

ENGINEERING MECHANICS

(Common to CE, ME, CSE, PCE, IT, Chem E, Aero E, AME, Min E, PE, Metal E)

Time: 3 hours

Max. Marks: 70

Question Paper Consists of **Part-A** and **Part-B**
 Answering the question in **Part-A** is Compulsory,
 Three Questions should be answered from **Part-B**

PART-A

- 1.(i) State the laws of friction
- (ii) State and prove Lami's theorem
- (iii) A semi-circular area is removed from a trapezium as shown in Fig.1 (dimensions in mm).

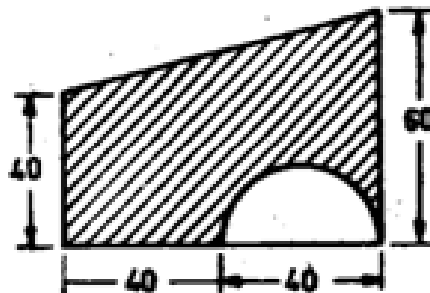


Fig:1

Determine the centroid of the remaining area (shown hatched).

- (iv) State and Prove the parallel axis theorem, to determine the moment of inertia of areas with the help of a neat sketch.
- (v) Establish the Relationship between Angular motion & linear motion
- (vi) Explain the concept of work? What are the units of work?

[3+4+5+6+2+2]

PART -B

- 2.(a) Three bars, hinged at A and D and pinned at B and C as shown in Fig:2 form a four-linked mechanism. Determine the value of P that will prevent movement of bars.

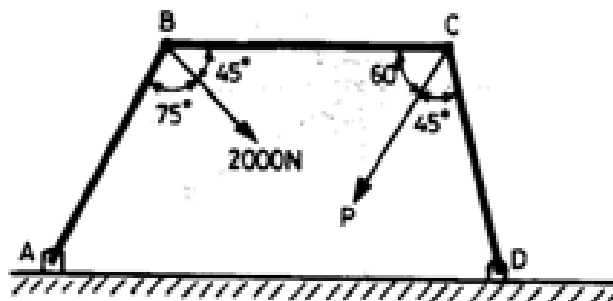


Fig:2

- (b) The position of a particle moving along a straight line is defined by the relation $x = t^3 - 9t^2 + 15t + 18$ where x is expressed in metre m and t in seconds. Determine the time, position, and acceleration of the particle when its velocity becomes zero?

[8+8]



- 3.(a) Determine the centroid of a triangle of base 'b' and height 'h'?
- (b) Three cylinders weighing 100 N each and of 80 mm diameter are placed in a channel of 180 mm width as shown in Fig:3

Determine the pressure exerted by (i) the cylinder A on B at the point of contact; (ii) the cylinder B on the base and on the wall.

[8+8]

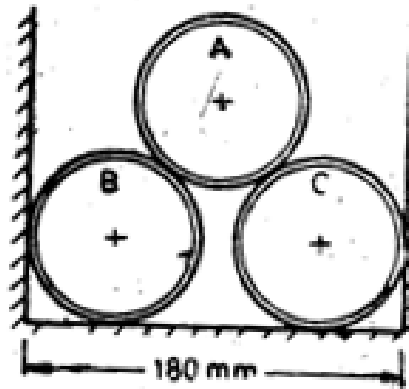


Fig.3

- 4.(a) Find the mass Moment of Inertia of circular plate of radius R and thickness t about its centroidal axis
- (b) A force of 250 N pulls a body of weight 500 N up an inclined plane, the force being applied parallel to the plane. If the inclination of the plane to the horizontal is 15° , find the coefficient of friction?

[8+8]

- 5.(a) Differentiate kinematics and kinetics?
- (b) Locate the co-ordinates of the centroid of the shaded area of a lamina shown in Fig:4?

