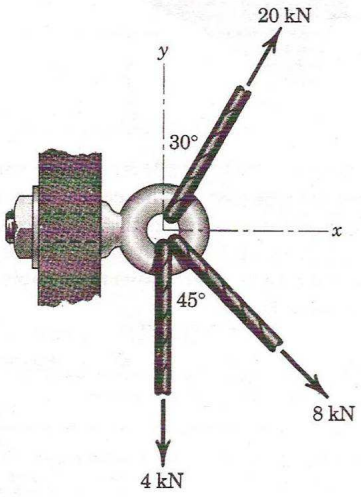
PROBLEMS

Introductory Problems

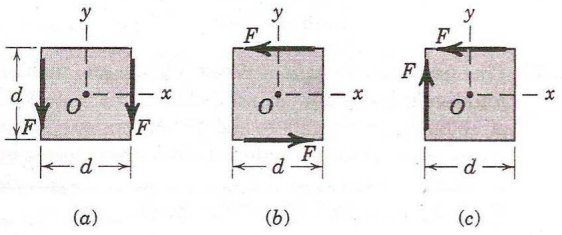
2/73 Determine the resultant **R** of the three tension forces acting on the eye bolt. Find the magnitude of **R** and the angle θ_x which **R** makes with the positive x-axis.

Ans. $R = 17.43$ kN, $\theta_x = 26.1°$



Problem 2/73

2/74 Determine the equivalent force–couple system at the center O for each of the three cases of forces being applied along the edges of a square plate of side d.



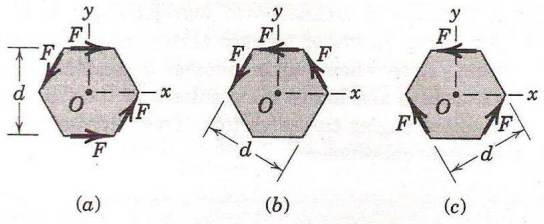
Problem 2/74

2/75 Determine the equivalent force–couple system at the origin O for each of the three cases of forces being applied along the edges of a regular hexagon of width d. If the resultant can be so expressed, replace this force–couple system with a single force.

Ans. (*a*) $\mathbf{R} = 2F\mathbf{i}$ along $y = -\dfrac{d}{2}$

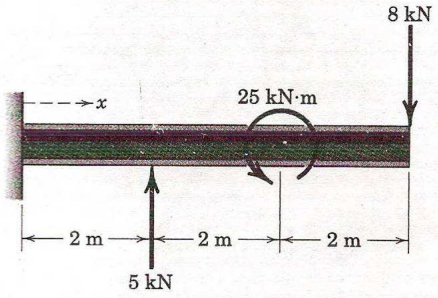
(*b*) $\mathbf{R} = -2F\mathbf{i}$ along $y = \dfrac{3d}{4}$

(*c*) $\mathbf{R} = F(-\mathbf{i} + \sqrt{3}\mathbf{j})$ along $y = -\sqrt{3}x + \dfrac{d}{2}$



Problem 2/75

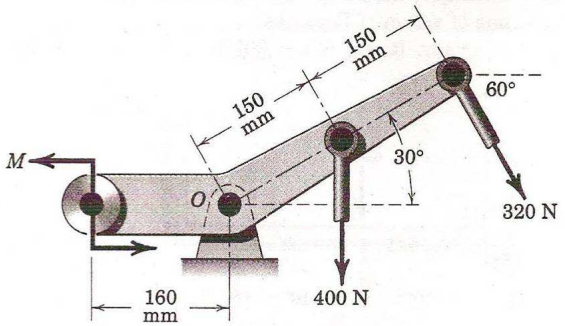
2/76 Determine and locate the resultant **R** of the two forces and one couple acting on the I-beam.



Problem 2/76

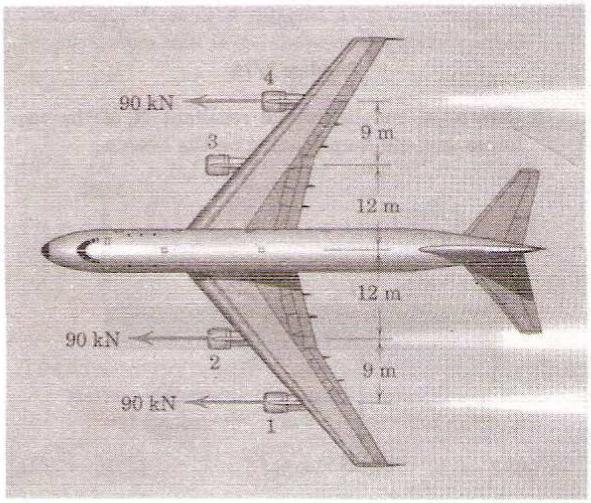
2/77 If the resultant of the two forces and couple M passes through point O, determine M.

