

Pokhara University

Pokhara Lekhnath-30, Kaski

Tutorials
on
Applied Mechanics I

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2017

Force and Moment

- 1 Determine the magnitude and direction of the resultant of the two forces shown, using (a) the parallelogram law (b) the sine law. [1391 N, 47.8°]

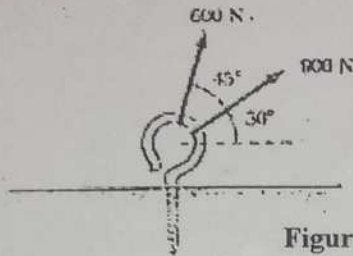


Figure 1

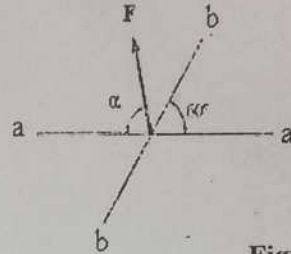


Figure 2

- 2 The force F of magnitude 1500 N is to be resolved into two components along line a-a and b-b. Determine the angle α , knowing that the components of F along line a-a to be 1200 N. [$\alpha = 76.4^\circ$]
- 3 Determine the magnitude of the resultant force $F_R = F_1 + F_2$ and its direction, measured counterclockwise from the positive u axis. (Given: $F_1=300\text{N}$, $F_2=500\text{N}$, $\alpha=30^\circ$, $\beta=45^\circ$, $\gamma=70^\circ$). [605N, 274.6°]

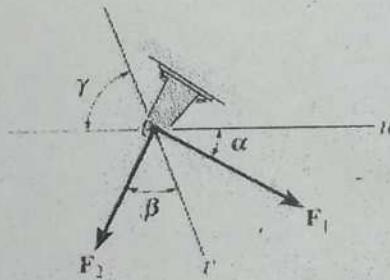


Figure 3

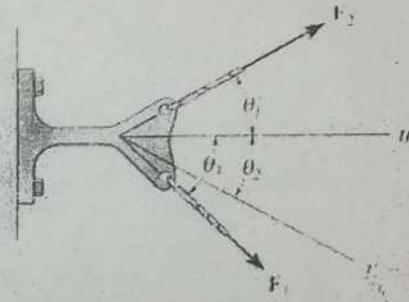


Figure 4

- 4 Resolve the force F_2 into components acting along the u and v axes and determine the components. Given: $F_1=25\text{N}$, $F_2=50\text{N}$, $\theta_1=30^\circ$, $\theta_2=30^\circ$, $\theta_3=45^\circ$. [$F_u=86.6\text{N}$, $F_v=-50\text{N}$]
- 5 Three forces act on the bracket. Determine the magnitude and direction θ of F_1 so that the resultant force is directed along the positive x' axis and has a magnitude of 800 N. [869 N, 21.3°]

Force and Moment

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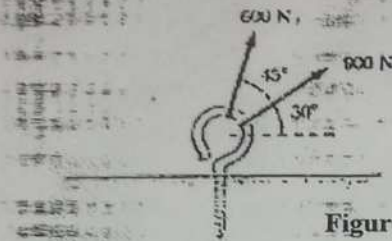


Figure 1

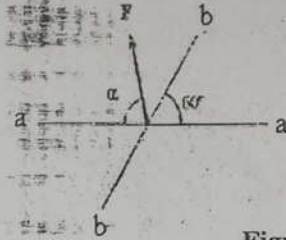


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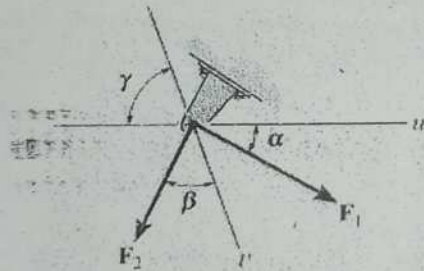


Figure 3

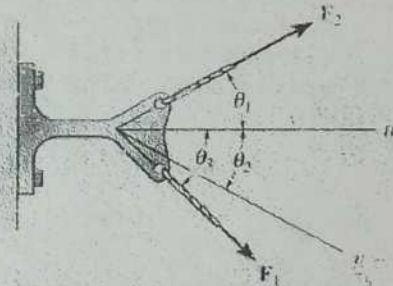


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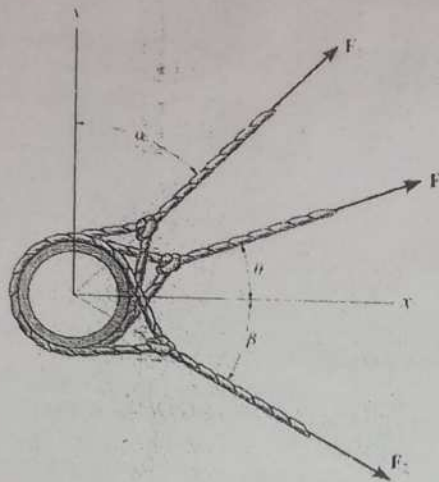


Figure 9

- 10 Determine the mass that must be supported at A and the angle θ of the connecting cord in order to hold the system in equilibrium. [43.1°, 20.5 kg]
- 11 The boat is to be pulled onto the shore using two ropes. If the resultant force is to be $F_1 (= 80 \text{ N})$, directed along the keel aa as shown, determine the magnitudes of forces T and P acting in each rope and the angle θ of P so that the magnitude of P is a minimum. T acts at θ from the keel as shown. Take $\theta_1 = 30^\circ$. [$\theta = 60^\circ$, $P = 40 \text{ N}$, $T = 69.3 \text{ N}$]

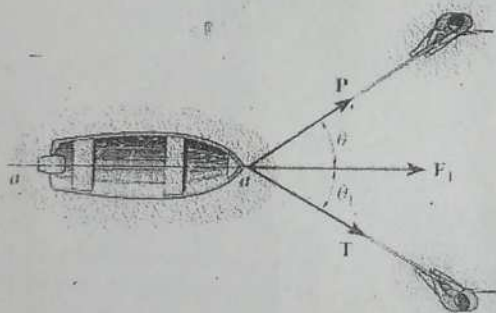


Figure 11

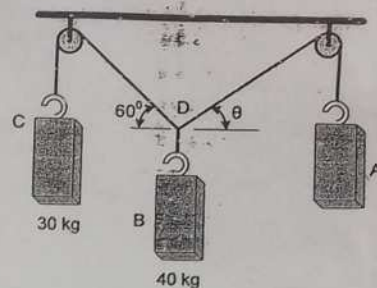


Figure 10

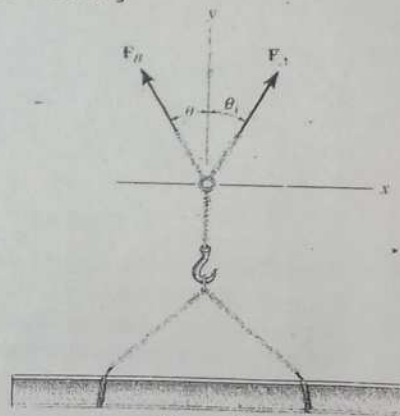


Figure 12

- 12 The beam is to be hoisted using two chains. Determine the magnitudes of forces F_A and F_B acting on each chain in order to develop a resultant force T directed along the positive y axis. Take $T = 600 \text{ N}$, $\theta_1 = 30^\circ$, $\theta = 45^\circ$. [$F_A = 439 \text{ N}$, $F_B = 311 \text{ N}$]
- 13 Two cables tied together at C are loaded as shown. Determine the range of values of W for which the tension will not exceed 1050 N in either cable. [$0 \leq W \leq 609 \text{ N}$]

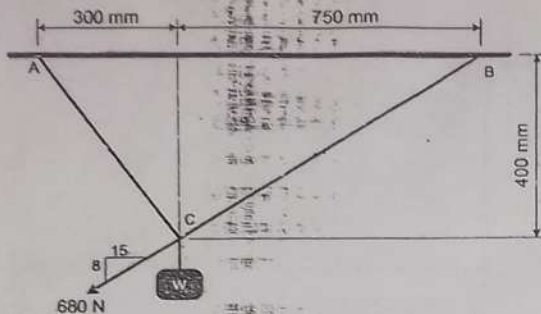


Figure 13

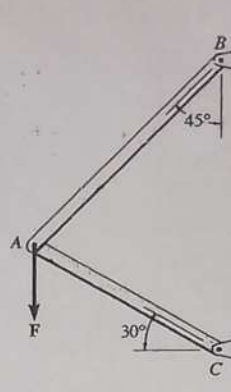


Figure 14

- 14 The vertical force $F = 500 \text{ N}$ acts downward at A on the two membered frame. Determine the magnitudes of the two components of F directed along the axes of AB and AC. [$F_{AC} = 366.02 \text{ N}$, $F_{AB} = -448.28 \text{ N}$]
- 15 Determine the magnitude and angle of F_1 so that particle P is in equilibrium. [552 N , 12.9°]

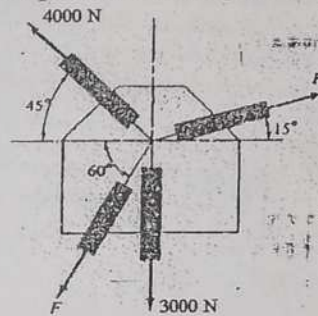
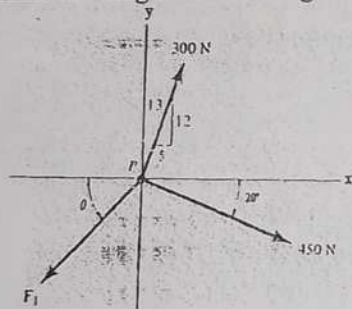


Figure 16

Figure 15

- 16 The forces on the gusset plate of a joint in a bridge trusses act as shown. Determine the values of P and F to maintain the equilibrium of the joint. [3342.78 N , 800.9 N]

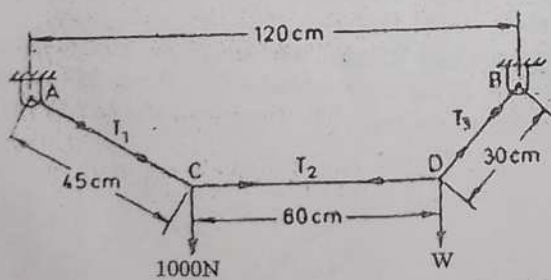


Figure 17

- 17 A rope is connected between two points A and B 120 cm apart at the same level. A load of 1000 N is suspended from a point C on the rope 45 cm from A as shown. Find the load that should be suspended from the rope D 30 cm from B, which will keep the rope CD level. [2000 N]
- 18 The cylinder at A has a weight of 20 lb, determine the weight of B and the force in each cord needed to hold the system in the equilibrium position shown.

$$[W_B = 47.8 \text{ lb}, T_{CD} = 34.1 \text{ lb}, T_{CE} = 38.6 \text{ lb}, T_{EG} = 54.6 \text{ lb}]$$

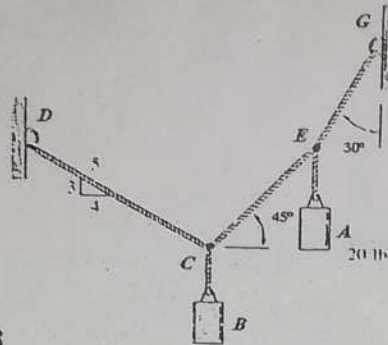


Figure 18

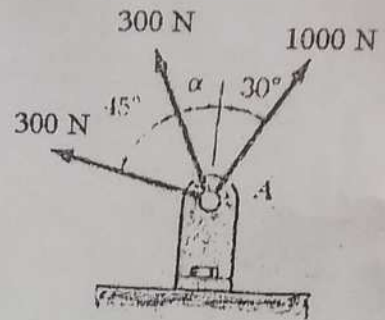


Figure 19

- 19 The directions of the 300 N forces may vary, but the angle between the forces is always 45° . Determine the value of α for which the resultant of the forces acting at A is directed vertically upward. [41.9°]
- 20 The disk has a mass of 20 kg and rests on the smooth inclined surface. One end of a spring is attached to the centre of the disk and the other end is attached to a roller at A. Consequently, the spring remains in the horizontal position when the disk is in equilibrium. If the unstretched length of the spring is 200 mm, determine its stretched length when the disk is in equilibrium. Neglect the size and weight of the roller. [568 mm]