[4+12]

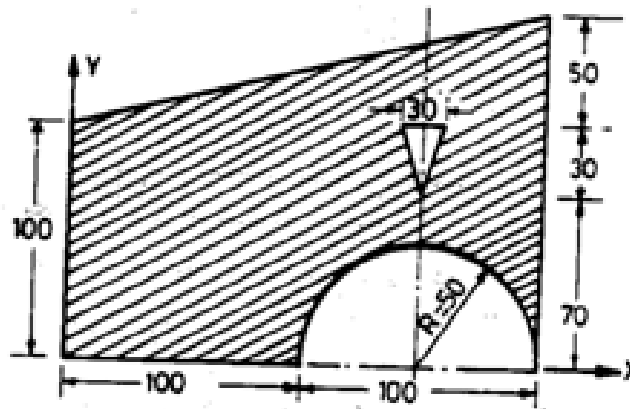


Fig:4



- 6.(a) Derive work energy equation for translation?
 (b) Two men carry a weight of 2 KN by means of two ropes fixed to the weight. One rope is inclined at 45° and the other at 30° with their vertices. Find the tension in each rope? [8+8]
- 7.(a) Locate the centre of gravity of the right circular cone of base radius r and height h shown in Fig:5

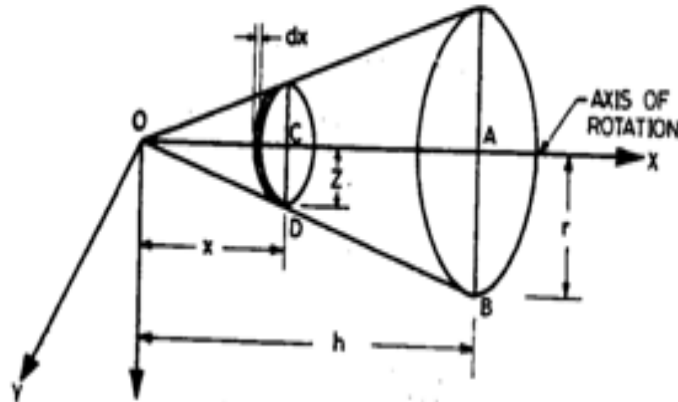


Fig:5

- (b) A bullet of weight 0.3 N is fired horizontally into a body of weight 100 N which is suspended by a string 0.8 m long. Due to this impact the body swings through an angle of 30° . Find the velocity of the bullet and the loss in the energy of the system? (as shown in Fig:6)

[8+8]

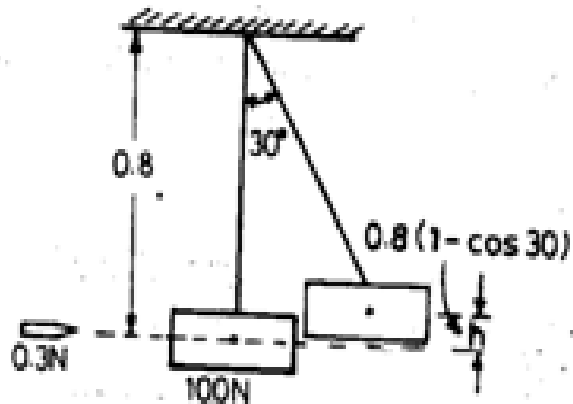


Fig:6



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PART-A

- 1.(i) Prove that angle of repose is same as the value of limiting angle friction?
- (ii) A uniform sphere of weight W rests between a smooth vertical plane and a smooth plane inclined at an angle with the vertical plane. Find the reaction at the contact surfaces.
- (iii) Determine the mass moment of inertia of a rectangular plate of size $a \times b$ and thickness about its centroidal axes.
- (iv) What is the difference between centroid and centre of gravity?
- (v) A stone is dropped into a well while splash is heard after 4.5 s. Another stone is dropped with an initial velocity v and the splash is heard after 4 s. If the velocity of a sound is 336 m/s, determine the initial velocity of second stone?
- (vi) Derive the equation for motion of connected bodies?

[3+4+4+4+4+3]

PART-B

- 2.(a) The block A shown in Fig.1 weighs 2000 N. The cord attached to A passes over a frictionless pulley and supports a weight equal to 800N. The value of coefficient of friction between A and the horizontal plane is 0.35. Solve for horizontal force P : (1) If motion is impending towards the left, and (2) If the motion is impending towards the right?

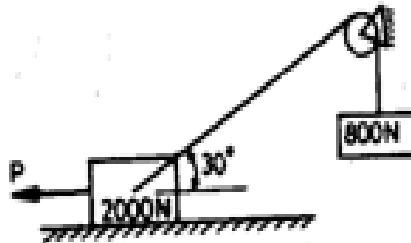


Fig.1

- (b) Derive work energy equation for translation?