Ans. $M = 148.0$ N·m CCW



Problem 2/77

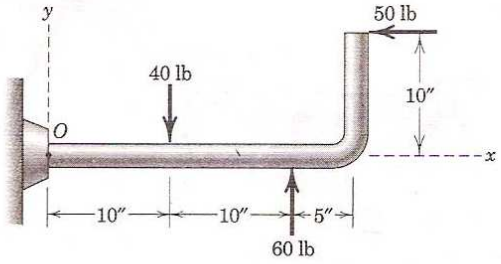
2/78 A commercial airliner with four jet engines, each producing 90 kN of forward thrust, is in a steady, level cruise when engine number 3 suddenly fails. Determine and locate the resultant of the three remaining engine thrust vectors. Treat this as a two-dimensional problem.



Problem 2/78

2/79 Replace the three forces acting on the bent pipe by a single equivalent force **R**. Specify the distance x from point O to the point on the x-axis through which the line of action of **R** passes.

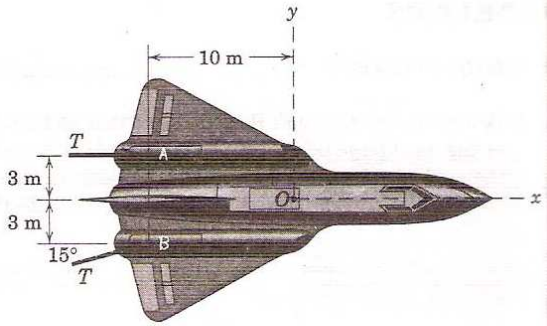
Ans. $\mathbf{R} = -50\mathbf{i} + 20\mathbf{j}$ lb, $x = 65$ in. (off pipe)



Problem 2/79

Representative Problems

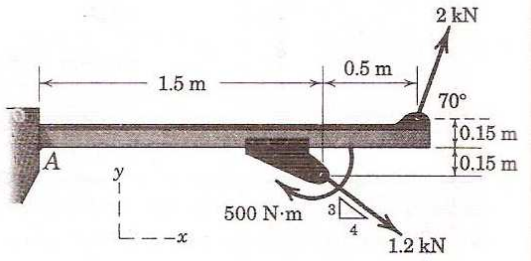
2/80 The directions of the two thrust vectors of an experimental aircraft can be independently changed from the conventional forward direction within limits. For the thrust configuration shown, determine the equivalent force–couple system at point O. Then replace this force–couple system by a single force and specify the point on the x-axis through which the line of action of this resultant passes. These results are vital to assessing design performance.



Problem 2/80

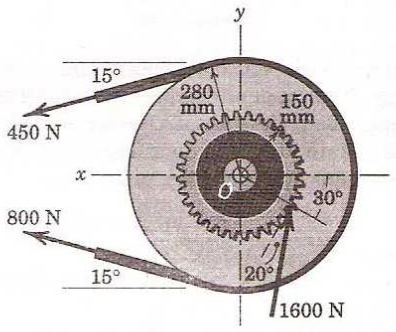
2/81 The flanged steel cantilever beam with rivete bracket is subjected to the couple and two force shown, and their effect on the design of the attach ment at A must be determined. Replace the tw forces and couple by an equivalent couple M and re sultant force **R** at A.

Ans. $\mathbf{R} = 1.644\mathbf{i} + 1.159\mathbf{j}$ k
$M_A = 2.22$ kN·m CC



Problem 2/81

2/82 The gear and attached V-belt pulley are turnin counterclockwise and are subjected to the tooth loa of 1600 N and the 800-N and 450-N tensions in th V-belt. Represent the action of these three forces b a resultant force **R** at O and a couple of magnitud M. Is the unit slowing down or speeding up?



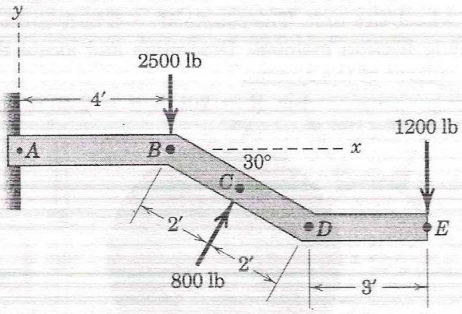
Problem 2/82

2/83 Replace the three forces which act on the bent bar by a force–couple system at the support point A. Then determine the x-intercept of the line of action of the stand-alone resultant force $\mathbf{R}$.

Ans. $\mathbf{R} = 400\mathbf{i} - 3010\mathbf{j}$ lb

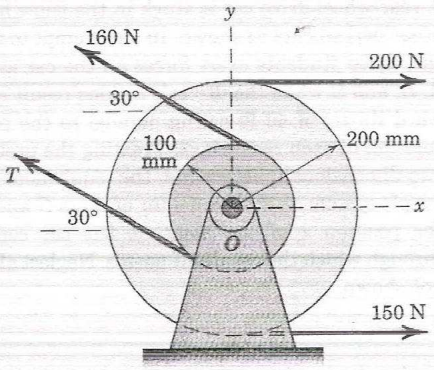
$M_A = 18{,}190$ lb-ft CW

$x = 6.05$ ft



Problem 2/83

2/84 Two integral pulleys are subjected to the belt tensions shown. If the resultant $\mathbf{R}$ of these forces passes through the center O, determine T and the magnitude of $\mathbf{R}$ and the counterclockwise angle θ it makes with the x-axis.

