(f) Distinguish between Newton's 2nd law of motion and d'Alambert's principle.

(g) Explain the principle of law of conservation of momentum.

(h) What do you mean by curvilinear translation ? Illustrate through an example.

(i) How do you find moment of inertia of a circular dise ? What do you mean by radius of gyration ?

(j) Describe the pure rolling motion of a cylinder on an inclined plane.

2. (a) A cylinder of weight W and radius R is supported against a smooth vertical wall and rests on a bar AB of length l and of negligible weight. The bar is hinged at A on the wall and is supported by a horizontal string BC. The point C is located vertically above the point A. Find the angle of inclination of the bar AB with the wall that the bar will make so that the tension in the string is minimum. Also find the tension in the string. 5

(Continued)

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

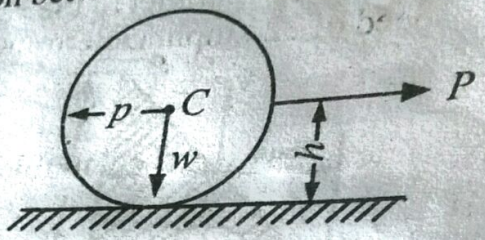

Fig.9

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

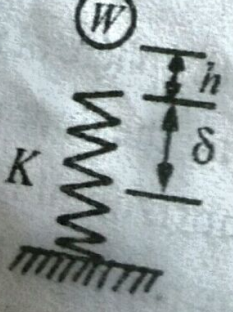

Fig.10

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bomb. Calculate also the direction and the velocity with which the bomb hits the target. 5

(b) A small car of weight W has four solid disc wheels, each of weight $\frac{W}{4}$ and radius 'r'. What acceleration will the car have in coasting down a straight track inclined to the horizontal by an angle α. if rolling resistance is neglected ? Assume that the wheels roll without sleep. 5

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

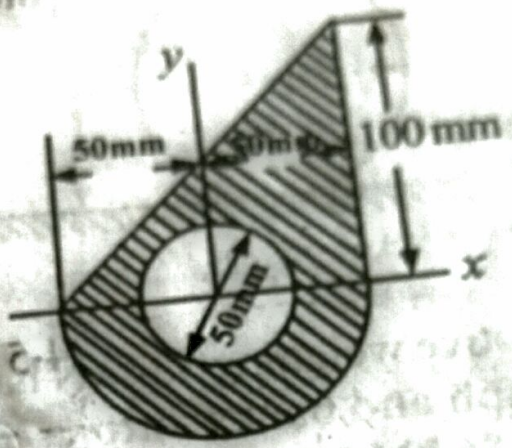


Fig.8

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 ?

(*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 heigh

7. (*a*) Neglecting friction and the inertia of pulleys determine the velocity of body *A* and body *B* after 3s if the system in Fig. 7(a) is released from rest.

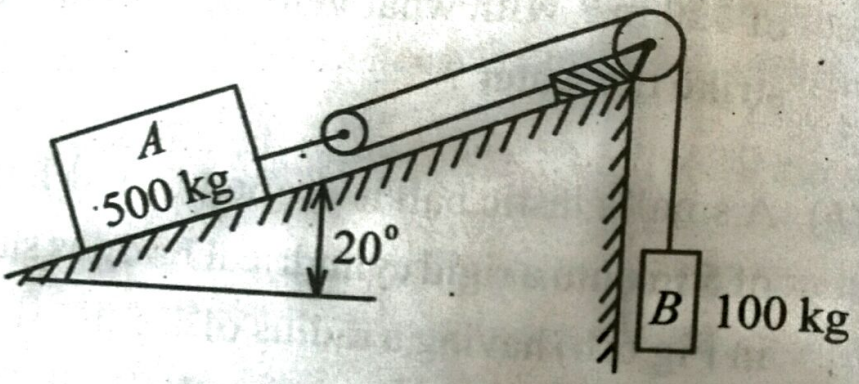


Fig. 7(a)

(*b*) A projectile is fired at a speed of 1000 m/s at an angle of 40° measured from an inclined surface which is at an angle of 20° from the horizontal. If we neglect friction, at what distance along the incline does the projectile hit the incline ? 5

8. (*a*) The motion of a particle *m* in the *xy* plane is defined by the equations

$$x = a \cos pt \text{ and } y = b \sin pt,$$

(b) Differentiate

(*i*) limiting friction
(*ii*) static friction
(*iii*) kinetic friction.

Explain with example.

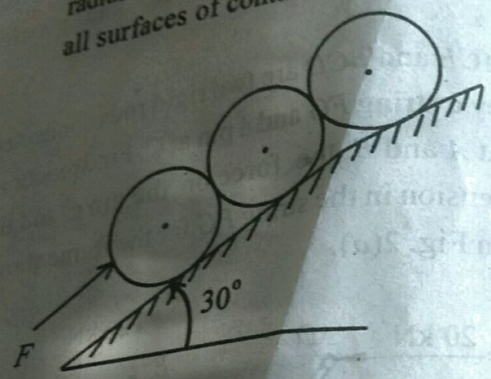
(c) How do you determine the resultant of the given system of coplanar parallel forces analytically ? Explain with examples.