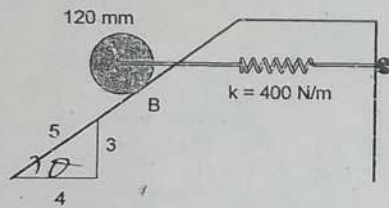


Figure 20

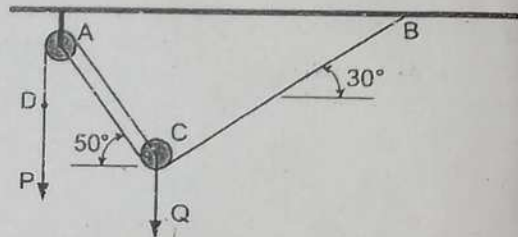


Figure 21

- 21 A load Q is applied to the pulley C, which can roll on the cable ACB. The pulley is held in the position shown by a second cable CAD, which passes over the pulley A and supports a load P. Knowing that $P = 800 \text{ N}$, determine (i) the tension in the cable ACB (ii) the magnitude of the load Q. [2.3 kN, 3.53 kN]
- 22 Two spheres I and II of radii 100 mm and 50 mm respectively are placed on a container as shown in the figure. Sphere I of mass 50 kg is suspended with a string AB of length 200 mm and sphere II of mass 25 kg is placed on top of it. Determine the tension in AB and the reaction from the container

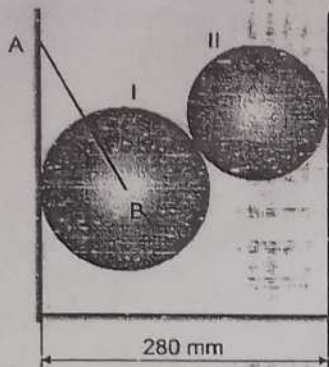


Figure 22

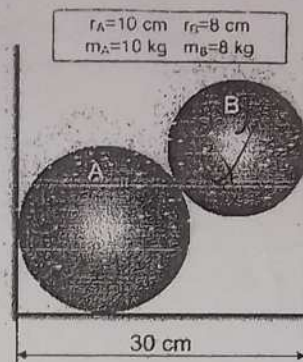


Figure 23.a

- 23 Two spheres A and B are placed in a container as shown in figure. Determine the reaction from the walls of the container: (Figure 23.a and Figure 23.b)

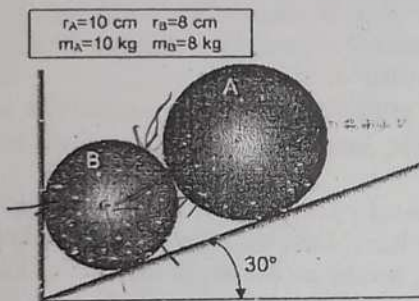


Figure 23.b

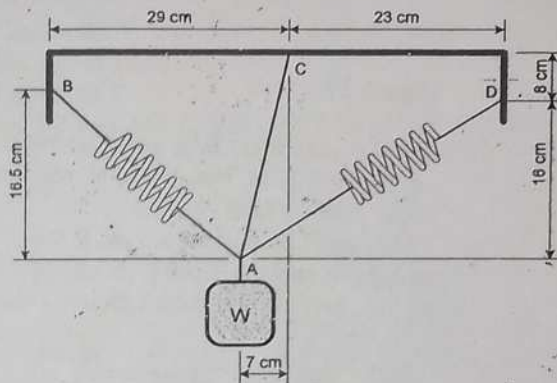


Figure 24

- 24 A block of weight W is suspended from a 25 cm long cord and two springs of which the unstretched lengths are 22.5 cm. Knowing that the constants of the springs are $k_{AB} = 9 \text{ N/cm}$ and $k_{AD} = 3 \text{ N/cm}$, determine (a) the tension in the cord, (b) the weight of the block.
- 25 Knowing that the tension in cable AC is 2130 N, determine the component of the force exerted on the plate at C . $[-1350 \text{ N}, 900 \text{ N}, -1350 \text{ N}]$

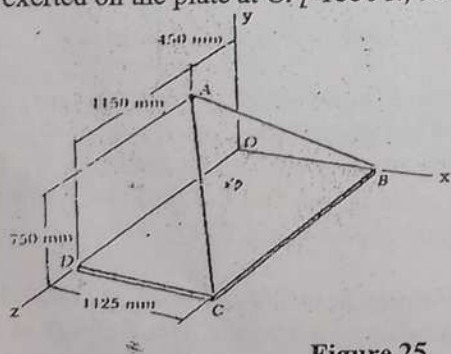


Figure 25

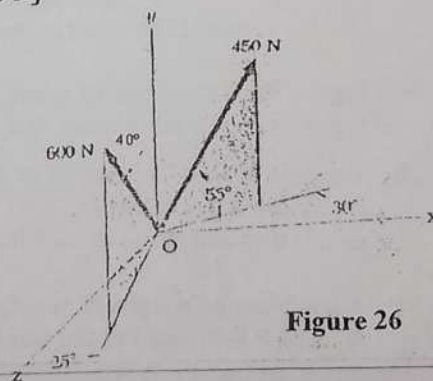


Figure 26

- 26 Determine the resultant of the two forces shown. $[940.21 \text{ N}, 65.73^\circ, 28.5^\circ, 76.44^\circ]$

- 27 Three forces act on a hook at D as shown. If their resultant force at D is $\mathbf{R} = -370\mathbf{j}$ N, determine the magnitude of each force. [130 N, 130 N, 175 N]

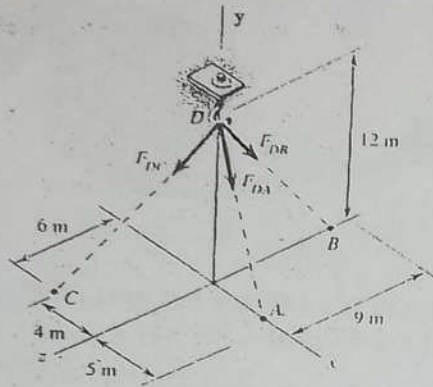


Figure 27

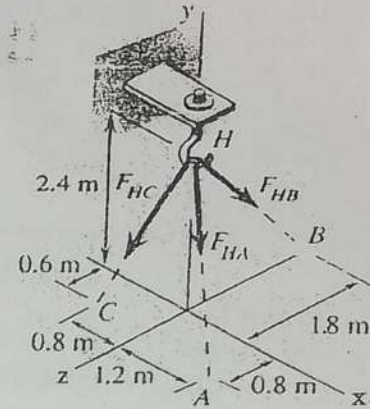


Figure 28

- 28 Three forces \mathbf{F}_{HA} , \mathbf{F}_{HB} , and \mathbf{F}_{HC} act on hook at H as shown. If the magnitude of these forces are $F_{HA} = 420$ N, $F_{HB} = 500$ N, and $F_{HC} = 390$ N, determine the resultant force \mathbf{R} acting on the hook. [$60\mathbf{i} - 1120\mathbf{j} - 90\mathbf{k}$ N]
- 29 The boom OA carries a load P and is supported by two cables as shown. Knowing that the tension in cable AB is 372 N and that the resultant of the load P and of the forces exerted at A by the two cables must be directed along OA, determine the magnitude of the load P. [548 N]

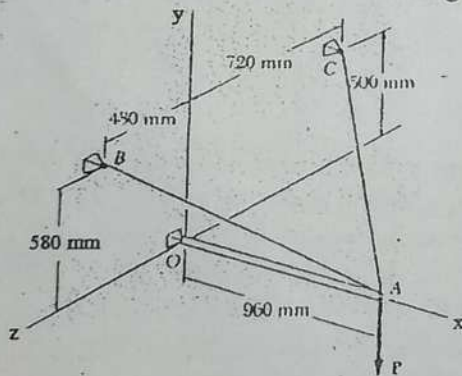


Figure 29

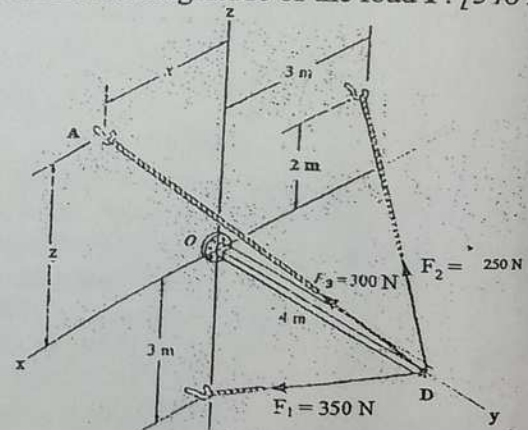


Figure 30

- 30 The pole is held in place three cables. If the force of each cable acting on the pole is shown, determine the position $(x, 0, z)$ for fixing cable DA so that the resultant force exerted on the pole is directed along its axis from D towards O. [2.34 m, 1.96 m]
- 31 A container of weight W is suspended from ring A, to which cables AC and AE are attached. A force P is applied to the end f of a third cable which passes over a pulley at B and through ring A and which is attached to a support at D. knowing that the tension in cable AC is 150 N, determine,

- i. The magnitude of the force P, [454 N]

ii. The weight W of the container. [1202 N]

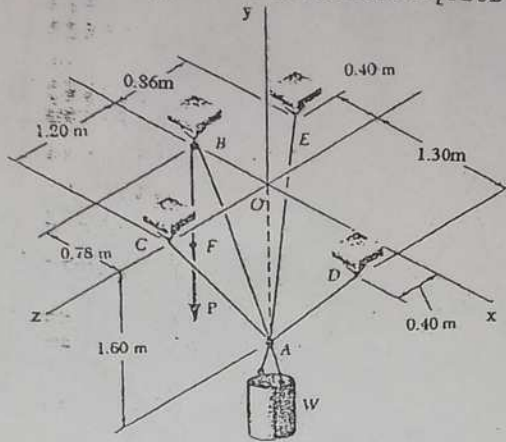


Figure 31

32 Three cables are connected at A, where the forces P and Q are applied as shown. Knowing that $Q = 3.6$ kN and that the tension in cable AD is zero, determine

- The magnitude and sense of P
- The tension in cables AB and AC. [-25.2 i kN, 2.25 kN, 16.65 kN]

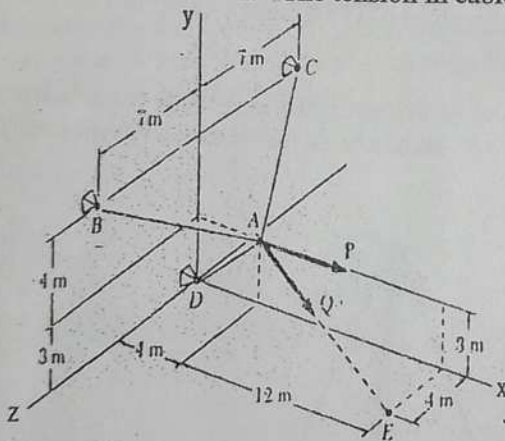


Figure 32

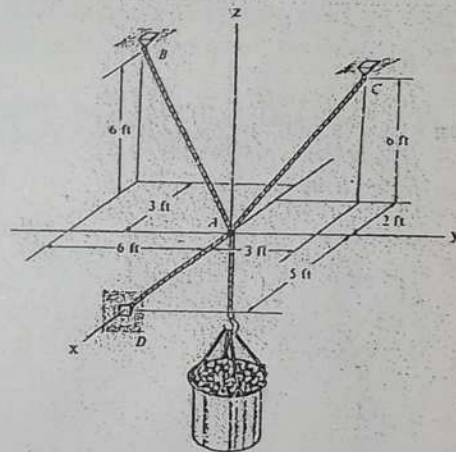


Figure 33

33 Determine the force in each cable needed to support the 500 lb bucket.

34 Three cables DA, DB, and DC are used to tie down a balloon at D as shown. Knowing that the balloon exerts as 640 N forces at D, determine the tension in each cable. [125 N, 260 N, 325 N]

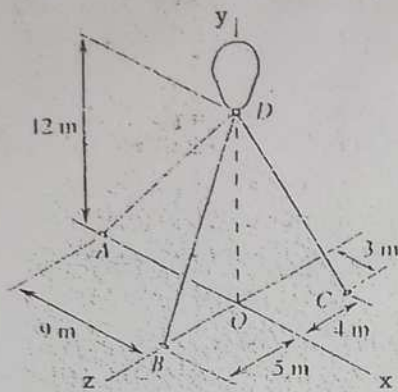


Figure 34

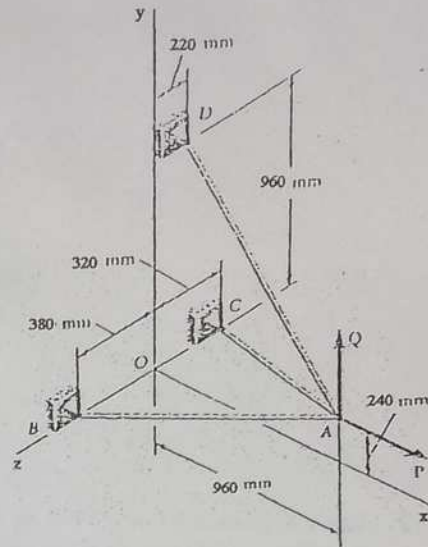


Figure 35

- 35 Three cables are connected at A, where the forces P and Q are applied as shown. Knowing that $P = 1200 \text{ N}$, determine the range of values of Q for which cable AD is taut. [$0 < Q < 300 \text{ N}$]
- 36 A horizontal circular plate weighing 62 N is suspended as shown from three wires that are attached to support D and that form 30° angles with the vertical. Determine the tension in each wire.