[8+8]



- 3.(a) What is free body diagram and what are the rules for drawing FBD?
 (b) Determine the maximum height h of the cylindrical portion of the body with hemispherical base shown in Fig.2 so that it is in stable equilibrium on its base.

[4+12]

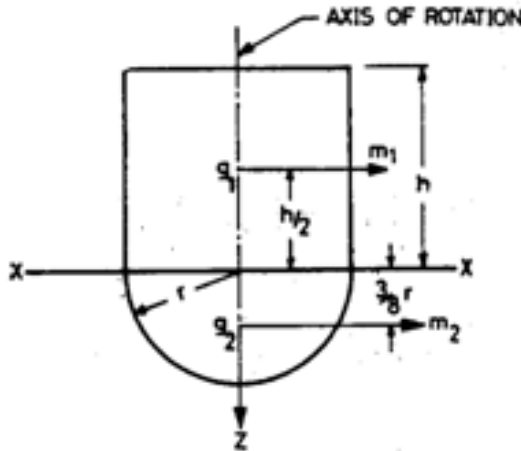


Fig.2

- 4.(a) Derive the centroid of a parabolic spandrel?
 (b) State the equations of equilibrium of a rigid body experiencing a planar motion? [8+8]
- 5.(a) Derive the Moment of Inertia of a quarter circle of radius ' r ' about the base and the centroidal axes?
 (b) A tripod is acted upon by forces at 'P' as shown in the Fig.3 Determine the forces in the legs of tripod if the legs rest on ground at A, B and C whose coordinates with respect to O are as shown in the Fig.3 The height of 'P' above the origin is 10 m.

[8+8]

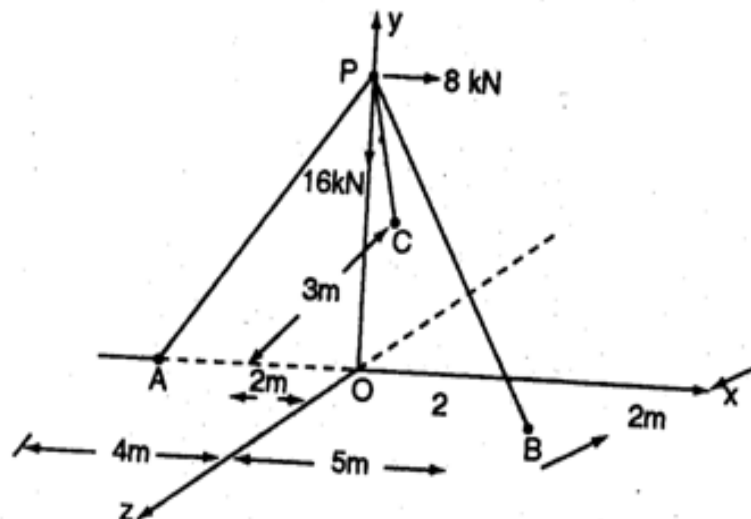


Fig.3



- 6.(a) A flywheel of 550 mm diameter is brought uniformly from rest up to a speed of 350 rpm in 20 s. Find the velocity and the acceleration of a point on its rim 3 s after starting from rest?
 - (b) The resultant of two forces acting at a point is 65 kN. It is observed that one force is double than that of the other and if the direction of one of them is reversed the resultant becomes 45 kN. Find the magnitudes of forces and the angle between them.
- [8+8]
- 7.(a) Determine the tension in the string and the velocity of 1500 N block shown in Fig.4 5 seconds after starting from
- (i) Rest
 - (ii) Starting with a downward velocity of 3 m/sec.
- Assume pulleys as weightless and frictionless.

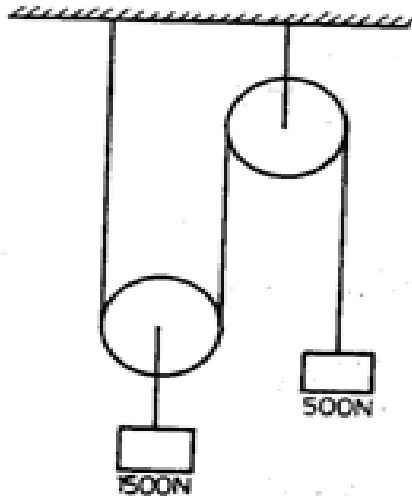


Fig.4

- (b) State and prove the Pappus theorems?