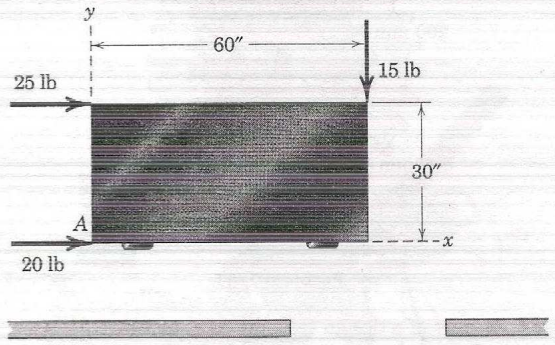


Problem 2/84

2/85 While sliding a desk toward the doorway, three students exert the forces shown in the overhead view. Determine the equivalent force–couple system at point A. Then determine the equation of the line of action of the resultant force.

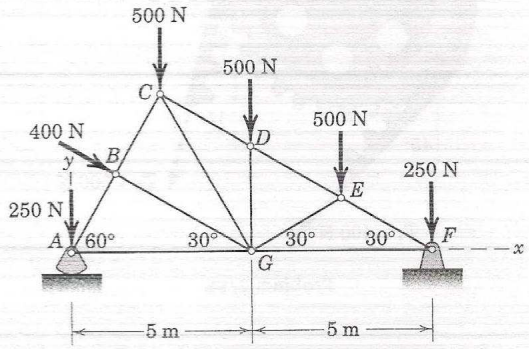
Ans. $\mathbf{R} = 45\mathbf{i} - 15\mathbf{j}$ lb, $\mathbf{M}_A = -1650\mathbf{k}$ lb-in.

$y = -\frac{1}{3}x + \frac{110}{3}$



Problem 2/85

2/86 The asymmetric roof truss is of the type used when a near normal angle of incidence of sunlight onto the south-facing surface ABC is desirable for solar energy purposes. The five vertical loads represent the effect of the weights of the truss and supported roofing materials. The 400-N load represents the effect of wind pressure. Determine the equivalent force–couple system at A. Also, compute the x-intercept of the line of action of the system resultant treated as a single force $\mathbf{R}$.



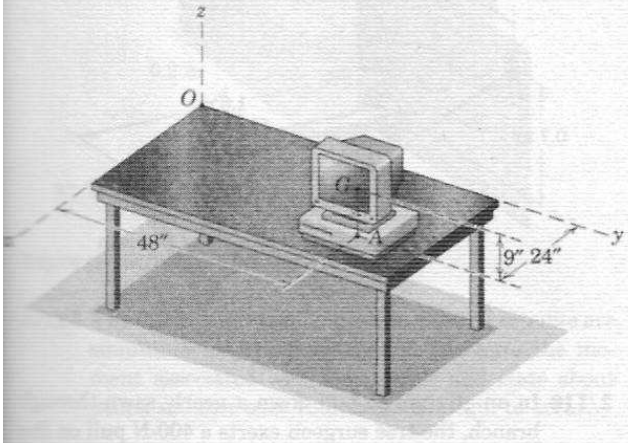
Problem 2/86

PROBLEMS

Introductory Problems

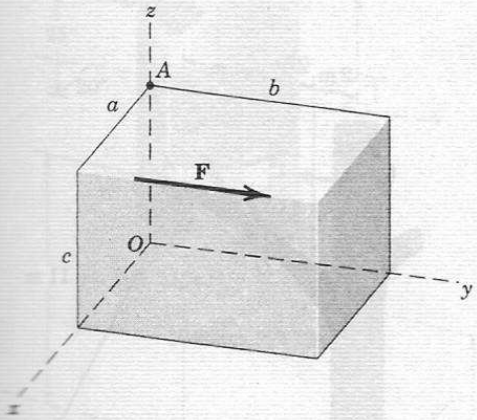
2/111 The weight of the computer system is 80 lb with center of gravity at point G. Determine the moment $\mathbf{M}_O$ of this weight about point O on the horizontal table top. Find the magnitude of $\mathbf{M}_O$.

Ans. $\mathbf{M}_O = -320\mathbf{i} + 160\mathbf{j}$ lb-ft, $M_O = 358$ lb-ft



Problem 2/111

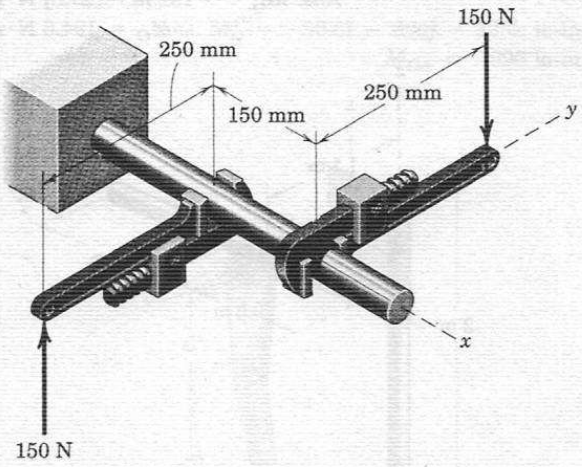
2/112 Determine the moments of force $\mathbf{F}$ about point O and about point A.