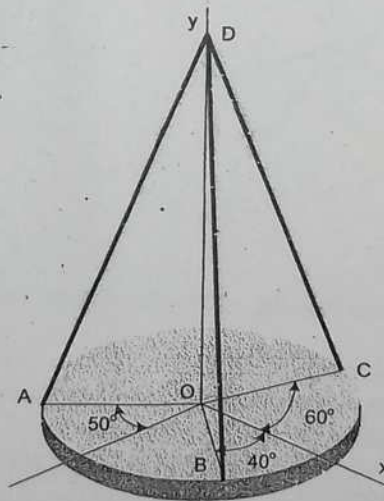


Figure 36

- 37 Determine the moment of each of the three forces about point A. [433 Nm, 1300 Nm, 800 Nm]

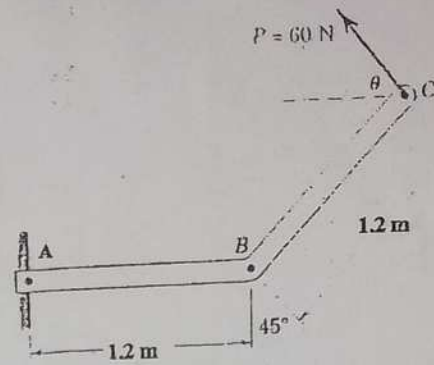
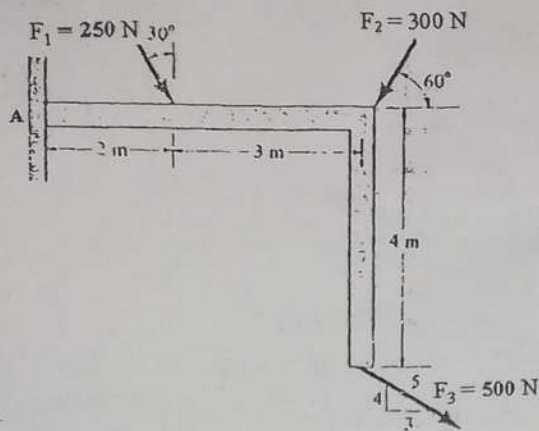


Figure 38

Figure 37

- 38 The 60 N force P is applied at point C of the bent bar. If $\theta = 45^\circ$, determine the moment of P about point A . For what value of the angle θ will the moment about point A be maximum? Determine this maximum value $(M_A)_{max}$.
- 39 Determine the direction θ of the force $F = 40$ N so that it produces (a) the maximum moment about point A and (b) the minimum moment about point A . Compute the moment in each case. Take $a = 8$ m and $b = 2$ m.

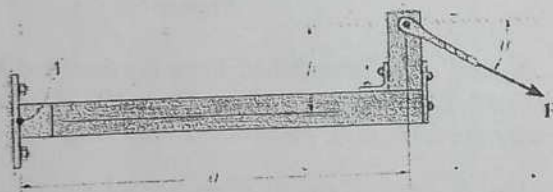


Figure 39

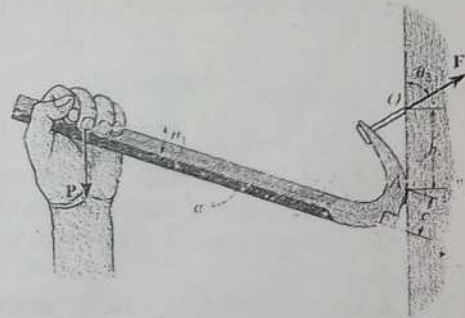


Figure 40

- 40 If it takes a force $F = 125$ N to pull the nail out, determine the smallest vertical force P that must be applied to the handle of the crowbar. Take $a = 14$ cm, $b = 3$ cm, $c = 1.5$ cm, $\theta_1 = 20^\circ$, $\theta_2 = 60^\circ$.
- 41 Determine the force P required to pull the roller of mass $M (= 50$ kg) over the smooth step. Take $a = 0.6$ m, $b = 0.1$ m, $\theta = 60^\circ$, $\theta_1 = 20^\circ$ [441 N]

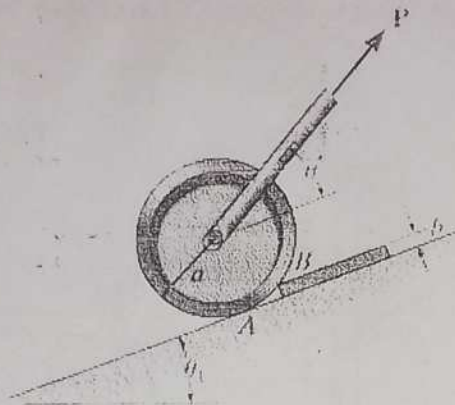


Figure 41

- 42 Find the moment of the forces F shown about the origin. $[-160 \mathbf{i} + 220 \mathbf{j} + 120 \mathbf{k} \text{ Nm}]$

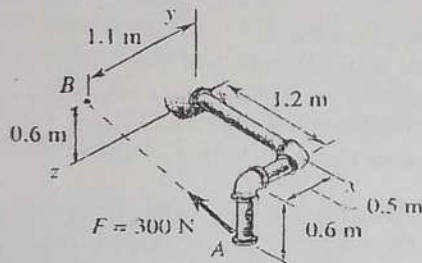


Figure 42

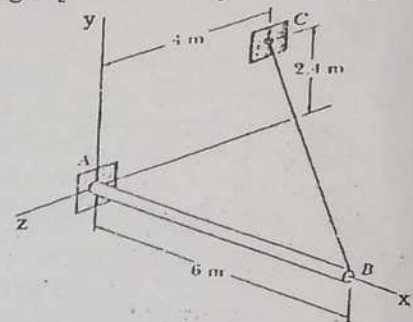


Figure 43

- 43 The 6 m boom AB has a fixed end A. A steel cable is stretched from the free end B of the boom to a point C located on the vertical wall. If the tension in the cable is 1900 N, determine the moment about A of the force exerted by the cable at B. $[6000 \mathbf{i} + 3600 \mathbf{j} \text{ Nm}]$
- 44 A force $\mathbf{F} = -5\mathbf{i} + 3\mathbf{j} - 4\mathbf{k}$ kN produces a moment $\mathbf{M}_O = -17\mathbf{i} - 7\mathbf{j} + 16\mathbf{k}$ kN.m about point O. If the forces acts at a point P having a y coordinate of $y = 2$ m. Determine the x and z coordinates.
- 45 A guyed pole is shown. The tensions in the cables AB and AC are $T_{AB} = 27$ kN and $T_{AC} = 28$ kN. Determine the range of the values of the tension T_{AD} in the cable AD for which the magnitude of the resultant moment developed at base O of the pole will not exceed 200 kN.m $[12.78 \text{ kN} < T < 57.2 \text{ kN}]$

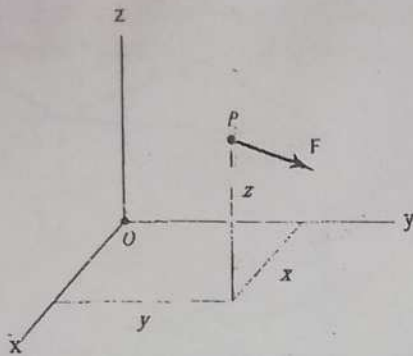


Figure 45

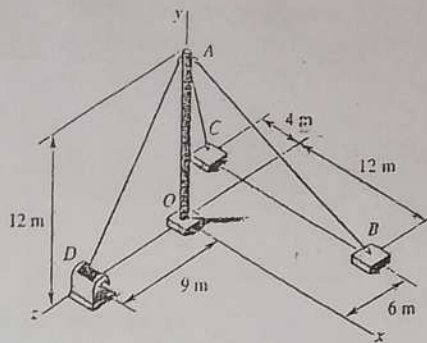


Figure 45

- 46 Compute the moment of a force $F = 10\mathbf{i} + 6\mathbf{j}$ N, which goes through $\mathbf{r}_a = 2\mathbf{i} + 6\mathbf{j}$ m, about a line going through points 1 and 2 having the respective position vectors; $\mathbf{r}_1 = 6\mathbf{i} + 10\mathbf{j} - 3\mathbf{k}$ m, $\mathbf{r}_2 = -3\mathbf{i} - 12\mathbf{j} + 6\mathbf{k}$ m.
- 47 (a) Find the moment about the origin of the force $F = 10\mathbf{i} + 6\mathbf{j} - 6\mathbf{k}$, acting at the point P (10, 3, 4) m. What is the moment of the force F about the point A (6, -4, -3) m?
 (b) Determine the moment of the force $F = 4\mathbf{i} + 5\mathbf{j} - 6\mathbf{k}$ acting at the point (2, 2, 1) with respect to the line passing from (1, 1, -1) and (2, -1, 3). The units of force and lengths are N and cm respectively.

- 48 Determine the magnitude of the moment of each of the three forces about the axis AB.

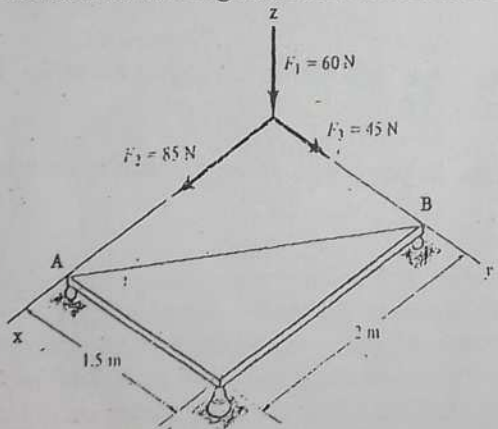


Figure 48

- 49 A force P of magnitude 2600 N acts on the frame shown at point E. Determine the moment of P about a line joining points O and D. [371 Nm]

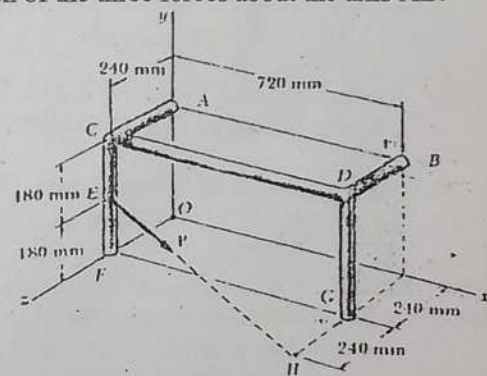


Figure 49

- 50 A plate in the shape of a parallelogram is acted upon by two couple. Determine (a) the moment of the couple formed by two 21 N forces, (b) the perpendicular distance between 12N forces, if the resultant of the two couples is zero, (c) the value of α if the resultant couple is 1.8 N.m clockwise and d is 1.05m.
- 51 Add the couples whose forces act along the diagonals of the sides of the rectangular parallelepiped.