(d) State the two theorems of Papus to determine the (*i*) surface area of revolution and
(*ii*) volume of revolution.
Compute the location of centre of volume of a right circular base cone of height 'h' and radius at base 'r'.

(e) Explain the principles used in method of sections in analysis of truss. Demonstrate through an example.

(f) State and explain the principle of virtual work. Demonstrate its application through an example.

(*b*) What is the force F to hold the three cylinders, each having a mass of 50 kg and radius 1 m each (Fig . 2(*b*) ? Take $\mu = 0{\cdot}2$ for all surfaces of contact. 5



3. (*a*) A beam is shown in *Fig.* 3(*a*). Determine the reactions at both supports *A* and *B*. 5

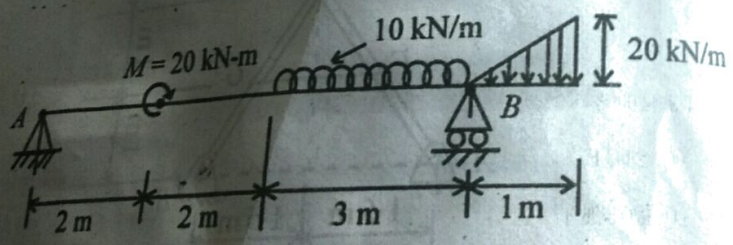


Fig. 3(*a*)

(*Continued*)

(*b*) Determine the position of the centroid of an area formed by the intersection of a parabola $ay = x^2$ and *a* straight line $y = x$. 5

4. (*a*) Find force in each member of the truss shown in *Fig.* 4(*a*). Use method of joints. 5

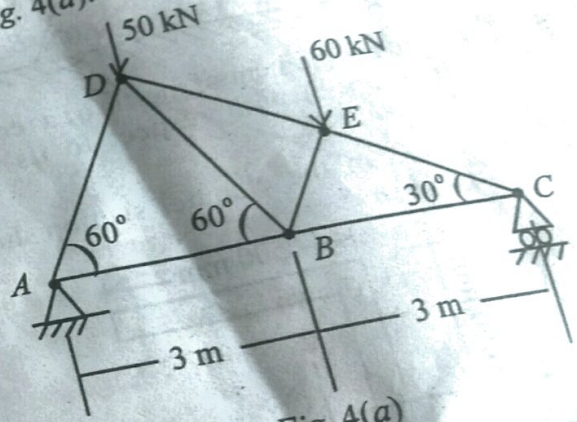


Fig. 4(*a*)

(*b*) Using the principle of virtual work, find the value of the angle θ defining the configuration of equilibrium of the system shown in *Fig.* 4(*b*). The balls *D* and *E* can slide freely

(Turn Over)

(*b*) A homogeneous light rod *ABCD* is bent as shown in Fig. 5(*b*) and is attached to a hinge at *C*. Determine the length *L* such that by the action of gravity alone the portion *BCD* remains horizontal. 5

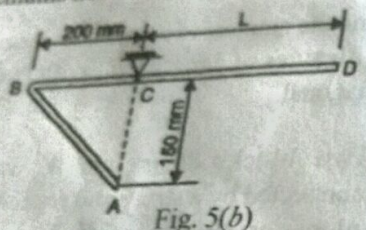


Fig. 5(*b*)

6. (*a*) A car moving at a speed of 150 km.p.h. is subjected to air resistance given by $F = 0{\cdot}4\ V^2$ N, where V = velocity, m/s. Determine the distance moved by the car before its speed becomes 40% of the initial speed. Mass of the car is 450 kg. 5

(*b*) A horizontal force *P* applied to the centre of the mass of a sphere of radius '*r*' and mass '*m*' causes it to roll without slipping. Find

(*i*) the acceleration of the sphere.

(Continued)

(*ii*) If the sphere is replaced by a disc of the same mass and radius, find the acceleration of the disc. The coefficient of friction μ is same in both the cases. 5

7. (*a*) Determine the potential energy of a body acted upon by a force which is inversely proportional to the square of the distance '*r*' from the source of the force. 5

(*b*) A vehicle starts from rest at a point '*O*' and travels along a straight line with acceleration 2 m/s^2. Another vehicle starts from rest at the same point 4 seconds later and, travels along the same path with an acceleration of 3 m/s^2. How far from '*O*' will be the location where the 2nd would overtake the first vehicle ? 5

8. (*a*) An aircraft moving horizontally at 55 km/h at a height of 500 m towards a target on the ground releases a bomb which hits it. Estimate the horizontal distance of the aircraft from the target when it, released the

(Turn Over)

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 ?