Problem 2/112

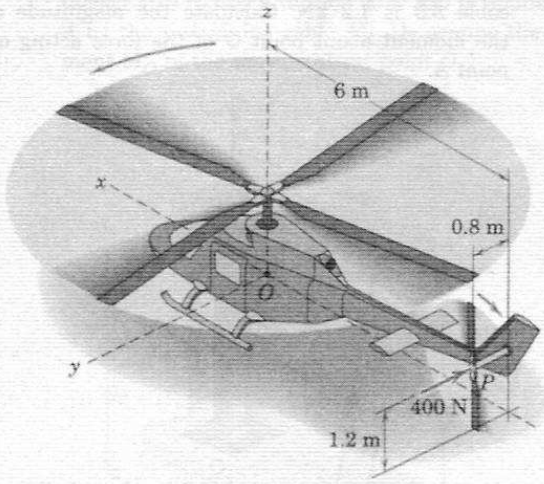
2/113 The two forces acting on the handles of the pipe wrenches constitute a couple $\mathbf{M}$. Express the couple as a vector.

Ans. $\mathbf{M} = -75\mathbf{i} + 22.5\mathbf{j}$ N·m



Problem 2/113

2/114 The helicopter of Prob. 2/58 is redrawn here with certain three-dimensional geometry given. During a ground test, a 400-N aerodynamic force is applied to the tail rotor at P as shown. Determine the moment of this force about point O of the airframe.

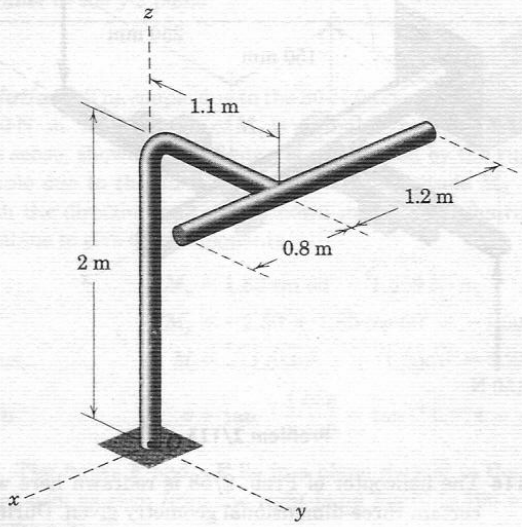


Problem 2/114

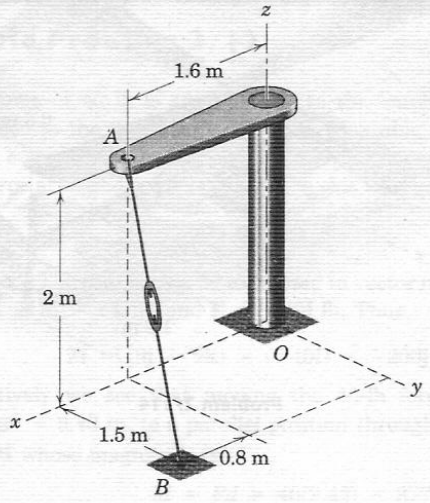
The structure shown is constructed of circular rod which has a mass of 7 kg per meter of length. Determine the moment $\mathbf{M}_O$ about O caused by the weight of the structure. Find the magnitude of $\mathbf{M}_O$.

Ans. $\mathbf{M}_O = -192.6\mathbf{i} - 27.5\mathbf{j}$ N·m

$M_O = 194.6$ N·m



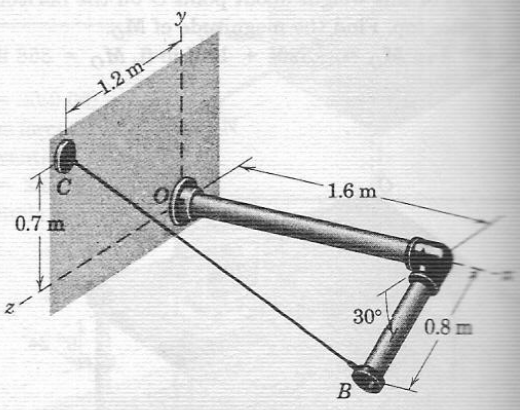
The turnbuckle is tightened until the tension in cable AB is 1.2 kN. Calculate the magnitude of the moment about point O of the force acting on point A.



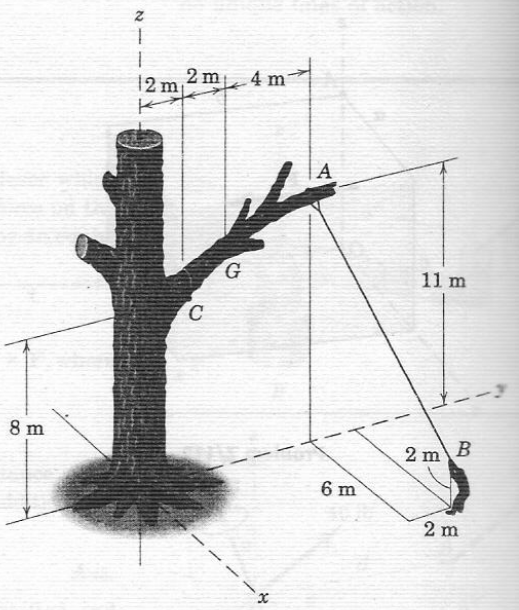
The right-angle pipe OAB [illegible] again here. Replace the 750-N tensile force [illegible] the cable exerts on point B by a force–couple [illegible] at point O.