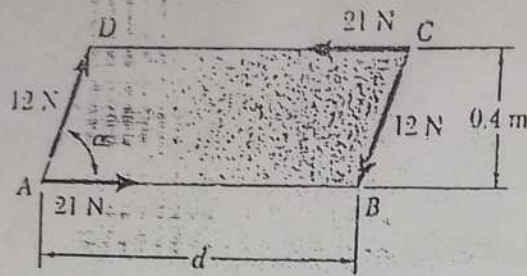


Figure 50

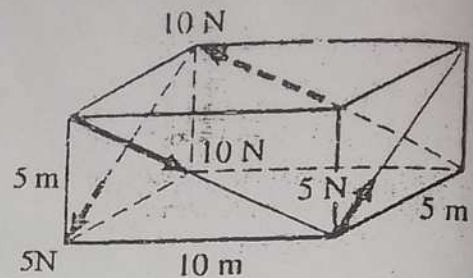


Figure 51

- 52 The 80 N horizontal force P acts on a bell cranks as shown. (a) Replace P with an equivalent force-couple system at B . (b) Find the two vertical forces at C and D which are equivalent to the couple found in part a.

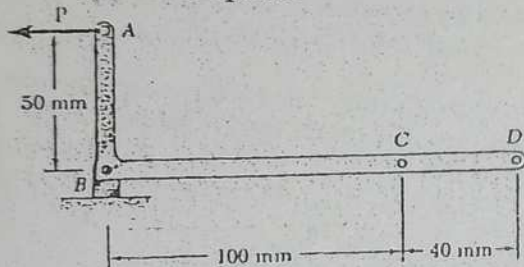


Figure 52

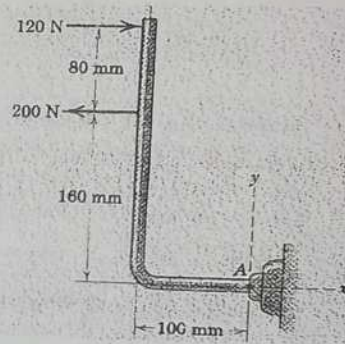


Figure 53

- 53 Replace the two forces acting on the bent pipe by a single equivalent force R . Specify the distance y from point A to the line of action of R .
- 54 For the system of forces shown, determine its equivalent force moment system at the origin O . $[100 \text{ N}, -53.1^\circ; 176 \text{ Nm}]$

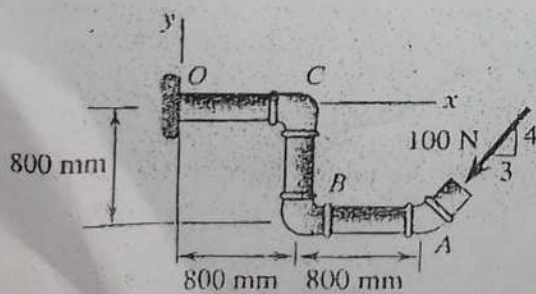


Figure 54

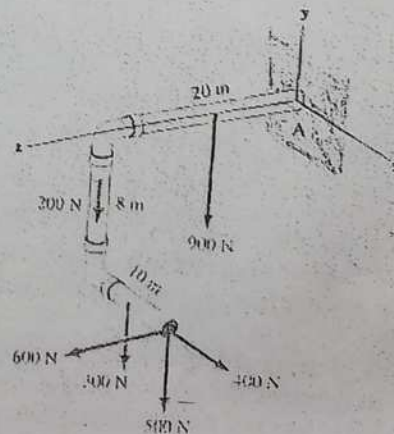


Figure 55

- 55 A machine component is subjected to the forces shown, each of which is parallel to one of coordinates axes. Replace these forces by an equivalent force-couple system at A . $[-300 \text{ i} - 240 \text{ j} + 25 \text{ k N}; -3 \text{ i} + 13.5 \text{ j} + 9 \text{ k N-m}]$

- 56 A square foundation mat supports the four columns with the weight as shown. Determine the magnitude and point of application of the resultant of the four loads. [$x = 3.5 \text{ m}$, $z = 3 \text{ m}$]

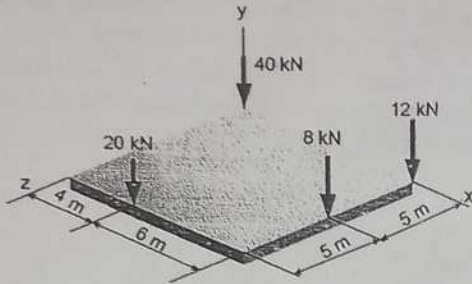


Figure 56

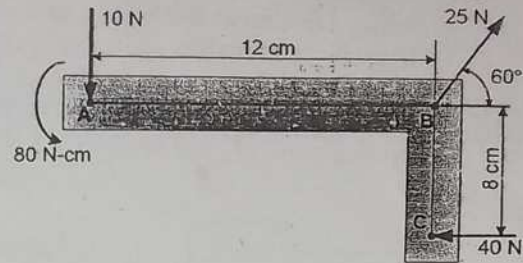


Figure 57

- 57 The three forces and a couple shown are applied to an angle bracket. (a) find the resultant of this system of forces. (b) Locate the points where the line of action of the resultant intersects line AB and BC.

- 59 The rectangular platform is hinged at A and B and supported by a cable which passes over frictionless hook at E as shown in figure. If the weight of platform is 1000 N, determine the tension in the cable. [527.43 N]

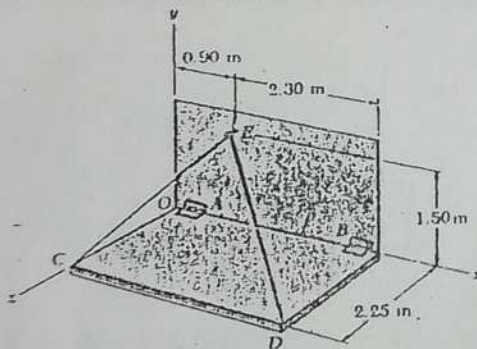


Figure 59

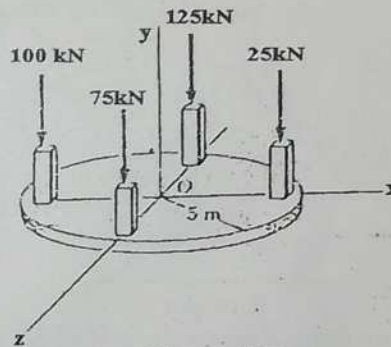


Figure 60

- 60 A concrete foundation mat of 5 m radius supports four equally spaced columns, each of which is loaded 4 m from the center of the mat. Determine the magnitude and the point of application of the resultant of the four loads. [325 kN, $x = -0.923 \text{ m}$, $z = -0.615 \text{ m}$]

- 61 The horizontal beam is supported by springs at its ends. If the stiffness of the spring A is $k_A = 5 \text{ kN/m}$, determine the required stiffness of the spring at B so that if the beam is loaded with the force $F = 800 \text{ N}$, it remains in the horizontal position both before and after loading. Take $a = 1 \text{ m}$ and $b = 2 \text{ m}$. [2.5 kN/m]

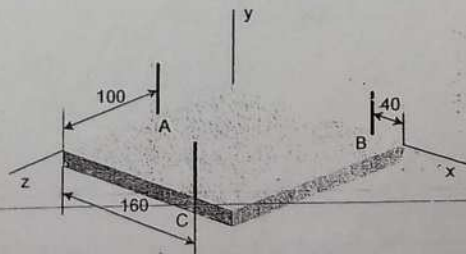
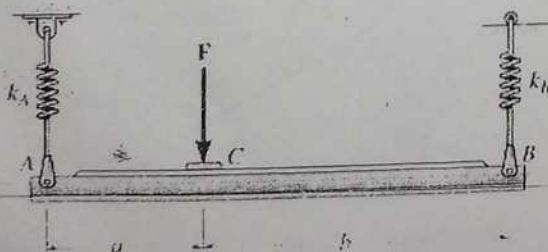


Figure 61

- 62 The 200×200 mm square plate shown has a mass of 25 kg and is supported by three vertical wires. Determine the mass and location of the lightest block which should be placed if the tensions in the cables are to be equal. [1.786 kg, $x = 200$ mm, $z = 100$ mm]

- 63 Two steel pipes AB and BC each having a weight per unit length of 30 N/m are welded together at B and are supported by three wires. Knowing that $a = 0.4$ m, determine the tension in each wire. [$T_A = 9$ N; $T_C = 4.5$ N; $T_D = 40.5$ N]

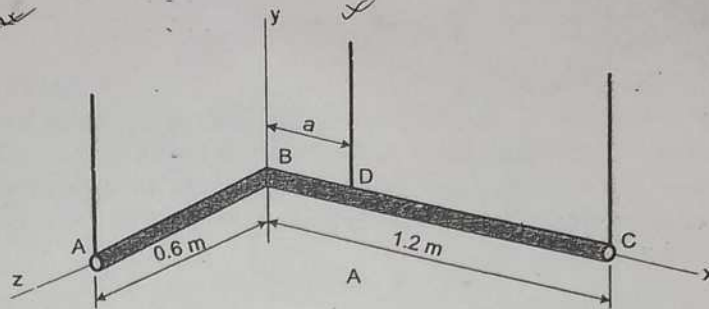
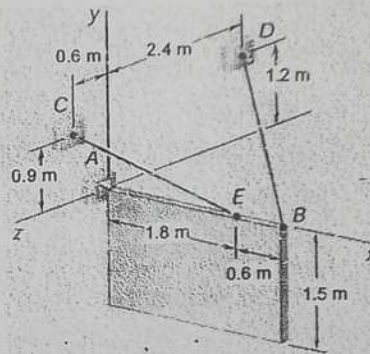


Figure 63

- 64 A $1.5 \text{ m} \times 2.4 \text{ m}$ sign board of uniform density weighs 1200 N and is supported by the ball and socket joint at A and by two cables. Determine the tension in each cable and the reaction at A .



Friction

- 1 A body of weight 300N is lying on a rough horizontal plane having coefficient of friction as 0.35. Find the magnitude of the force P, which can move body, while acting at an angle of 25°. [99.6 N]

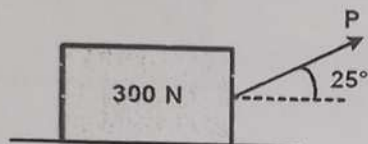


Figure 1

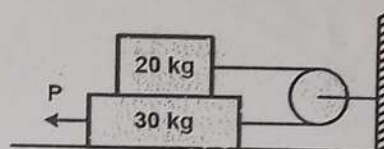


Figure 2

- 2 The coefficient of friction are $\mu_s = 0.40$ and $\mu_k = 0.3$ between all surface of contacts. Determine the smallest force P required to start the 30 kg block moving if cable AB is attached as shown. [353 N]
- 3 If the static coefficient of friction for all the surfaces is 0.35, find the force F needed to start the 200N weight moving to the right. [128.2 N]

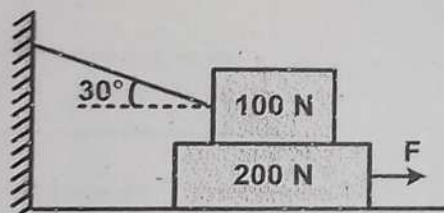


Figure 3

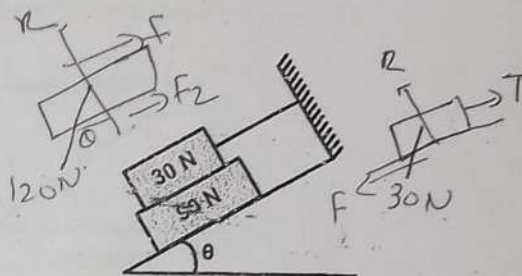


Figure 4

- 4 What should be the value of angle so that motion of the 90 N block impends down the plane? The coefficient of friction for all surfaces is $1/3$. [29.05°]
- 5 Knowing that the coefficient of friction between the 25 kg block and the incline is $\mu_s = 0.25$ determine, (a) smallest value of P required to start the block moving up the incline (b) the corresponding value of β . [170.5 N, 14°]

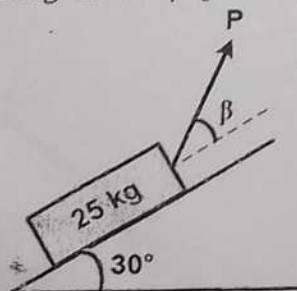


Figure 5

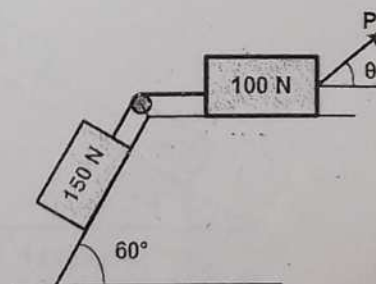


Figure 6

- 6 Referring to the figure shown, determine the least value of P to cause the system to impend

rightward. Assume the coefficient of friction between the block and incline surface to be 0.2 and pulley to be frictionless. [161.9 N, 11.3°]

- 7 Knowing that $\theta = 40^\circ$ determine the smallest force P for which equilibrium of the 7.5 kg block is maintained. Take $\mu_s = 0.45$ and $\mu_k = 0.35$. [74.5 N]

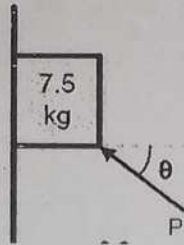


Figure 7

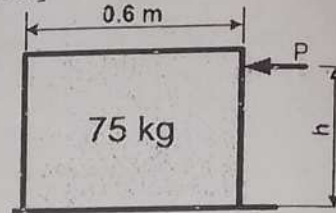


Figure 8

- 8 A box of mass 75 kg rests on floor. The static coefficient of friction for contact surface is 0.2. What is the highest position for a horizontal load P that permits it to just move box without over turning? [1.5 m]
- 9 The coefficients of friction between the block and incline are $\mu_s = 0.35$ and $\mu_k = 0.25$. Determine whether the block is in equilibrium and find the magnitude and direction of friction force when $\theta = 30^\circ$ and $P = 150$ N.