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

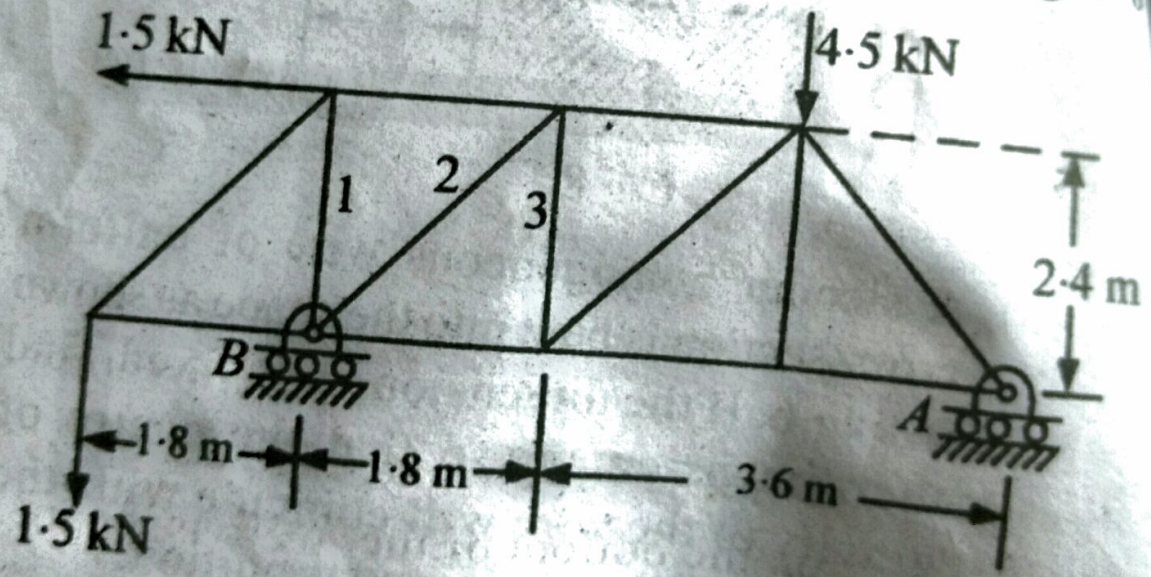


Fig.7

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

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

2×10

1. Answer the following :

(*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 FBDs for the identical spheres *A* and *B*, kept in a horizontal channel as shown in Fig. 1.

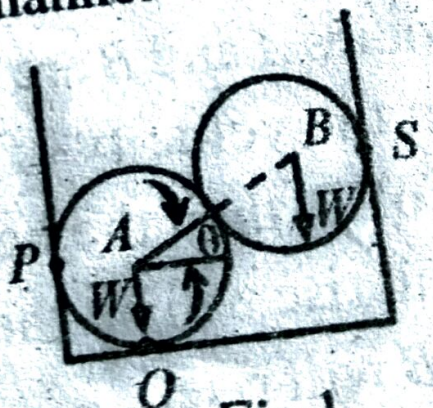


Fig.1

(Turn O

(b) A shell is fired from a hill 150 m high above a plain. The angle α of firing is 15° above the horizontal, and the muzzle velocity V_0 is 1000 m/s. At what horizontal distance, d, will the shell hit the plain if we neglect friction of the air ? What is the maximum height of the shell above the plain ? 5

8. (a) The wheel of a small gyroscope is set spinning by pulling on a string wound around the shaft. Its moment of inertia is $I = 6000$ kg-mm^2 and the diameter of the shaft on which the string is wound is 12 mm. If 750 mm of string is pulled off with a constant force of 50 N, what angular velocity will be imparted to the wheel ? 5

(b) The cylinder shown weighs 500 N and has a radius of gyration of 0·3 m. What is the minimum coefficient of friction at A that will prevent the body from moving ? Using half of this coefficient of friction, how far

does point O move in 1·2 s if the cylinder is released from rest ? Refer Fig. 8(b). 5

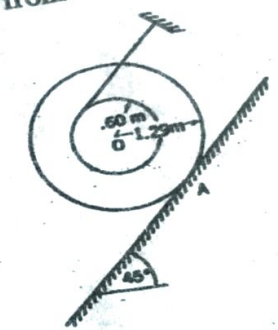


Fig. 8(b)

find

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

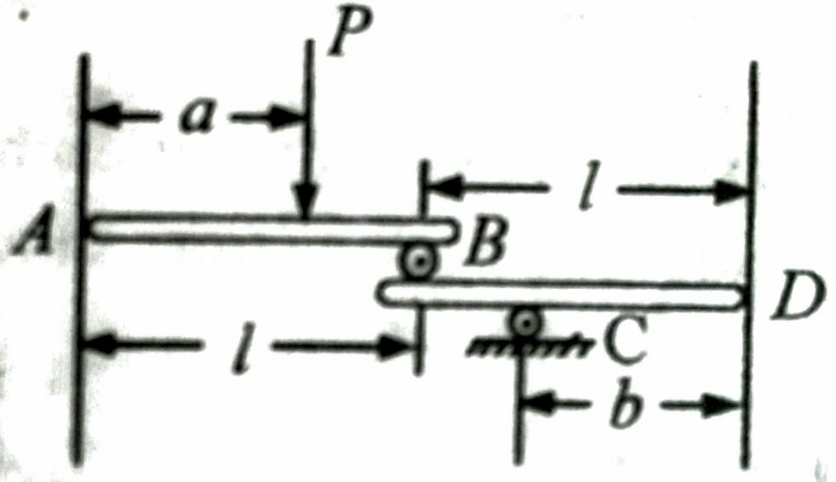


Fig.5

(*b*) A slender homogeneous wire of uniform

magnitude of P is maximum, and the corresponding magnitude of P. 5

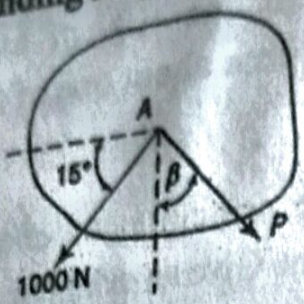


Fig. 2 (*a*)