[10+6]



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PART-A

- 1.(i) State and prove Varignon's theorem?
 (ii) Three forces of magnitudes P, 100 N and 200 N are acting at a point O as shown in Fig.1 Determine the magnitude and direction of the force P

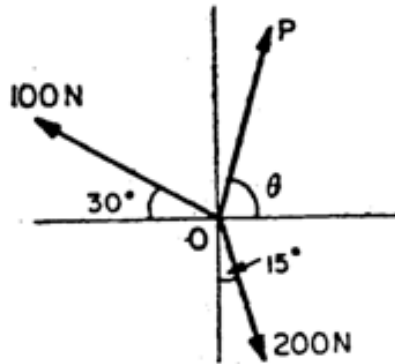


Fig.1

- (iii) Determine the CG of a flat plate of thickness 't', unit weight of the material ' γ '.
 (iv) Determine the mass moment of inertia of a uniform rod of length L about its: (a) centroidal axis normal to rod, and (b) axis at the end of the rod and normal to it.
 (v) A pendulum consists of a bob of 4 kg mass, supported by a thin rod pivoted at 1 m from the centre of the bob. The bob is moved, so that the rod makes an angle of 20° with the vertical and then released. What is the linear and angular velocity of the bob, when it swings back to the vertical position? The weight of the rod and the frictional resistance may be neglected?
 (vi) A bus is travelling on a curved portion of a highway of radius 600m at a speed of 108 km/h. The brakes are suddenly applied, which causes the speed to reduce at a constant rate of 1.5 m/s^2 . Calculate the magnitude of the total acceleration of the bus (i) immediately after the brakes have been applied. [4+4+3+4+4+3]

PART -B

- 2.(a) Two blocks A and B each weighing 1500 N are connected by a uniform horizontal bar which weighs 1000 N. If the angle of limiting friction under each block is 15° , find the force P directed parallel to the 60° inclined plane that will cause motion impending to the right. (as shown in Fig.2)



Fig.2



- (b) Determine the radius of gyration of the body shown in Fig.3 about centroidal x axis. The grooves are semicircular with radius 40 mm. All dimensions shown are in mm.

[8+8]

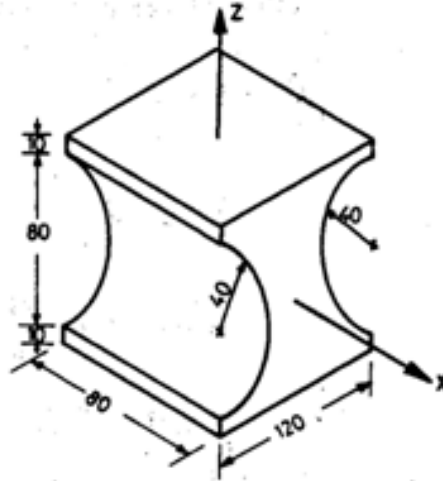


Fig.3

- 3.(a) Two cylinders, A of weight 4000 N and B of weight 2000 N rest on smooth inclines as shown in Fig.4. They are connected by a bar of negligible weight hinged to each cylinder at its geometric centre by smooth pins. Find the force P to be applied as show in the figure such that it will hold the system in the given position

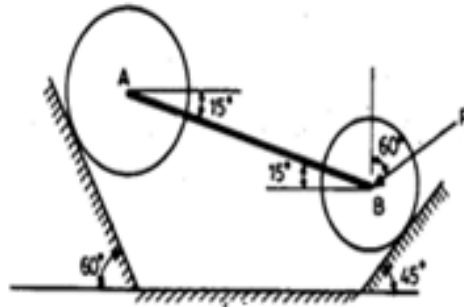


Fig.4

- (b) A wheel, rotating about a fixed axis at 30 r.p.m is uniformly accelerated for 50 seconds, during which time it makes 40 revolution. Find: (i) angular velocity at the end of this interval, and (ii) time required for the speed to reach 80 revolution per minute.

[8+8]



- 4.(a) Determine the coordinates x_c and y_c of the centre of a 100 mm diameter circular hole cut in a thin plate so that this point will be the centroid of the remaining shaded area shown in Fig.5 (All dimensions are in mm).