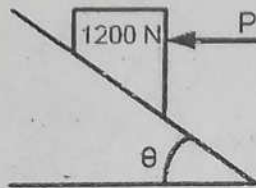


Figure 9

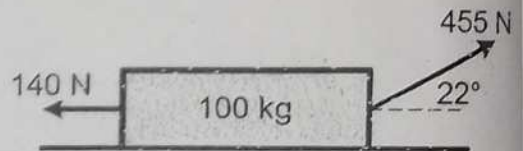


Figure 10

- 10 Find the friction force for the block shown and state whether the block is in equilibrium or in motion. Also determine the additional force P that must be added to 140 N force to just move the block to left. [$\mu_s = 0.2$]
- 11 Two masses $m_1 = 22.5$ kg and $m_2 = 14$ kg are tied together by a rope parallel to the incline plane surface as shown in figure. If μ_s for m_1 is 0.25 and that for m_2 is 0.5 find (a) value of θ for which masses will just start slipping (b) tension in the rope. [19.08°, 20 N]

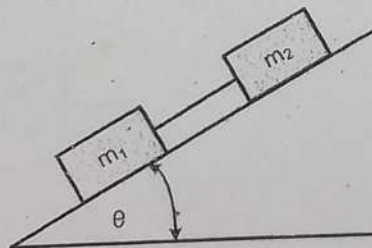


Figure 11

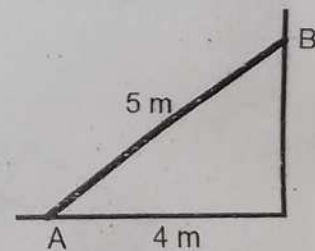


Figure 12

- 12 A uniform ladder of length 5 m and weighing 20 N is placed against a smooth vertical wall with lower end 4 m away from the wall. If the ladder is just to whip, determine, (a)

coefficient of friction (b) friction force acting on ladder at point of contact between ladder and floor. [0.667, 13.4 N]

13. A small ladder of uniform bar weighing 60 kg is constructed to move in the smooth vertical guides. If $\mu_s = 0.80$, determine horizontal force P required to initiate slipping at A.

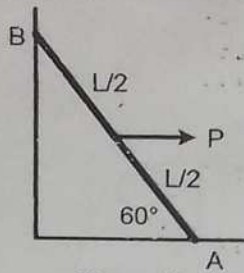


Figure 13

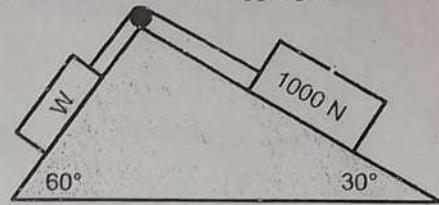


Figure 14

14. Two planes AC and BC are inclined at 60° and 30° to the horizontal. A load of 1000 N rests on inclined plane BC and W on AC as shown. Determine the range of W for the equilibrium. Take μ_s for right plane as 0.80 and that of left plane as 0.28. [266.5 N, 969.3 N]

Equilibrium or in
to just move
the incline
) value of θ

vertical wall
etermine, (a)

Centroid and Moment of Inertia

- 1 Derive the centroid and moment of inertia of followings by first principal method
 - a. Rectangle
 - b. Triangle
 - c. Circle
 - d. Semi circle
 - e. Quarter circle

- 2 Locate the centroid of the composite line shown.

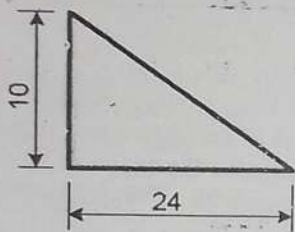


Figure 2.1

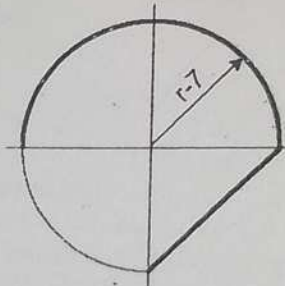


Figure 2.2

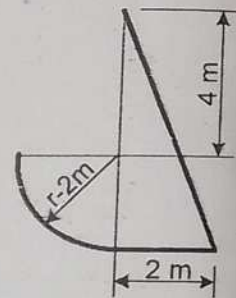


Figure 2.3

- 3 Find the centroid and moment of inertia of the shaded area by the direct integration.

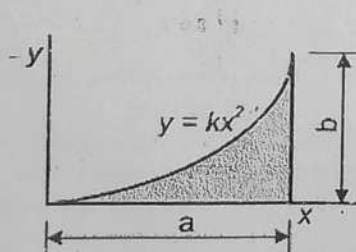


Fig: 3.1

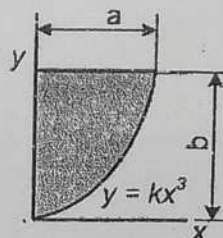


Fig: 3.2

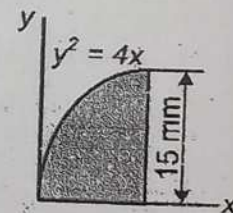


Fig: 3.3

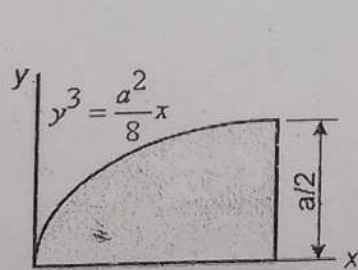


Fig: 3.4

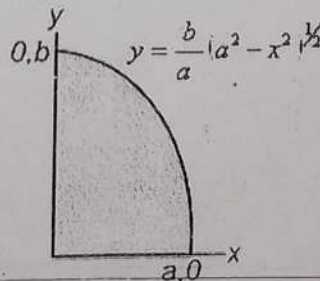


Fig: 3.5

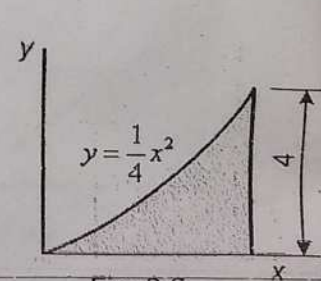


Fig: 3.6

4 Find the centroid and moment of inertia of the shaded composite area.

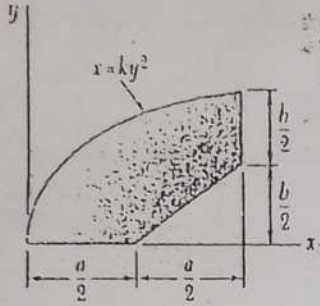


Figure 4.1

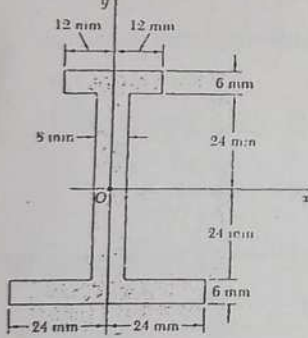


Figure 4.4

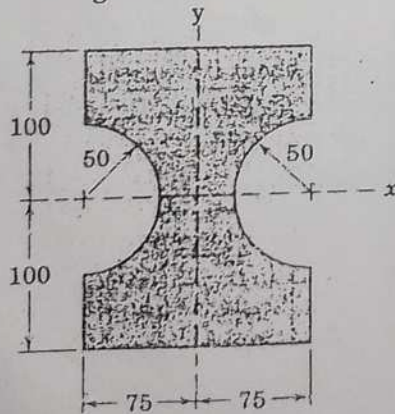


Figure 4.7

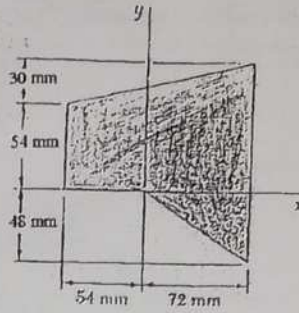


Figure 4.2

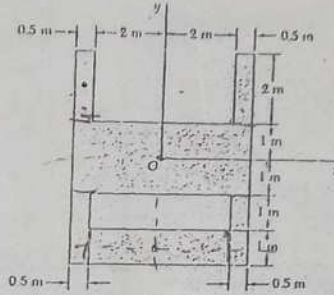


Figure 4.5

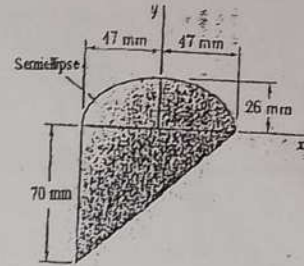


Figure 4.3

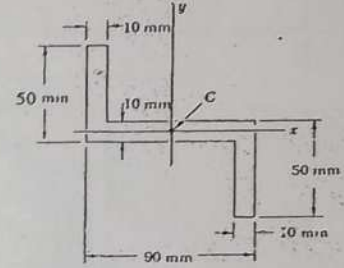


Figure 4.6

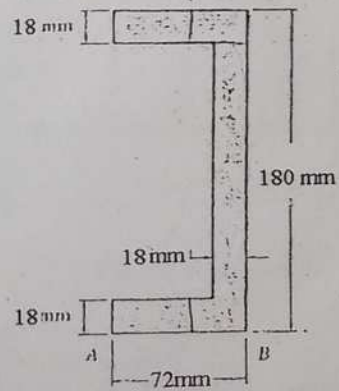


Figure 4.8

- 5 Locate the centroid and moment of inertia of the area bounded by the curves as shown.

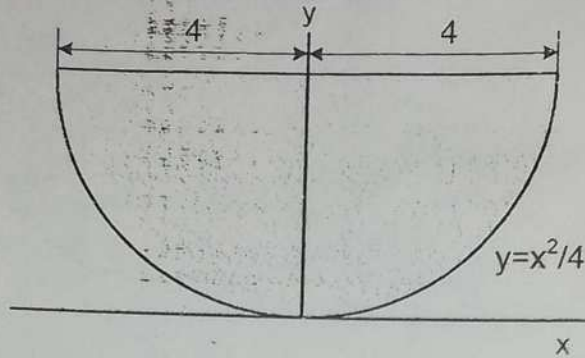


Figure 5.1

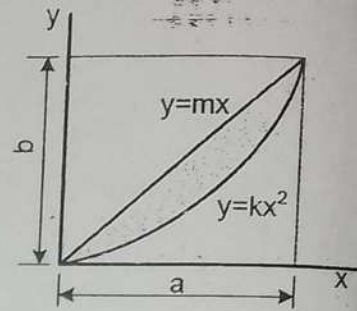


Figure 5.2

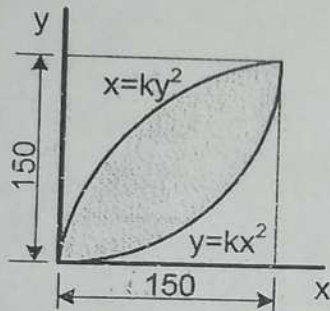


Figure 5.3

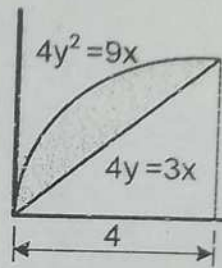


Figure 5.4

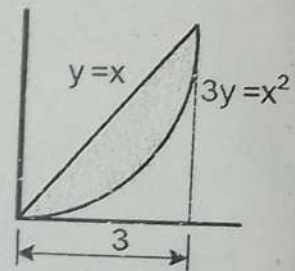


Figure 5.5

Beam and Truss

Draw shear force and bending moment diagram for the following loaded beams.