(*b*) Two heavy right circular rollers of diameters D and d, respectively, rest on a rough horizontal plane as shown in Fig. 2(*b*). The larger roller has a string wound around it to which a horizontal force P can be applied as shown. Assuming that the coefficient of friction μ has the same value for all surfaces of contact, determine the condition (i.e. value of $\mu = ?$) under which the larger roller can be pulled over the smaller one. 5

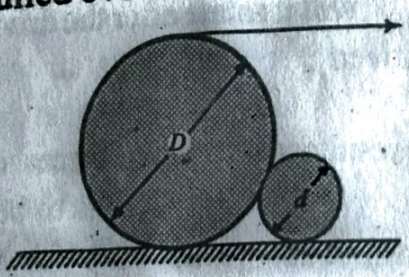


Fig. 2 (*b*)

Set-1

ENGINEERING MECHANICS

Full Marks : 70

Time : 3 hours

Answer Q. No. 1 and any five from the rest

The figures in the right-hand margin indicate marks

1. Answer the following questions : 2×10

(*a*) State Varignon's principle. Explain by an example.

(*b*) Distinguish between static and kinetic friction. Which has a larger value?

(*c*) What is the relation between the number of joints and number of members for a truss to be designated as a perfect truss ? If this condition is not satisfied, what will be the framed structure called ?

(Turn Over)

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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.

(b) A slender prismatic bar AB of length 'l' and weight 'w' stands in a vertical plane and is supported by smooth surfaces at A (on a horizontal plane) and B (on a transverse vertical plane). Using the principle of virtual work, find the magnitude of the horizontal force P applied at A to keep the bar in equilibrium. 5

5. (a) For a rectangular plate 10 cm × 20 cm size, find the centroidal rectangular moments of inertia I_{xx} and I_{yy}. Find also the moment of inertia of the plate about an axis perpendicular to the plate and passing through the centroid. 5

(b) Find the centroid of the angle section shown in Fig. 5(b). Also find the moments of inertia I_{xx} and I_{yy} where xx and yy are the axes parallel to the legs and pass through the centroid . 5

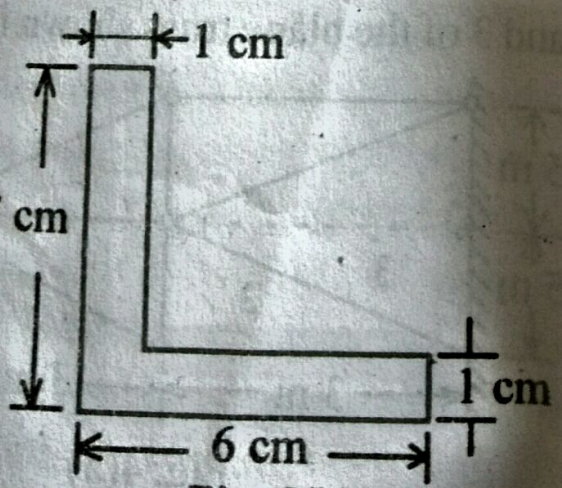

Fig. 5(b)

(Continued)

6. (a) A ship while being l
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(*b*) The resultant of two forces, when they act at an angle of 60° is 280 N. If the same forces act at right angles, their resultant is $20\sqrt{136}$ N. Find the magnitudes of the forces. 5

3. (*a*) Two identical rollers, each weighing 200 N, are supported by smooth inclined plane of 30° to the horizontal and a smooth vertical wall. Find reactions induced at all points of contact. 5

(*b*) A circular hole of radius $\frac{R}{2}$ is drilled out off a circular plate of radius R. Find the distance between the centres of the plate and the hole, if the centre of the mass of the remainder lies on the extreme left point on the circumference of the hole. 5

4. (*a*) Find the axial force in each of the bars 1,2, and 3 of the plane truss shown in Fig. 4(a).