Ans. $\mathbf{R} = -598\mathbf{i} + 411\mathbf{j} +$ [illegible]

$\mathbf{M}_O = -361\mathbf{i} - 718\mathbf{j} +$ [illegible]

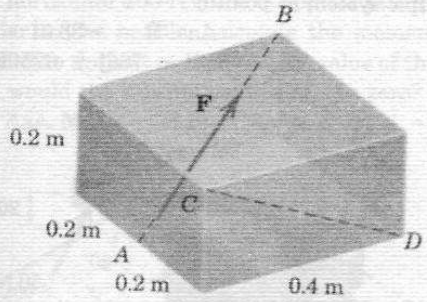


In an attempt to pull down a nearly sawn-[illegible] branch, the tree surgeon exerts a 400-N pull on the line which is looped around the branch at A. Determine the moment about point C of the force exerted on the branch and state the magnitude of this moment.

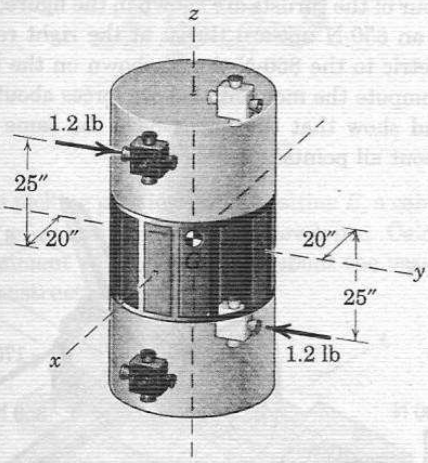


The figure of Prob. 2/101 is shown again here. If the magnitude of the moment of **F** about line *CD* is 50 N·m, determine the magnitude of **F**.

Ans. $F = 228$ N



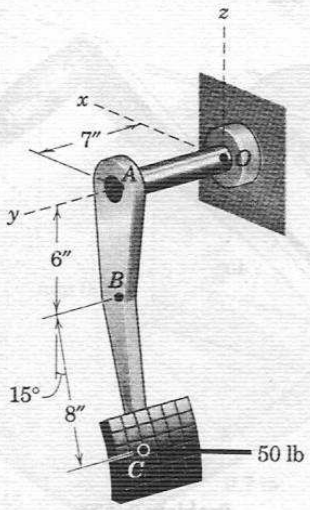
Two 1.2-lb thrusters on the nonrotating satellite are simultaneously fired as shown. Compute the moment associated with this couple and state about which satellite axes rotations will begin to occur.



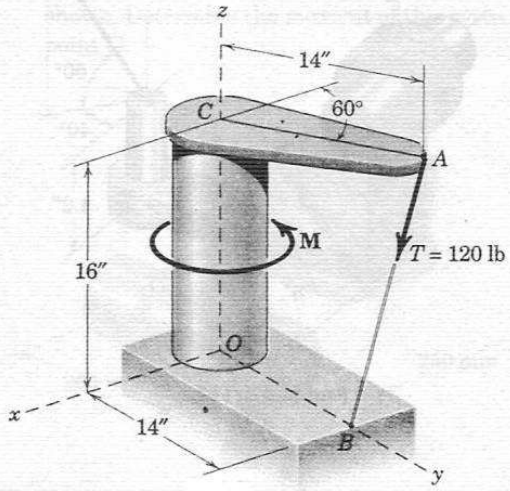
A 50-lb force is applied to the control pedal as shown. The force lies in a plane parallel to the *x*-*z* plane and is perpendicular to *BC*. Determine the moments of this force about point *O* and about the shaft *OA*.

Ans. $\mathbf{M}_O = -90.6\mathbf{i} - 690\mathbf{j} - 338\mathbf{k}$ lb-in.

$M_{OA} = -690$ lb-in.

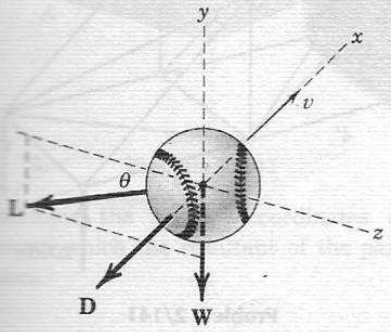


A moment (torque) **M** applied to the shaft and attached arm causes a tension *T* of 120 lb applied to *A* by the restraining cable *AB*. Determine the moment $\mathbf{M}_O$ of the tension about point *O*.

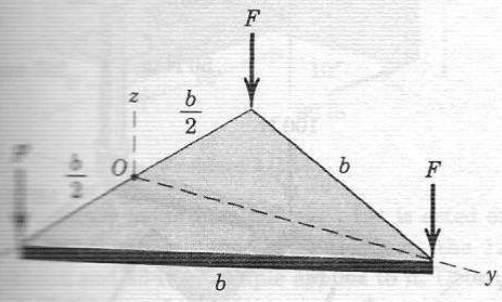


A baseball is thrown with spin so that three concurrent forces act on it as shown in the figure. The weight W is 5 oz, the drag D is 1.7 oz, and the lift L is perpendicular to the velocity $\mathbf{v}$ of the ball. If it is known that the y-component of the resultant is -5.5 oz and the z-component is -0.866 oz, determine L, θ, and R.