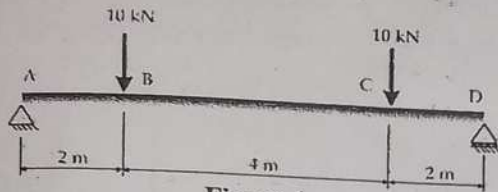


Figure 1

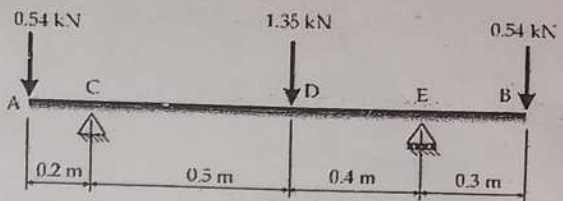


Figure 2

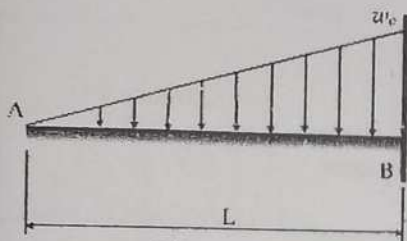


Figure 3

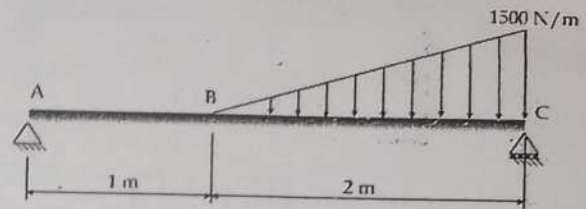


Figure 4

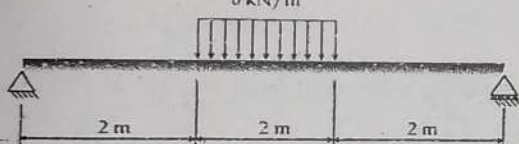


Figure 5

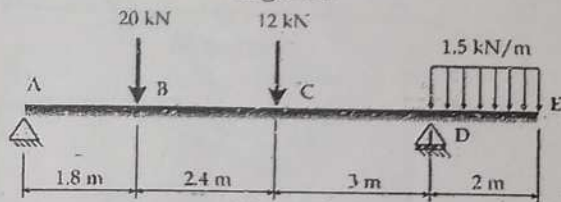


Figure 6

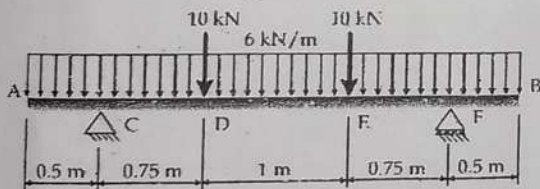


Figure 7

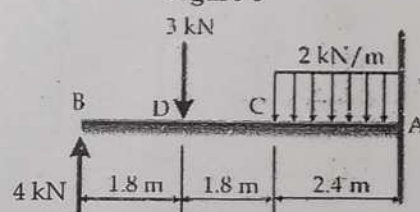


Figure 8

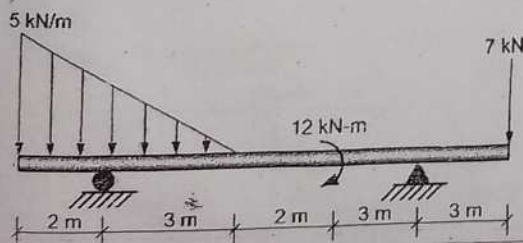


Figure 9

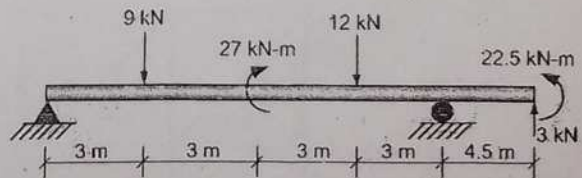


Figure 10

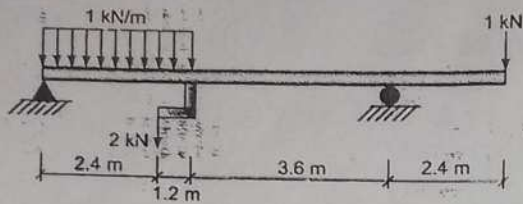


Figure 11

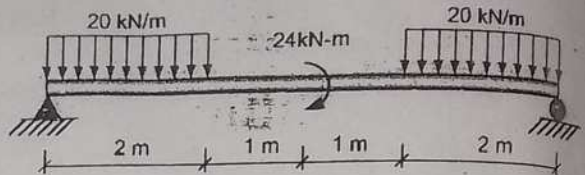


Figure 12

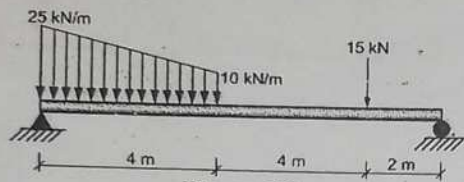


Figure 13

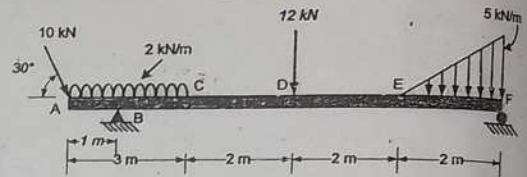


Figure 14

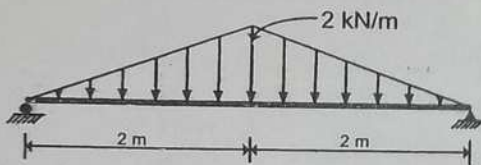


Figure 15

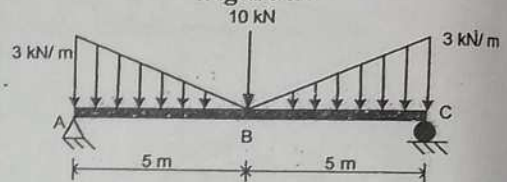


Figure 16

Analyze the force in each member of following truss by Method of Joint and Method of Section.

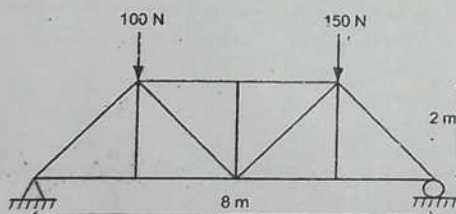


Figure 1

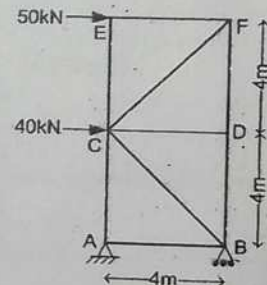


Figure 2

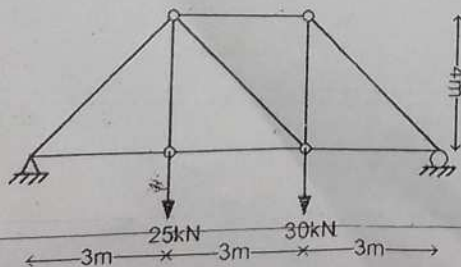


Figure 3

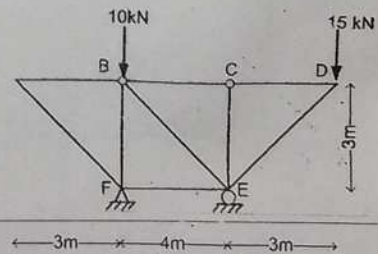


Figure 4

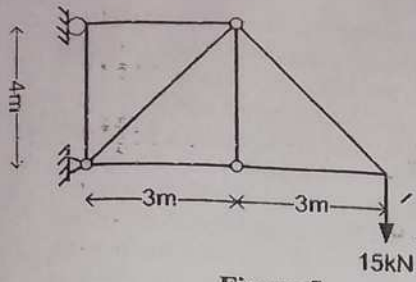


Figure 5

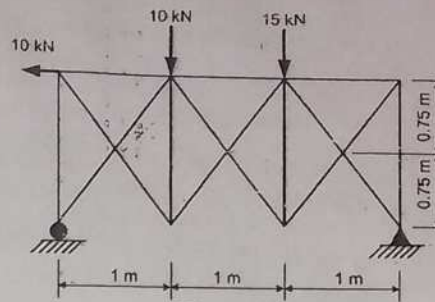


Figure 6

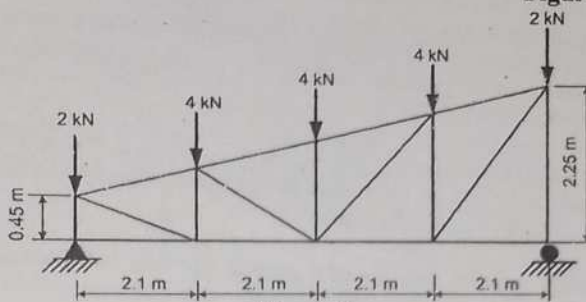


Figure 7

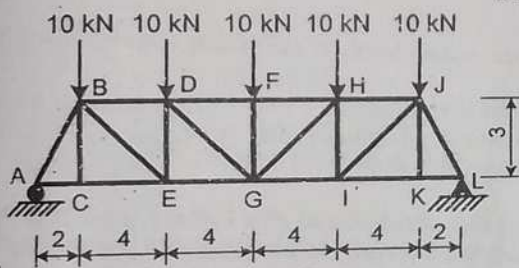


Figure 8

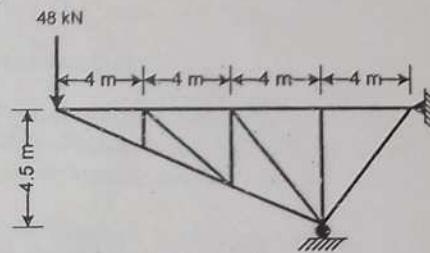


Figure 9

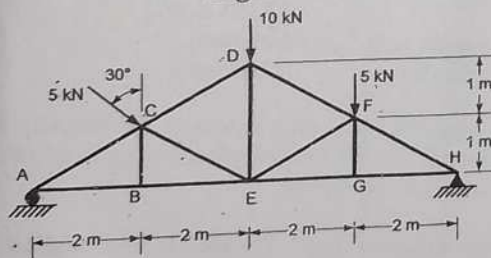


Figure 10

Kinematics of particle

- 1 The motion of the particle is defined by the relation $x = t^3 - 6t^2 + 9t + 5$, where x is expressed in meter and t in sec. Determine,
 - a. when velocity is zero [1s, 3s]
 - b. the position, acceleration and total distance travelled when $t = 5$ [25m, 18m/s², 28m]
- 2 The motion of the particle is defined by the relation $a = 9t + 5$, where 'a' is expressed in m/s² and t in s. At $t = 0$, $v = 2$ m/s and $x = 5$ m.
 - a. Write equations of motion [$v = 4.5t^2 + 5t + 2$, $x = 1.5t^3 + 2.5t^2 + 2t + 5$]
 - b. Determine the position, velocity and acceleration at $t = 4$ s [149m, 94m/s, 41m/s²]
- 3 The acceleration of the particle is defined by the relation $a = -2$ m/s². Initially if velocity (v_0) = 8m/s and position (x_0) = 3 m, determine the position, velocity and the total distance travelled at the instant of 6s. [15m, -4m/s, 20m]
- 4 The relationship between velocity of a particle and time is expressed as $v = -3t^2 + 18t$. How far the particle would travel between $t = 4$ s and $t = 10$ s and what will be the acceleration at these two times? [236m, -6m/s², -42 m/s²]
- 5 The acceleration of the particle is defined by the relation $a = 9 - 3t^2$. The particle starts at $t = 0$ with $v = 0$ and $x = 15$ m. Determine,
 - a. the time when velocity is again zero [3s]
 - b. the position and velocity when $t = 4$ s [23m, -28m/s]
 - c. the total distance traveled by the particle from $t = 0$ to $t = 4$ s [32.5m]
- 6 The acceleration of a particle is defined by the relation $a = 25 - 3x^2$, where a is expressed in mm/sec² and x in mm. The particle starts with no initial velocity at the position $x = 0$. Determine
 - a. the velocity when $x = 2$ mm [9.165 mm/s]
 - b. the position where the velocity is again zero [± 5 mm]
 - c. the position where the velocity is maximum. [2.89 mm]
- 7 The acceleration of the particle is directly proportional to time t . At $t = 0$, the velocity of the particle is 400mm/s. Knowing that $v = 360$ mm/s and $x = 500$ mm when $t = 1$ s, determine the velocity, the position and the total distance traveled when $t = 7$ s. [17.64m/s, 41.54m, 41.160m]
- 8 The acceleration of the particle is defined by the relation $a = -kx^{-2}$. The particle starts with no initial velocity at $x = 800$ mm and it is observed that its velocity is 6m/s when $x = 500$ mm. Determine,
 - a. the value of k [24m³/s²]
 - b. the velocity of the particle when $x = 250$ mm. [11.49m/s]
- 9 The velocity of the particle is defined by the relation $v = 8 - 0.02x$. Knowing that $x = 0$ at $t = 0$ determine,
 - a. the total distance traveled before the particle come to rest. [400m]
 - b. the acceleration at $t = 0$ [-0.16 m/s²]
 - c. the time when $x = 100$ m [14.38s]