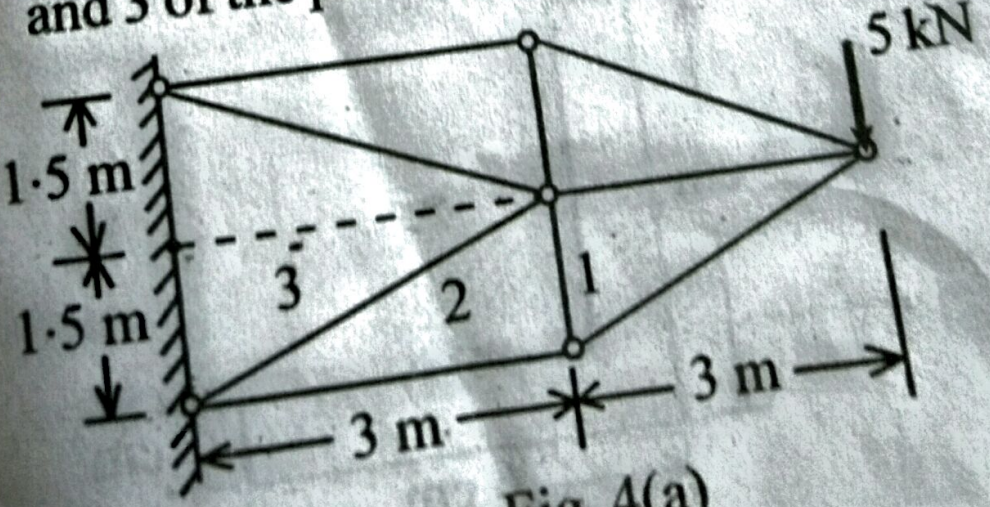
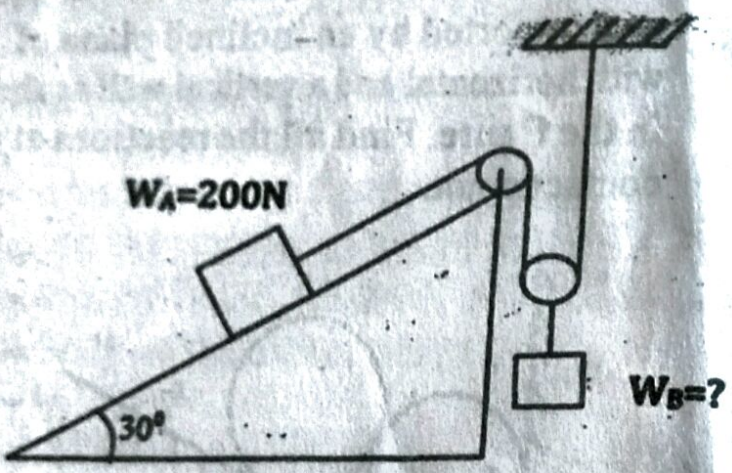


Fig. 4(a)

of the larger force is reversed and the other remains unaltered, the resultant reduces to 180 N. Determine the magnitude of the forces and the angle between the forces. 5

(b) Using the principle of virtual work determine the weight W_B for which the motion of the block A is impending up the plane. Given : coefficient of friction between block A and the plane is 0·3 and the pulleys are smooth. 5



4. (a) A ball is dropped from the top of a tower 30 m height. At the same instant a second ball is thrown upward from the ground with an inital velocity of 15 m/sec. When and where do they cross and with what relative velocity ? 5

(Continued)

(*d*) Using the second theorem of Papus, calculate the centroid of a semi-circular area of radius '*r*'.

(*e*) State the relation between the number of joints and number of members for a perfect structure. What happens if this condition is not satisfied ?

(*f*) Analyse the motion of two masses m_A and m_B ($m_A > m_B$) hanging at the two ends of a weightless string lying on a smooth pulley.

(*g*) Derive the expression of the acceleration of a thin disc of radius '*r*' and mass '*m*' rolling down a rough inclined plane.

(*h*) By means of a rope, a body of weight *W* is moved vertically upward with a constant acceleration '*a*'. Find the tensile force in the rope.

(*i*) State and explain the law of conservation of energy. Give an example.

(Continued)

(*j*) Define the term "Coefficient of restitution" in case of impacting bodies. What are its values in case of elastic and plastic collisions ?

2. (*a*) *ACE* and *BCD* are two rigid rods connected by a string *FG* and a pin at C. Find reactions at *A* and *B*, the force on the pin C and the tension in the string *FG* for the frame shown in Fig. 2(*a*). 5

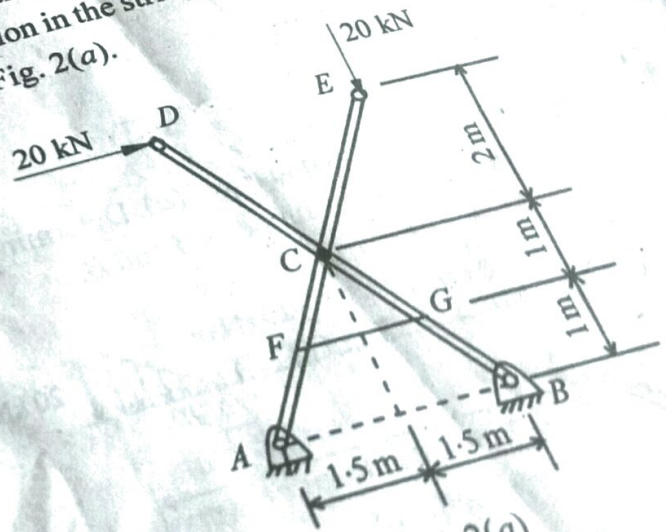


Fig. 2(*a*)

Full Marks : 70

Time : 3 hours

Q. No. 1 is compulsory and answer any five from the rest

The figures in the right-hand margin indicate marks

1. Answer *all* questions : 2×10

(*a*) A body is rotating with an angular velocity of 5 radians/sec. After 4 seconds, the angular velocity of the body becomes 13 radians/sec. Determine the angular acceleration of the body.