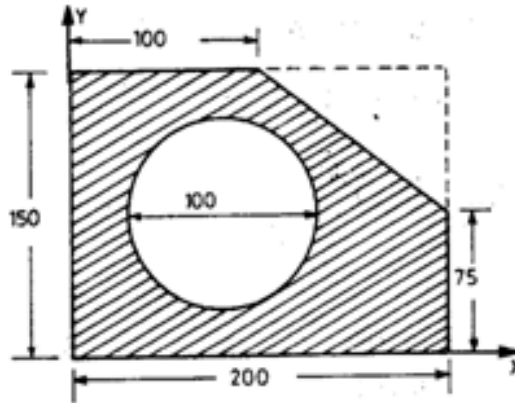


Fig.5

- (b) A gun of mass 2500 kg fires horizontally a shell of mass 40 kg with a velocity of 350 m/s. What is the velocity with which the gun will recoil? Also determine the force required to stop the gun in 0.8m. In how much time will it stop? [8+8]
- 5.(a) Determine the mass moment of inertia of a solid sphere of radius R about its diametral axis?
- (b) Two smooth spheres each of radius 100 mm and weight 100 N, rest in a horizontal channel having vertical walls, the distance between which is 360 mm. Find the reactions at the points of contacts A,B,C and D shown in Fig.6 (All dimensions are in mm)

[6+10]

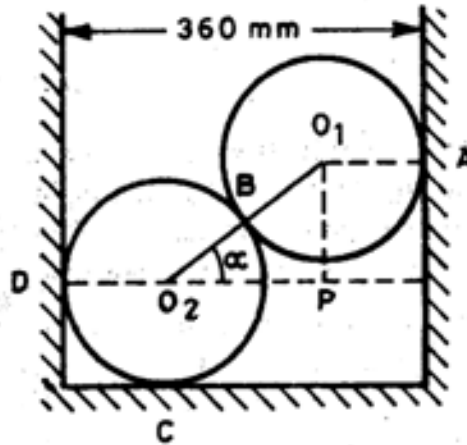


Fig.6



- 6.(a) An elevator of gross weight 4500 N starts to move upwards with a constant acceleration and acquires a velocity of 1.2 m/s after travelling a distance of 2.4 m. Find the pull in the cable during acceleration motion. If the elevator, when stopping, moves with a constant deceleration from a constant velocity of 1.8 m/s and comes to rest in 2 s, calculate the force transmitted by a man weighing 600 N to the floor during stopping.
- (b) What should be the value of μ in Fig.7 which will make the motion of 900 N block down the plane to impend? The coefficient of friction for all contact surfaces is $\frac{1}{3}$.

[8+8]

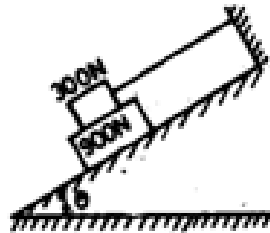


Fig.7

- 7.(a) Determine the constant force P that will give the system of bodies shown in Fig.8 a velocity of 3m/sec after moving 4.5 m from rest. Coefficient of friction between the blocks and the plane is 0.3. Pulleys are smooth.

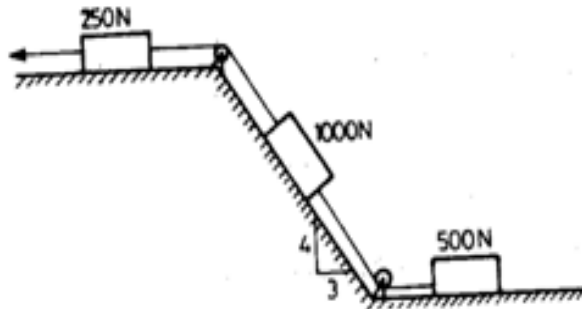


Fig.8

- (b) Locate the centroid of the I-section shown in Fig.9 (All dimensions are in mm)

[8+8]