- 10 A stone thrown vertically upward from a point upon a bridge located 40 m above the water. Knowing that it strikes the water 4 sec after release. Determine
- speed with which the stone was thrown upward. [9.62 m/s]
 - The speed with which the stone strikes the water. [29.8 m/s downward]
- 11 The speed of a racing car is increased at a constant rate from 100 km/hr to 120 km/h over a distance of 180m along a curve of 240 m radius. Determine the magnitude of the total acceleration of the car after it has traveled 120 m along the curve. [4.264 m/s²]
- 12 An outdoor track is 130 m in diameter. A runner increases his speed at a constant rate from 4 to 7 m/s over a distance of 30 m. Determine the total acceleration of the runner 2 s after he begins to increase his speed. [0.68 m/s²]
- 13 A bus starts from rest on a curve of 300 m radius and accelerates at the constant rate at = 0.75 m/s². Determine the distance and the time that the bus will travel before the magnitude of its total acceleration is 0.9 m/s². [99.5m, 16.3s]
- 14 A shot is fired with a bullet from a point 20m in front of vertical wall 10 m high. Find the minimum angle of projection with horizontal to enable the shot to just clear the wall [30.2°]

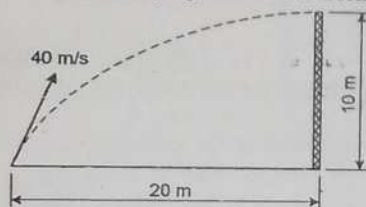


Figure 14

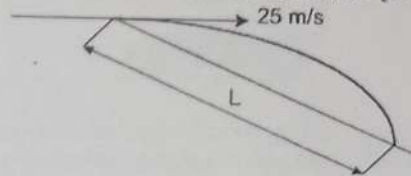


Figure 15

- 15 A ski jumper starts with a horizontal take off velocity of 25m/s and lands on straight landing hill inclined at 30°. Determine a) the time between take off and landing b)the length of the jump [85 m]
- 16 A girl throws a ball with an initial velocity 18m/s. Determine.
- the maximum height h at which the ball can strike the wall [14.61m]
 - the corresponding angle made with horizontal [65.6°]

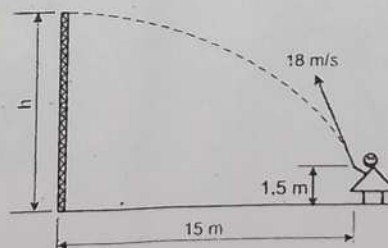


Figure 16

- 17 A golfer hits a golf ball with an initial velocity of 48m/s at an angle of 25° with the horizontal. Knowing that the fairway slopes downward at an average angle of 5°, determine the distance d between the golfer and point B where the ball first lands. [215m]

- 22 Car A and B are traveling in adjacent highway lanes and $t = 0$ have the positions and speed s shown knowing that car A has a constant acceleration of 0.6 m/s^2 and that B has a constant deceleration of 0.4 m/s^2 . Determine (a) when and where A will overtake B, (b) the speed of each car at that time. [(a) 13.81 sec, 202.91 m (b) $V_A = 18.84 \text{ m/s}$, $V_B = 10.3 \text{ m/s}$]

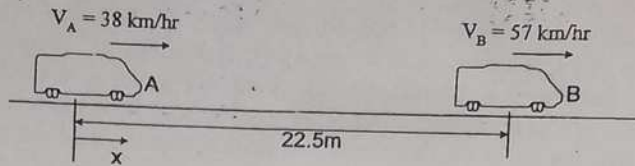


Figure 22

- 23 Car A and B are traveling respectively at the constant speeds $(v_A)_0 = 36 \text{ km/h}$ and $(v_B)_0 = 27 \text{ km/h}$ on an ice-covered road. To avoid overtaking car B, the driver of car A applies his brakes so that his car decelerates at a constant rate of 0.042 m/s^2 . Determine the distance d between the cars at which the driver of car A must apply his brakes to just avoid colliding with car B.

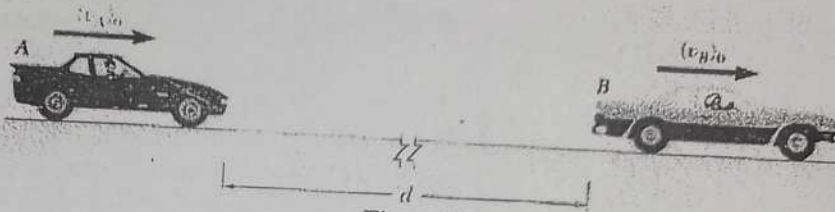


Figure 23



Figure 17

- 18 A basketball player shoots when she is 5 m from the backboard. Knowing that the ball has an initial velocity v_0 at an angle of 30° with the horizontal, determine the value of v_0 when d is equal to a) 228 mm, b) 430 mm [9.34 m/s, 9.27 m/s]

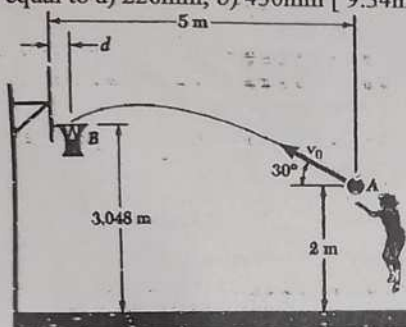


Figure 18

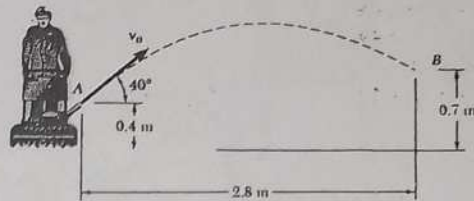


Figure 19

- 19 A homeowner uses a snow-blower to clear his driveway. Knowing that the snow is discharged at an average angle of 40° with the horizontal, determine the initial velocity v_0 of the snow.
- 20 As cam A rotates, follower wheel B rolls without slipping on the face of the cam. Knowing that the normal components of the acceleration of the points of contact at C of the cam A and the wheel B are 0.66 m/s^2 and 6.8 m/s^2 respectively, determine the diameter of the follower wheel. [11.65 mm]
- 21 The rotation of rod OA about O is defined by the relation $\theta = 2t^2$ where θ is expressed in radians and t in seconds. Collar B slides along the rod in such a way that its distance from O is $r = 60t^2 - 20t^3$, where r is expressed in millimeters and t in seconds. When $t = 1 \text{ s}$, determine a) velocity of collar b) total acceleration of the collar [0.204 mm/s $e_r - 5.71 \text{ mm/s}^2 e_\theta$, $22.8 \text{ mm/s}^2 e_r + 1.633 \text{ mm/s}^2 e_\theta$]

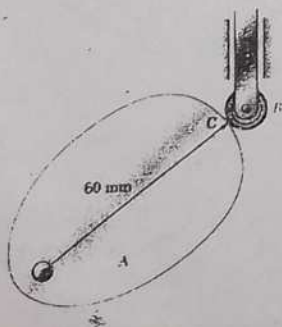


Figure 20

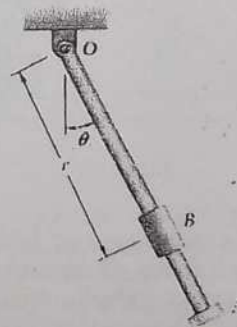


Figure 21

Kinetics of particle

1. A single wire ACB passes through a ring at C that is attached to a 5 kg sphere which revolves at constant speed v in the horizontal circle as shown. Knowing that $\theta_1 = 50^\circ$ and $d = 0.8\text{m}$ and that the tension in both portions of the wire is 34N , determine
 - i) The angle θ_2 [36.9°]
 - ii) The speed v [3.88m/s]

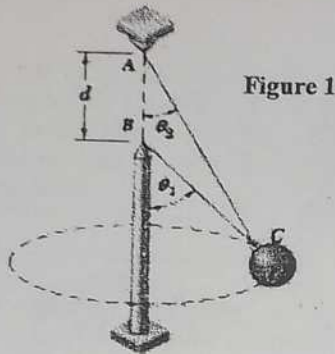


Figure 1

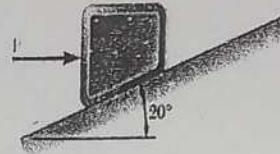


Figure 2

2. A 5 kg block is at rest on an incline when a constant horizontal force P is applied to it. The static and kinematic coefficient of friction between the block and incline are 0.3 and 0.25 respectively. Knowing that the speed of block is 12m/s after 6s determine the magnitude of P [44.84N]
3. The two blocks ($m_a = 100\text{ kg}$, $m_b = 150\text{ kg}$) shown are originally at rest. Assuming that the coefficients of friction between the blocks and the inclines are $\mu_s = 0.25$ and $\mu_k = 0.20$, determine
 - a) acceleration of block A
 - b) tension in the cord

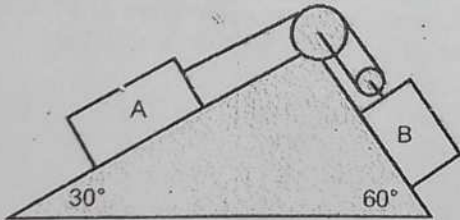


Figure 3

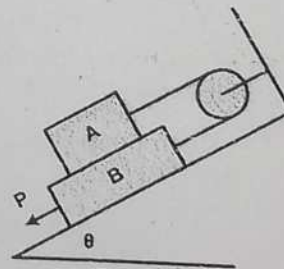


Figure 4

4. Block A has a mass of 25kg and block B a mass of 15 kg . The coefficient of friction between all the surfaces are $\mu_s = 0.20$ and $\mu_k = 0.15$. Knowing that $\theta = 25^\circ$ and that the magnitude of force applied to block B is 250N , determine
 - c) acceleration of block A [2.21m/s²]
 - d) tension in the cord [192.3N]

5. The acceleration of a package sliding down section AB of incline ABC is 5 m/s^2 . Assuming that the coefficient of kinetic friction is the same for each section, determine the acceleration of the package on section BC of the incline. [2.09 m/s^2]

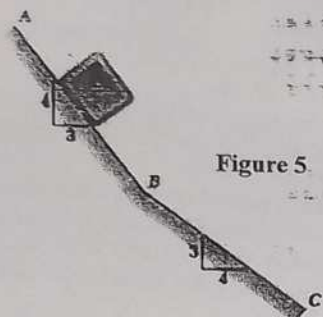


Figure 5

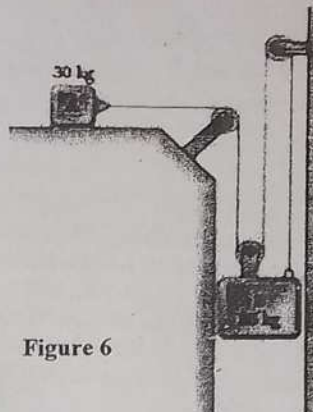


Figure 6

6. The two blocks shown are originally at rest. Neglecting the masses of pulleys and the effect of friction in the pulleys and assuming that the coefficients of friction between block A and the horizontal surface are $\mu_s = 0.25$ and $\mu_k = 0.2$ determine
- The acceleration of each block [$0.698\text{ m/s}^2 \rightarrow , 0.233\text{ m/s}^2 \uparrow$]
 - Tension in the cable [79.8 N]
7. The two blocks shown are originally at rest. Neglecting the masses of pulleys and the effect of friction in the pulleys and assuming that the coefficients of friction between block A and the horizontal surface as 0.25, determine
- the acceleration of each block [$a_A = 2.1\text{ m/s}^2, a_B = 1.05\text{ m/s}^2$]
 - the tension in the cable [700 N]