(*b*) State parallel axis theorem with simple sketch.

(*c*) Write the conditions of equilibrium of a system of parallel forces acting in a plane.

(*Turn Over*)

5. (a) Using the principle of virtual work, find the reaction R_A for the truss supported and loaded as shown in Fig. 5(a). 5

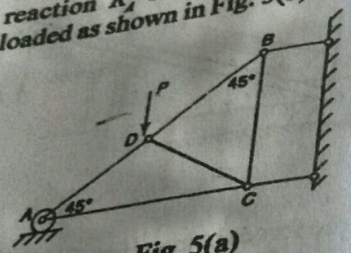


Fig. 5(a)

(b) Find I_{xx}, I_{yy} and polar moment of inertia of a thin rectangular plate of width 'b' and depth 'd'. $x-y$ are the centroidal axes. 5

6. (a) A wood block weighing 25 N rests on a smooth horizontal surface. A revolver bullet weighing 0·15 N is shot horizontally into the block. If the block attains a velocity of 3 m/s, what was the muzzle velocity of the bullet ? 5

(b) If the system in Fig. 6(b) is released from rest in the configuration shown, find the

velocity 'V' of the block Q after it falls a distance $h = 3$ m. Neglect friction and inertia of the pulleys. Assume $P = Q = 45$ N. 5

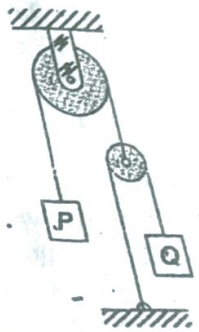


Fig. 6(b)

7. (a) At instant $t = 0$, a locomotive starts to move with uniformly accelerated speed along a circular curve of radius $r = 600$ m and acquires by the end of the first 60 s of motion a speed equal to 24 kmp.h. Find the tangential and normal acceleration at the instant $t = 30$ s. 5

Set- 1

Full Marks : 70

Time : 3 hours

Answer Q. No. 1 and any five questions from the rest

The figures in the right-hand margin indicate marks

1. Answer the following questions : 2×10

   (*a*) Prove that the moment of a force about any point is equal to the sum of moments of its components about that point.

   (*b*) State parallelogram law of forces. Derive the expression for finding resultant of two forces acting at a point.

   (*c*) State and explain principle of virtual work.

   (*d*) State the laws of Coulomb friction.

   (*e*) What is area moment of inertia of a plane lamina. Explain by an example.

(*Turn Over*)

where a, b, and p are constants. Calculate the moment of momentum of the particle with respect to the origin. 5

(*b*) The wheel of a small gyroscope is set spinning by pulling on a string wound around the shaft. The moment of inertia of the wheel is 5×10^{-3} kg-m^2 and the diameter of the shaft on which the string is wound is 12·5 mm. If 900 mm of string is pulled off with a constant force of 53·4 N, what rpm will be imparted to the wheel ? 5

7. (a) A small block of weight $W = 44{\cdot}5$ N is given an initial velocity $v_0 = 3$ m/s down the inclined plane oriented at 30° to the horizontal. If the coefficient of friction between the plane and the block $\mu = 0{\cdot}3$, find the velocity V of the block after it has travelled a distance of 15 m along the incline. 5

(b) A wood block weighing 44 N rests on a rough inclined plane, the coefficient of friction between the two being $\mu = 0{\cdot}4$. If a bullet weighing 0·23 N is fired horizontally into the block with a muzzle velocity $V = 600$ m/s, how far will the block be displaced from its initial position ? Assume that the bullet remains inside the block after the impact. 5

8. (a) The maximum range of a projectile is 1800 m. At what angle of elevation α will the range be 1350 m if the initial velocity remains unchanged. 5

(*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,

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B.Tech-2nd

Engineering Mechanics

Full Marks : 70

Time : 3 hours

Answer Q. No. 1 and any five from the rest

The figures in the right-hand margin indicate marks

2×10

1. Answer the following :

(a) A hinged square *ABCD* (Fig. 1(a) with diagonal *BD* is subjected to the action of two equal and opposite forces as shown. Determine the forces produced in all the bars.

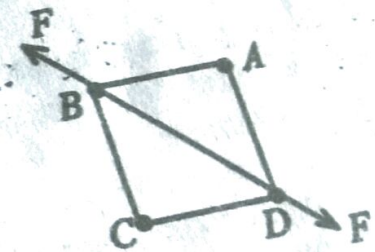
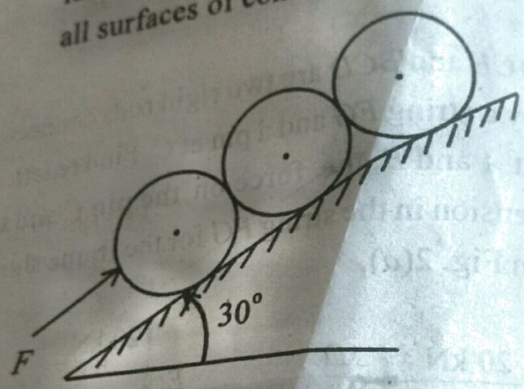