Ans. $L = 1$ oz, $\theta = 30°$, $R = 5.82$ oz



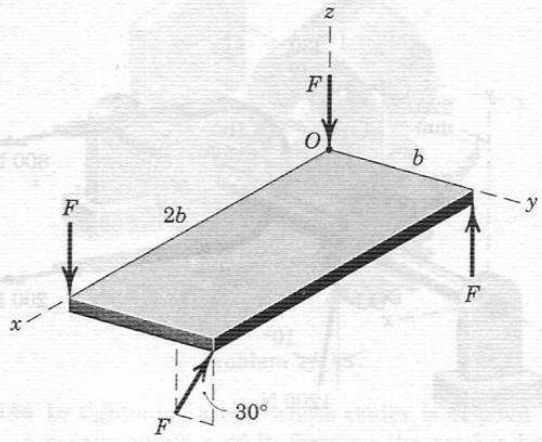
Three equal forces are exerted on the equilateral plate as shown. Reduce the force system to an equivalent force–couple system at point O. Show that $\mathbf{R}$ is perpendicular to $\mathbf{M}_O$.



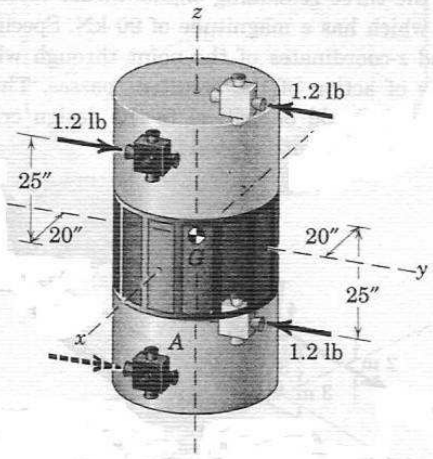
The thin rectangular plate is subjected to the four forces shown. Determine the equivalent force–couple system at O. Is $\mathbf{R}$ perpendicular to $\mathbf{M}_O$?

Ans. $\mathbf{R} = F(0.5\mathbf{j} - 0.1340\mathbf{k})$

$\mathbf{M}_O = Fb(1.866\mathbf{i} + 0.268\mathbf{j} + \mathbf{k})$, yes



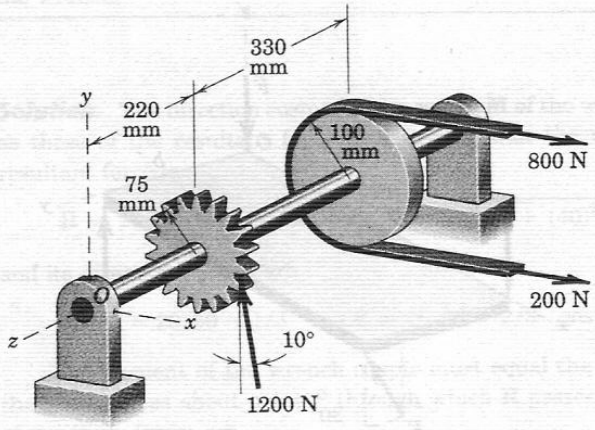
The spacecraft of Prob 2/120 is repeated here. The plan is to fire four 1.2-lb thrusters as shown in order to spin up the spacecraft about its z-axis, but the thruster at A fails. Determine the equivalent force–couple system at G for the remaining three thrusters.



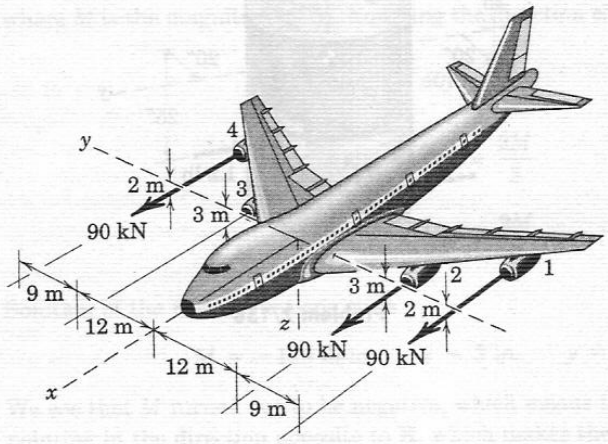
The pulley and gear are subjected to the loads shown. For these forces, determine the equivalent force–couple system at point O.