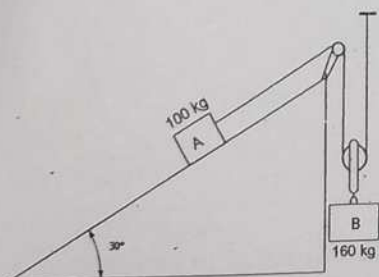


Figure 7

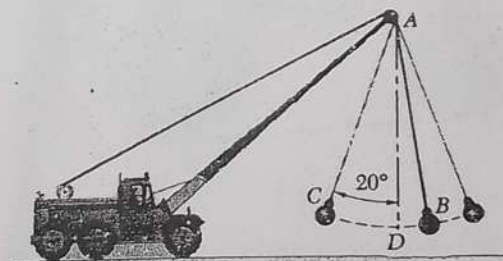


Figure 8

8. A 60 kg wrecking ball is attached to a 15 m long steel cable AB and swings in the vertical arc shown. Determine the tension in the cable (a) at the top C of the swing, (b) at the bottom D of the swing, where the speed of B is 4.2 m/s.
9. A 5 kg package is projected down the incline with an initial velocity of 4 m/s knowing that the coefficient of friction between the package and the incline is 0.35, determine

- i. the velocity of the package after 3 m of motion
- ii. distance d at which the package comes to rest

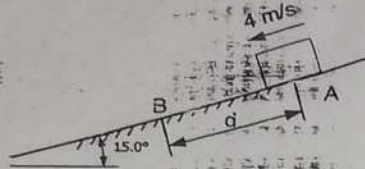


Figure 9

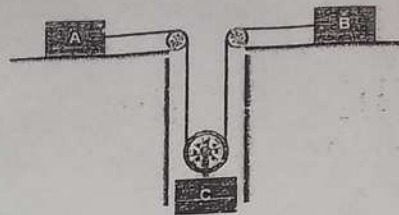


Figure 10

10. Three blocks A ($m_A = 10 \text{ kg}$), B ($m_B = 15 \text{ kg}$) and C ($m_C = 25 \text{ kg}$) are connected by rope and pulley arrangement as shown in the figure. The coefficient of kinematic friction between the contact plane and the block A and B is 0.3.
11. A string connecting a 5 kg ball and a 10 kg block is passed over an ideal pulley of negligible radius as shown. The pulley is then rotated about the axis a-a, which is assumed to pass through both the centre of the pulley and C.G. of the 10 kg wt. If the amount of string on the ball side of the pulley is 3 m. What must be the constant speed of the ball to prevent the 10 kg block from falling?

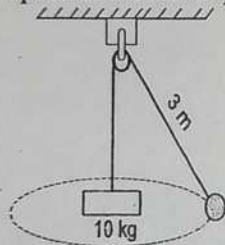


Figure 11

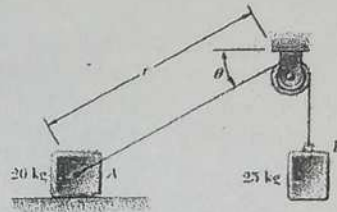


Figure 12

12. Two blocks are released from rest when $r = 0.8 \text{ m}$ and $\theta = 30^\circ$. Neglecting the mass of the pulley and the effect of friction in the pulley and between block a and the horizontal surface, determine (a) the initial tension in the cable, (b) the initial acceleration of block A and B. [126.6 N, 5.48 m/s^2 , 4.75 m/s^2]

Kinematics of Rigid Body

1. A body rotates according to the relation $\alpha = 3t^2 + 4$, angular displacement being measured in radians and time in seconds. If its initial angular velocity is 4 rad per sec. and the initial angular displacement is zero, compute the values of θ and ω for the instant, when $t = 3$ sec. [$\omega = 43 \text{ rad/sec}$, $\theta = 50.25 \text{ rad}$]

2. If the hoisting gear A has an initial angular velocity 8 rad/sec clockwise and an angular acceleration 1.5 rad/sec^2 anticlockwise. Determine the velocity and acceleration of block C in 2 sec. [$V_C = 125 \text{ mm/sec upward}$, $a_C = 37.5 \text{ mm/sec}^2 \text{ downward}$]

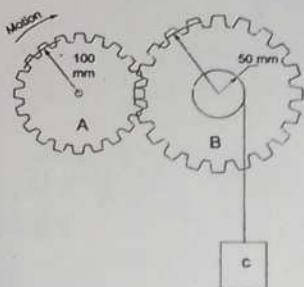


Figure 2

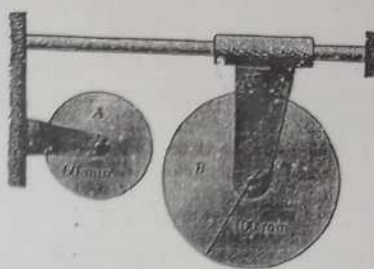


Figure 3

3. Disk B is at rest when it brought into contact with disk A which is rotating freely at 450 r/min clockwise. After 6 s of slippage, during which each disk has a constant angular acceleration, disk A reaches a final angular velocity of 140 r/min clockwise. Determine the angular acceleration of each disk during the period of slippage.

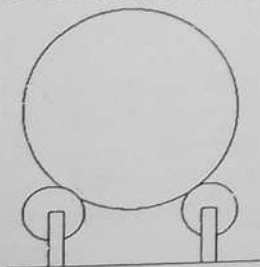


Figure 4

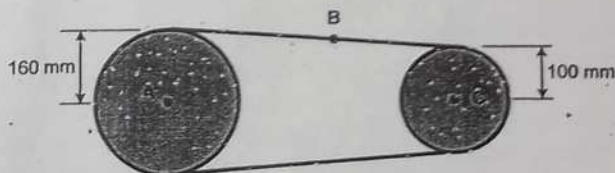


Figure 5

4. A mixing drum of 125mm outside radius rests on two casters each of 25mm radius. The drum executed 15 revolutions during the time interval t , while its angular velocity is being increased uniformly from 20 to 50 rpm. Knowing that no slippage occurs between the drum and casters determine, (a) Angular acceleration of the casters [0.61 rad/s^2], (b) Time interval t [25.71 s]
5. The belt shown moves over two pulleys without slipping. At the instance shown the pulleys are rotating clockwise and the speed of point B on the belt is 4 m/s, increasing at the rate of 32 m/s^2 . Determine, at this instant, (a) angular velocity and angular acceleration of each pulley, (b) the acceleration of point P on pulley C. [25 rad/s CW , $200 \text{ rad/s}^2 \text{ CW}$, 40 rad/s CW , 320 rad/s^2 , $163.2 \text{ m/s}^2 \angle 11.3^\circ$]

Kinetics of Rigid Body

1. Each of the pulleys shown has a mass moment of inertia of 20 kg m^2 and is initially at rest. The outside radius is 0.4 m and the inner radius is 0.2 m . Determine (a) the angular acceleration of each pulley, (b) the angular velocity of each pulley after point A on the cord has moved 3 m .

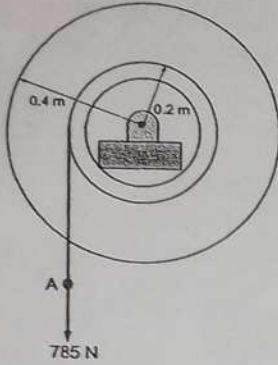


Figure 1.a

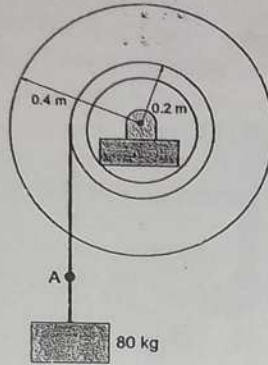


Figure 1.b

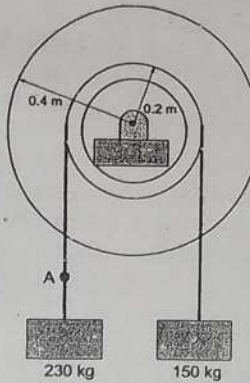


Figure 1.c

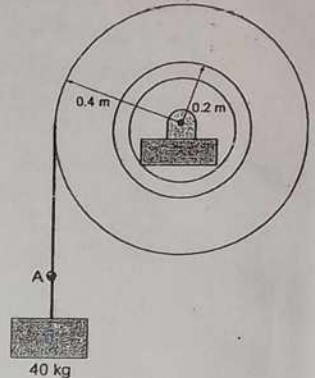


Figure 1.d

2. The flywheel weighs 250 lb and has a radius of gyration of 15 in . A block A of weight 30 lb is attached to a wire wrapped around the rim of radius $r = 20 \text{ in}$. The system is released from rest. Neglecting the effect of friction, determine
- The acceleration of block A. [5.66 ft/sec^2]
 - The speed of block A after it has moved 6 ft . [8.24 ft/sec]

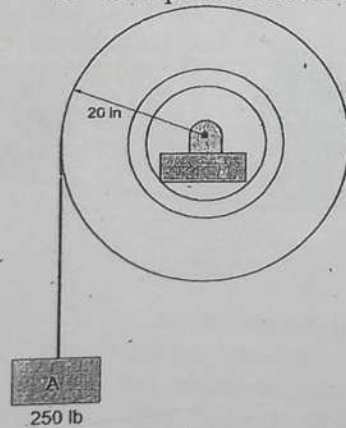


Figure 2

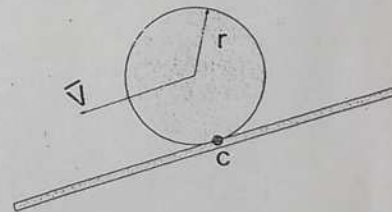


Figure 3

3. A sphere, a cylinder and a hoop each having the same mass and the same radius, are released from rest on an incline. Determine the velocity of each body after it has rolled through a distance corresponding to a change in elevation h . [$0.845\sqrt{2gh}$, $0.816\sqrt{2gh}$, $0.707\sqrt{2gh}$]

4. A flywheel of centroidal radius of gyration $K = 500$ mm is rigidly attached to a shaft of radius $r = 40$ mm which may roll along parallel rails. Knowing that the system is released from rest, determine the distance through which it will roll in 20 s. [3.85m]

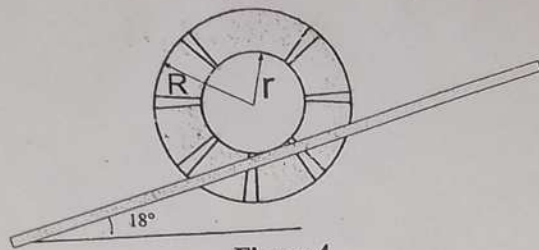


Figure 4

5. The mass and radius of friction disk B are $m_B = 5$ kg and $r_B = 90$ mm; the mass and radius of friction disk A are $m_A = 2$ kg and $r_A = 60$ mm. The disks are at rest when a couple M of moment is applied to disk A. Assuming that no slipping occurs between the disks, determine (a) the angular acceleration of each disk, (b) the friction force that disk A exerts on disk B.

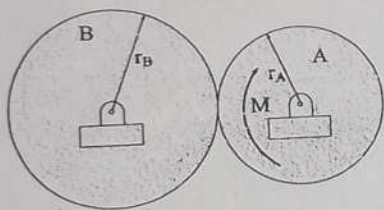


Figure 5

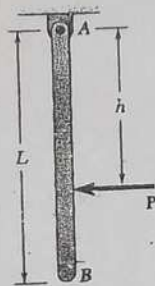


Figure 6

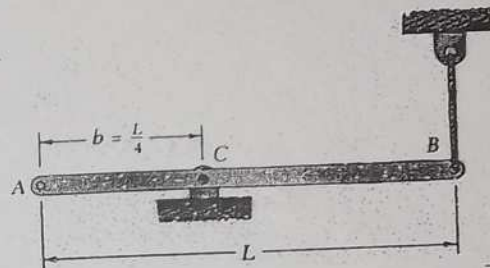


Figure 7

6. A uniform slender rod of length $L = 0.9$ m and mass $m = 2$ kg hangs freely from a hinge at A. If a force P of magnitude 6 N is applied at B horizontally to the left ($h = L$), determine (a) the angular acceleration of the rod, (b) the components of the reaction at A.
7. A uniform rod of length L and mass m is supported as shown. If the cable attached at the end B suddenly breaks, determine (a) the acceleration of end B, (b) the reaction at the pin support