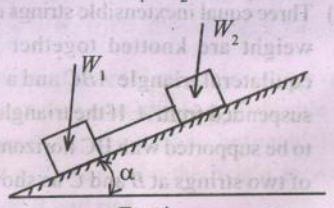

Fig.4

3. (*a*) Two horizontal beams are arranged as shown in *Fig.*5. Determine the reaction produced at the support C due to the action of a vertical load P applied to the beam AB as shown. 5

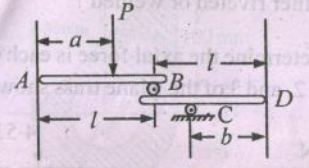

Fig.5

(*b*) A slender homogeneous wire of uniform cross-section is bent into the shape as shown in *Fig.*6. If the dimension 'a' is fixed, find the dimension '*b*' so that the centre of gravity of the wire will coincide with the centre C of the semicircular portion. 5

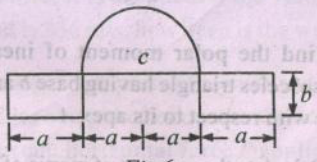

Fig.6

4. (*a*) When a plane truss is said to be a rigid frame work ? Why the members or bars are assumed to be connected at their ends by frictionless hinges although the joints are either riveted or welded ? 2

(*b*) Determine the axial force is each of the bars 1, 2, and 3 of the plane truss shown in *Fig.*7. 8

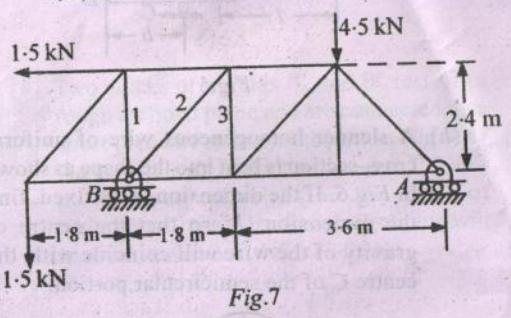

*Fig.*7

5. (*a*) Find the polar moment of inertia of an isosceles triangle having base *b* and attitude *h* with respect to its apex *A*. 3

(*b*) Calculate the moment of inertia of the shaded

area, shown in *Fig.*8, with respect to the controidal axis parallel to the *x*-axis. 7

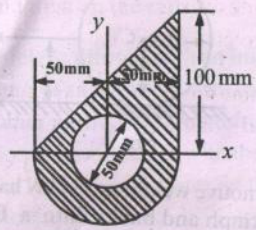

*Fig.*8

6. (*a*) A stone is dropped into a well and falls vertically with constant acceleration $g = 9{\cdot}81$ m/s^2. The sound of impact of the stone on the bottom of the well is heard 6·5 s after it is dropped. If the velocity of sound is 336 m/s, how deep is the well ? 5

(*b*) A homogenous sphere of radius *r* and weight *W* slides along the door under the action of a constant horizontal force *P* applied to a string as shown in Fig.9 Determine the height

h during this motion if the coefficient of friction between sphere and floor is μ. 5

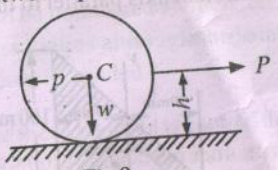

Fig.9

7. (*a*) A locomotive weighing 534 kN has a velocity of 16 kmph and backs into a freight car weighing 86 kN that is at rest on a level track. After coupling is made, with what velocity 'v' will the entire system continue to move ? 5

(*b*) When a ball of weight W rests on a spring of constant k (Fig.10), it produces a static deflection of 25 mm. How much will the same ball compress the spring if it is dropped from a height, $h = 0{\cdot}3$ m ? Neglect the mass of the spring. 5

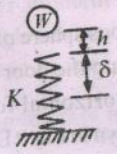

Fig.10

(*Continued*)

8. (*a*) A locomotive of weight $W = 534$ kN goes around a curve of radius $r = 300$ m at a uniform speed of 72 kmph. Determine the total lateral thrust on the rails. 4

(*b*) A particle is thrown with an initial velocity of 10 m/s at an angle 45° with the horizontal. If another particle is thrown from the same position at an angle 60° with the horizontal, find the velocity of the later for the following situations : 6

(*i*) Both has same range

(*ii*) Both has same time of flight.