Fig. 1 (a)

(*b*) What is the force F to hold the three cylinders, each having a mass of 50 kg and radius 1 m each (Fig . 2(*b*) ? Take $\mu = 0{\cdot}2$ for all surfaces of contact. 5



3. (*a*) A beam is shown in *Fig.* 3(*a*). Determine the reactions at both supports *A* and *B*. 5

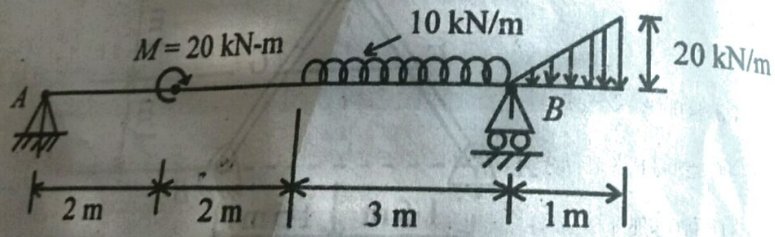


Fig. 3(*a*)

(*Continued*)

(*b*) Determine the position of the centroid of an area formed by the intersection of a parabola $ay = x^2$ and *a* straight line $y = x$. 5

4. (*a*) Find force in each member of the truss shown in *Fig.* 4(*a*). Use method of joints.

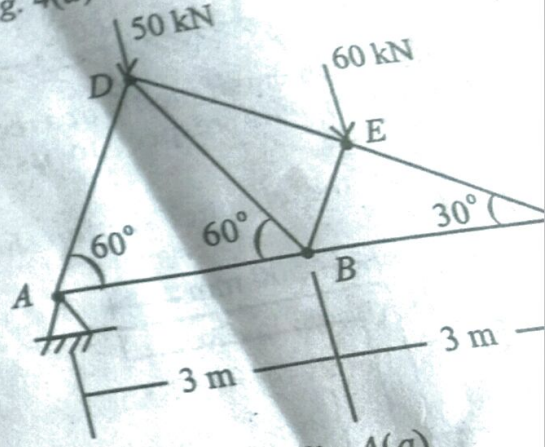


Fig. 4(*a*)

(*b*) Using the principle of virtual wo
value of the angle θ defining
ration of equilibrium of the sys
Fig. 4(*b*). The balls D and E

along the bars AC and BC but the string DE connecting them is inextensible.

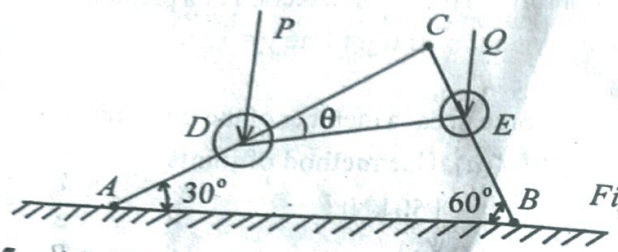
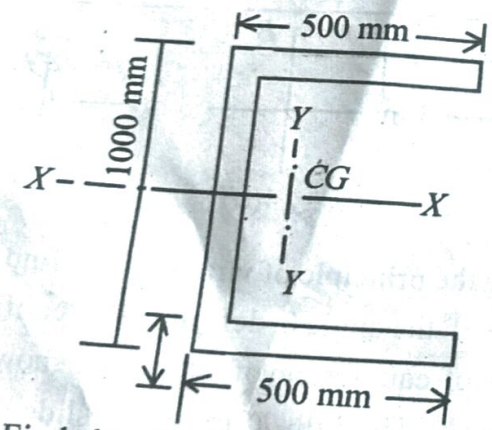


Fig. 4(*b*)

5. (*a*) Find the moment of inertia of a rectangular area ($a \times b$) with respect to its base of width 'b'. 5

(*b*) Find I_{xx} of the channel section shown in *Fig.* 5(*b*). 5



Find also the I_{yy}. *Fig.* 5(*b*)

(*Continued*)

6. (*a*) The greatest possible acceleration or deceleration that a train may have is a, and its maximum speed is V. Find the minimum time in which the train can get from one station to the next if the total distance is s. 5

(*b*) Two blocks of weight P and Q are connected by a flexible but inextensible cord and supported as shown in *Fig.* 6(*b*). If the coefficient of friction between the block P and the horizontal surface is μ and all other friction are negligible, find (*i*) the acceleration of the system. (*ii*) the tensile force in the chord. 5

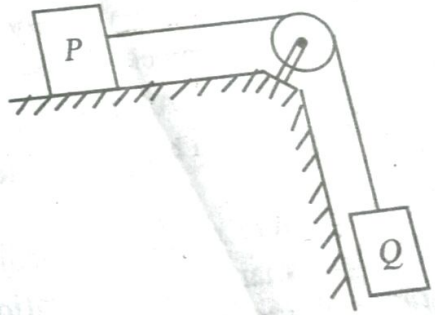


Fig. 6(*b*)

(Turn Over)