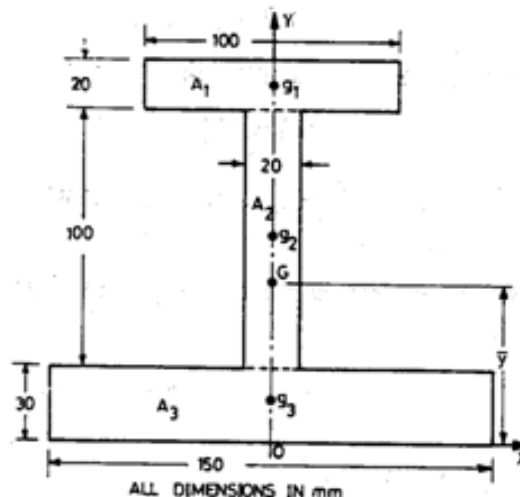


Fig.9



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PART-A

- 1.(i) A force $F=10i+13j-12k$ acts a point O, which is the origin. Find the magnitude and the direction of the force.
- (ii) Write about different types of equilibrium?
- (iii) State and prove Pappus theorems?
- (iv) A semi-circle of 90 mm radius is cut out from a trapezium section as shown in Fig.1 (All dimensions are in mm)

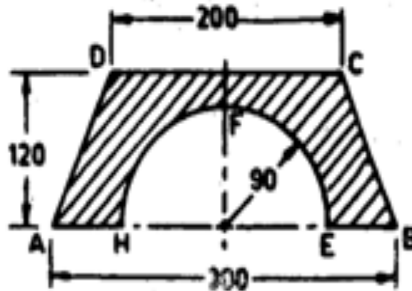


Fig.1

- (v) A bullet is fired at a angle of 45° with the horizontal with a velocity of 275 m/sec. How high the bullet will rise and what will be its horizontal range? Take $g=9.8 \text{ m/sec}^2$.
- (vi) A body weighing 300 N is pushed up a 30° plane by a 400 N force acting parallel to the plane. If the initial velocity of the body is 1.5 m/sec and coefficient of kinetic friction is $\mu=0.2$, what velocity will the body have after moving 6m?

[3+3+4+4+4+4]

PART-B

- 2.(a) Two smooth spheres each of radius 100 mm and weight 100 N, rest in a horizontal channel having vertical walls, the distance between which is 360 mm. Find the reactions at the points of contacts A,B,C and D shown in Fig.2 (All dimensions are in mm)

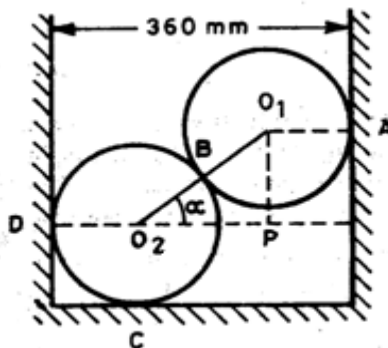


Fig.2



- (b) Determine the time required for the weights shown in Fig.3 to attain a velocity of 9.81 m/sec. What is tension in the chord? Take $\mu=0.2$ for both planes. Assume the pulleys as frictionless

[8+8]

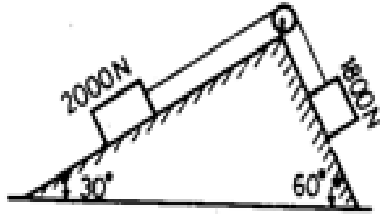


Fig.3

- 3.(a) A ladder 5 metres long rests on a horizontal ground and leans against a smooth vertical wall at an angle 70° with the horizontal. The weight of the ladder is 900 newtons and acts at its middle. The ladder is at the point of sliding, when a man weighing 750 newtons stands on a rung 1.5 metre from the bottom of the ladder.
- (b) Determine the constant force P that will give the system of bodies shown in Fig.4 a velocity of 3m/sec after moving 4.5 m from rest. Coefficient of friction between the blocks and the plane is 0.3. Pulleys are smooth.

[8+8]

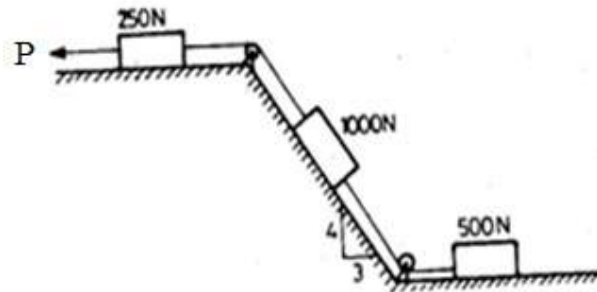


Fig.4

- 4.(a) Two blocks A and B each weighing 1500 N are connected by a uniform horizontal bar which weighs 1000 N. If the angle of limiting friction under each block is 15° , find the force P directed parallel to the 60° inclined plane that will cause motion impending to the right.(as shown in Fig.5)