Ans. $\mathbf{R} = 792\mathbf{i} + 1182\mathbf{j}$ N

$\mathbf{M}_O = 260\mathbf{i} - 504\mathbf{j} + 28.6\mathbf{k}$ N·m



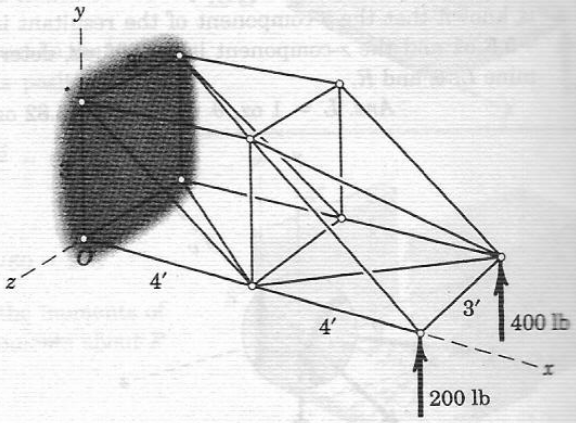
The commercial airliner of Prob. is redrawn here with three-dimensional information supplied. If engine 3 suddenly fails, determine the resultant of the three remaining engine thrust vectors, each of which has a magnitude of 90 kN. Specify the y- and z-coordinates of the point through which the line of action of the resultant passes. This information would be critical to the design criteria of performance with engine failure.



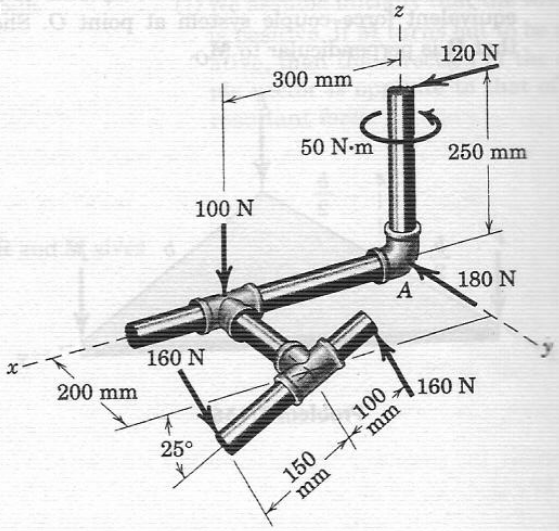
Two upward loads are exerted on the small three-dimensional truss. Reduce these two loads to a single force–couple system at point O. Show that $\mathbf{R}$ is perpendicular to $\mathbf{M}_O$. Then determine the point in the x-z plane through which the resultant passes.

Ans. $\mathbf{R} = 600\mathbf{j}$ lb, $\mathbf{M}_O = 1200\mathbf{i} + 4800\mathbf{k}$ lb-ft

$x = 8$ ft, $z = -2$ ft



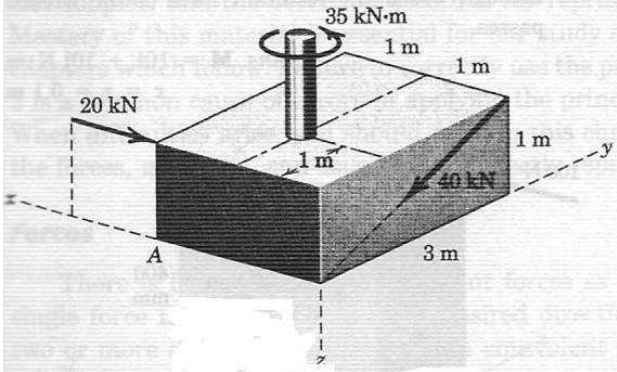
Represent the resultant of the force system acting on the pipe assembly by a single force $\mathbf{R}$ at A and a couple $\mathbf{M}$.



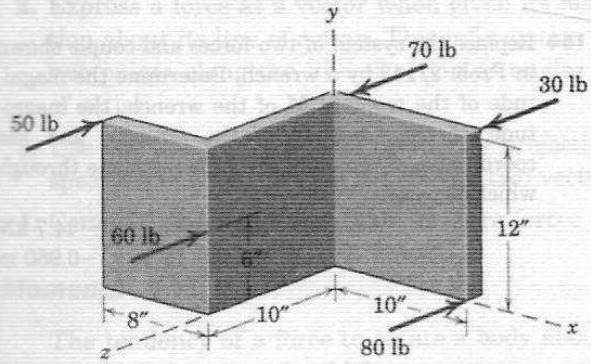
Replace the two forces and single couple by an equivalent force–couple system at point A.

Ans. $\mathbf{R} = -20\mathbf{i} - 37.9\mathbf{j} + 12.65\mathbf{k}$ kN

$\mathbf{M} = 45.3\mathbf{j} + 40.9\mathbf{k}$ kN·m



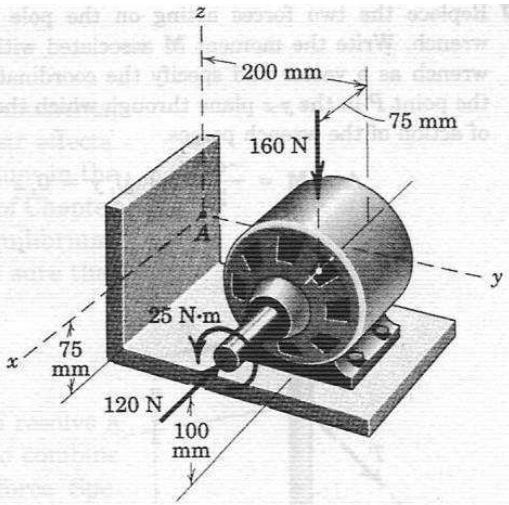
Determine the x-and y-coordinates of a point through which the resultant of the parallel forces passes.