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

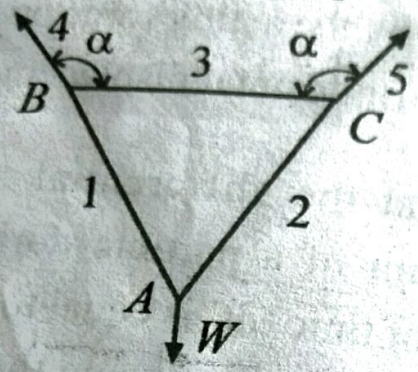


Fig.3

(*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

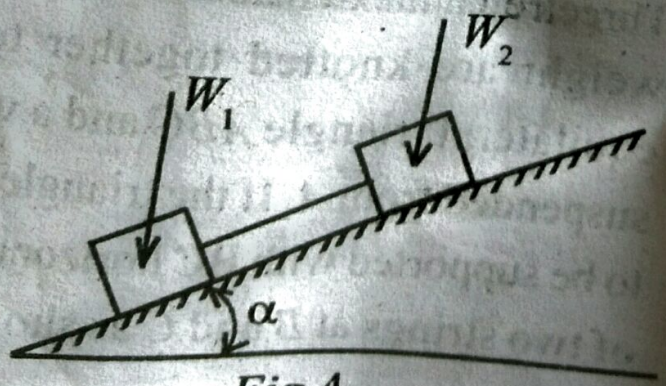


Fig.4

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

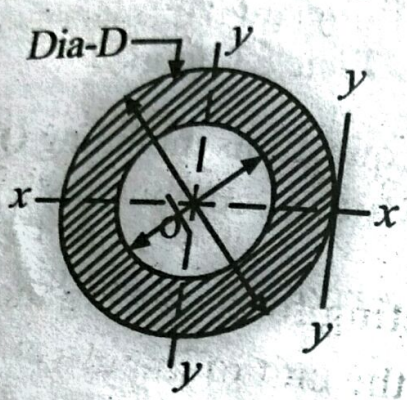


Fig.2

(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.

(Continued)

6. (*a*) A ship while being launched slips down the skids with uniform acceleration. If 10s is required to traverse the first 4·8 m, what time will be required to slide the total distance of 120 m ? With what velocity will the ship strike the water ? 5

(*b*) A small elastic ball is droped from a height of 5 m onto a rigid cylindrical body as shown in Fig.6(b) having a radius of 1.5 m. At what position on the *x*-axis does the ball land ? Assume perfect elastic collision. 5

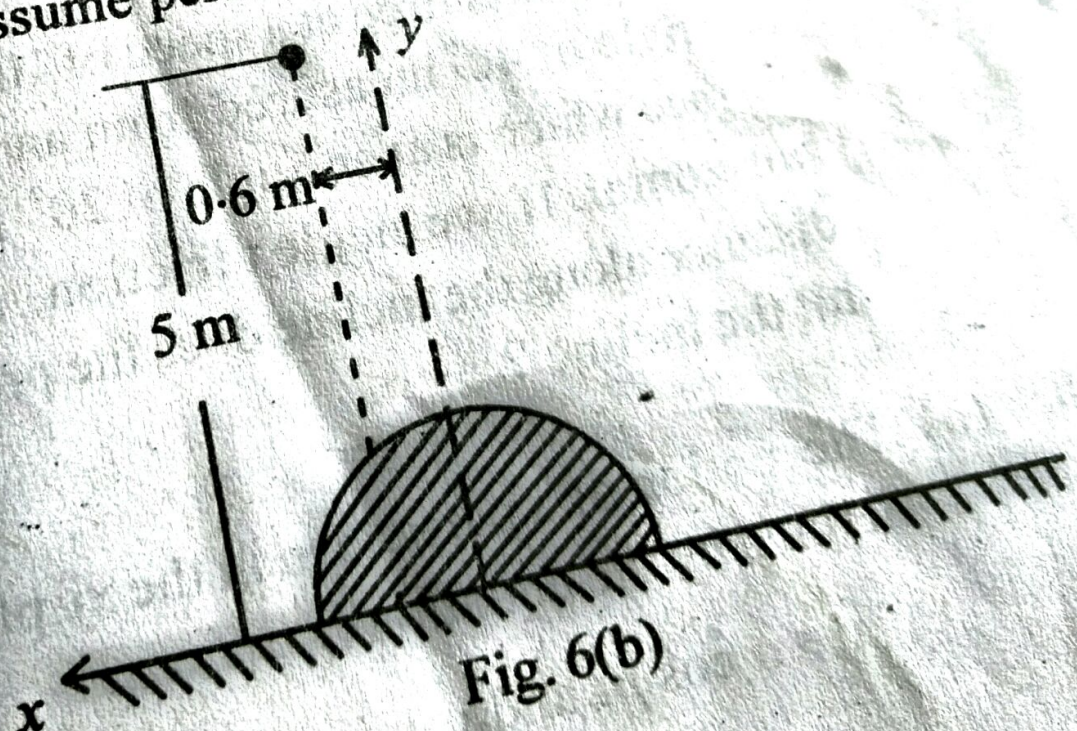


Fig. 6(b)

(Turn