Fig.5



- (b) Identify the co-ordinates of the centroid of plane area shown in Fig.6? (All dimensions are in mm)

[8+8]

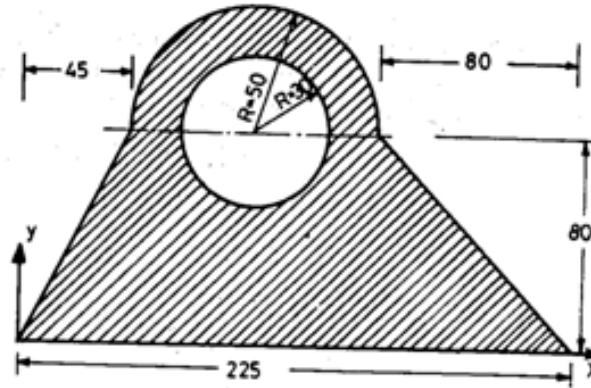


Fig.6

- 5.(a) Determine the coordinates x_c and y_c of the centre of a 100 mm diameter circular hole cut in a thin plate so that this point will be the centroid of the remaining shaded area shown in Fig.7 (All dimensions are in mm).

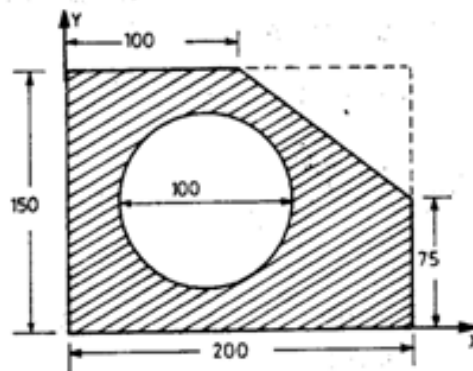


Fig.7

- (b) What is the value of P in the system shown in Fig.8 to cause the motion to impend? Assume the pulley is smooth and coefficient of friction between the other contact surfaces is 0.02.

[8+8]

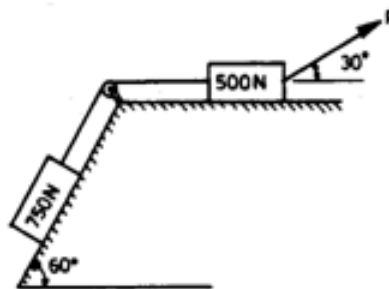


Fig.8



- 6.(a) Define (i) Angular displacement (ii) Angular velocity (iii) Angular acceleration.
 (b) Determine the coordinates of the centroid of the plane area shown in Fig.9 with reference to the axes shown. Take $x=40$ mm.

[8+8]

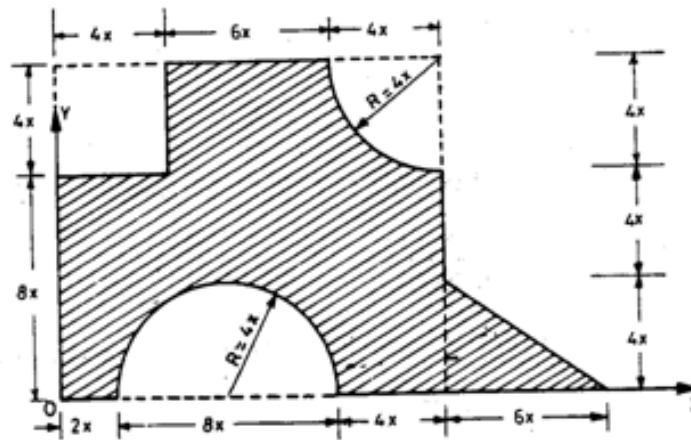


Fig.9

- 7.(a) Derive the parallel axis theorem in mass moment of inertia?
 (b) A stone is dropped into a well without initial velocity. It splash is heard after 3.5 seconds. Another stone is dropped with some initial velocity and its splash is heard after 3 seconds. Determine the initial velocity of the second stone if velocity of sound is 335 m/sec.

[8+8]