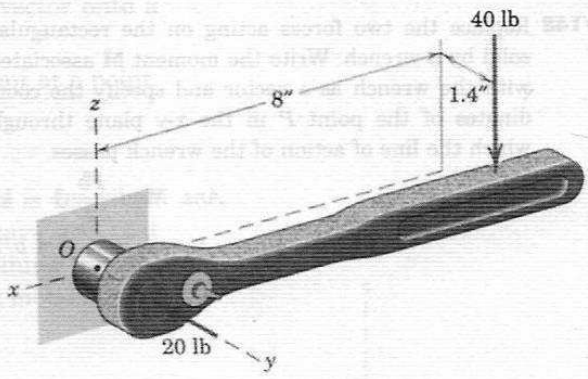
The motor mounted on the bracket is acted on by its 160-N weight, and its shaft resists the 120-N thrust and 25-N·m couple applied to it. Determine the resultant of the force system shown in terms of a force $\mathbf{R}$ at A and a couple $\mathbf{M}$.

Ans. $\mathbf{R} = -120\mathbf{i} - 160\mathbf{k}$ N

$\mathbf{M} = -7\mathbf{i} + 9\mathbf{j} + 24\mathbf{k}$ N·m

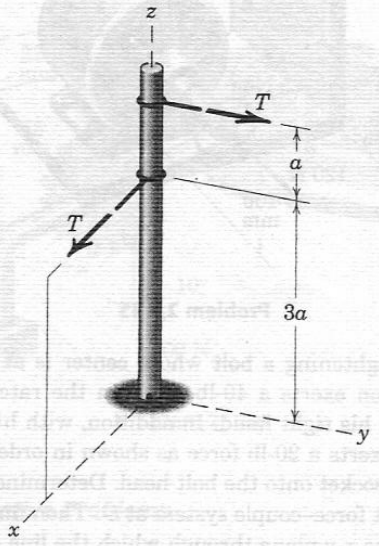


In tightening a bolt whose center is at point O, a person exerts a 40-lb force on the ratchet handle with his right hand. In addition, with his left hand he exerts a 20-lb force as shown in order to secure the socket onto the bolt head. Determine the equivalent force–couple system at O. Then find the point in the x-y plane through which the line of action of the single-force resultant passes.



Replace the two forces acting on the pole by a wrench. Write the moment **M** associated with the wrench as a vector and specify the coordinates of the point P in the y-z plane through which the line of action of the wrench passes.

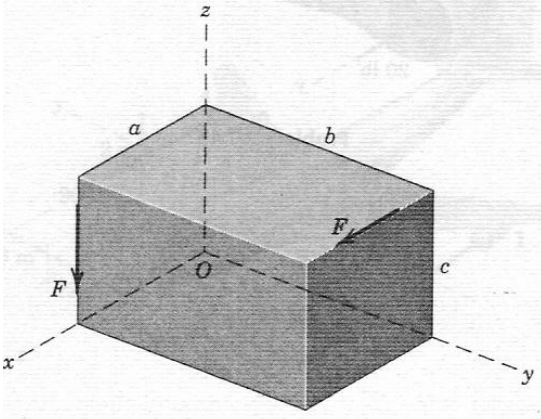
Ans. $\mathbf{M} = \dfrac{-aT}{2}(\mathbf{i} + \mathbf{j}),\ y = 0,\ z = \dfrac{7a}{2}$



Replace the two forces acting on the rectangular solid by a wrench. Write the moment **M** associated with the wrench as a vector and specify the coordinates of the point P in the x-y plane through which the line of action of the wrench passes.

Ans. $\mathbf{M} = \dfrac{Fb}{2}(\mathbf{i} - \mathbf{k})$

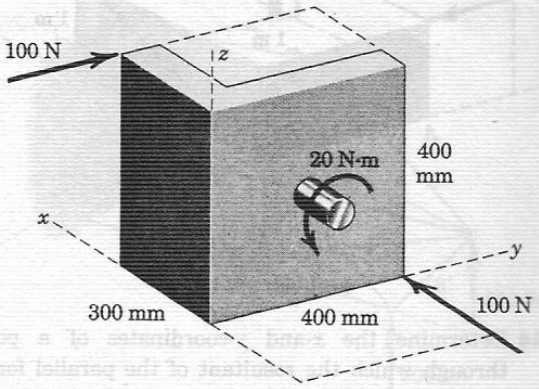
$x = a + c,\ y = b/2$



The resultant of the two forces and couple may be represented by a wrench. Determine the vector expression for the moment **M** of the wrench and find the coordinates of the point P, in the x-z plane through which the resultant force of the wrench passes.

Ans. $\mathbf{M} = 10\mathbf{i} + 10\mathbf{j}$ N·m

$x = z = 0.1$ m



Replace the system of two forces and couple shown in Prob. 2/143 by a wrench. Determine the magnitude of the moment **M** of the wrench, the magnitude of the force **R** of the wrench, and the coordinates of the point P in the x-y plane through which **R** passes.

Ans. $M = 26.9$ kN·m, $R = 44.7$ kN

$x = 0.221$ m, $y = -0.950$ m