Problem Set 2

Problem 2.1 Extremizing a Moment Due to a Force
Determine the direction θ of the force $F = 40$ lb. so that it produces
a) the maximum moment about point A, and
b) the minimum moment about point A.

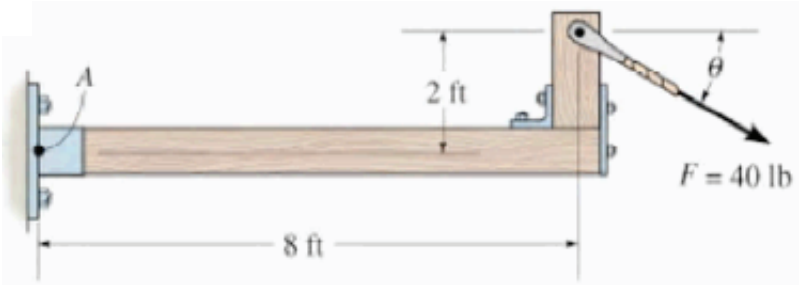

Figure P2.1: Problem 2.1

Problem 2.2 Moment of a Force-Vector Formulation

Determine the magnitude of the force **F** that should be applied at the end of the lever such that this force creates a clockwise moment about point O of 15 N m when $\theta = 30°$.

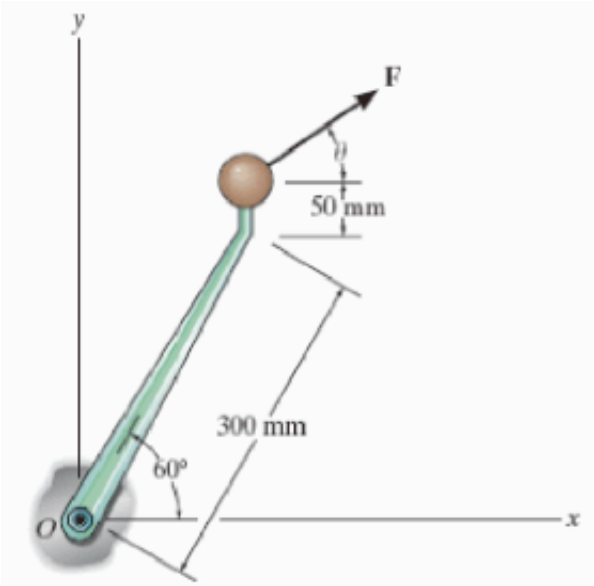

Figure P2.2: Problem 2.2

Problem 2.3

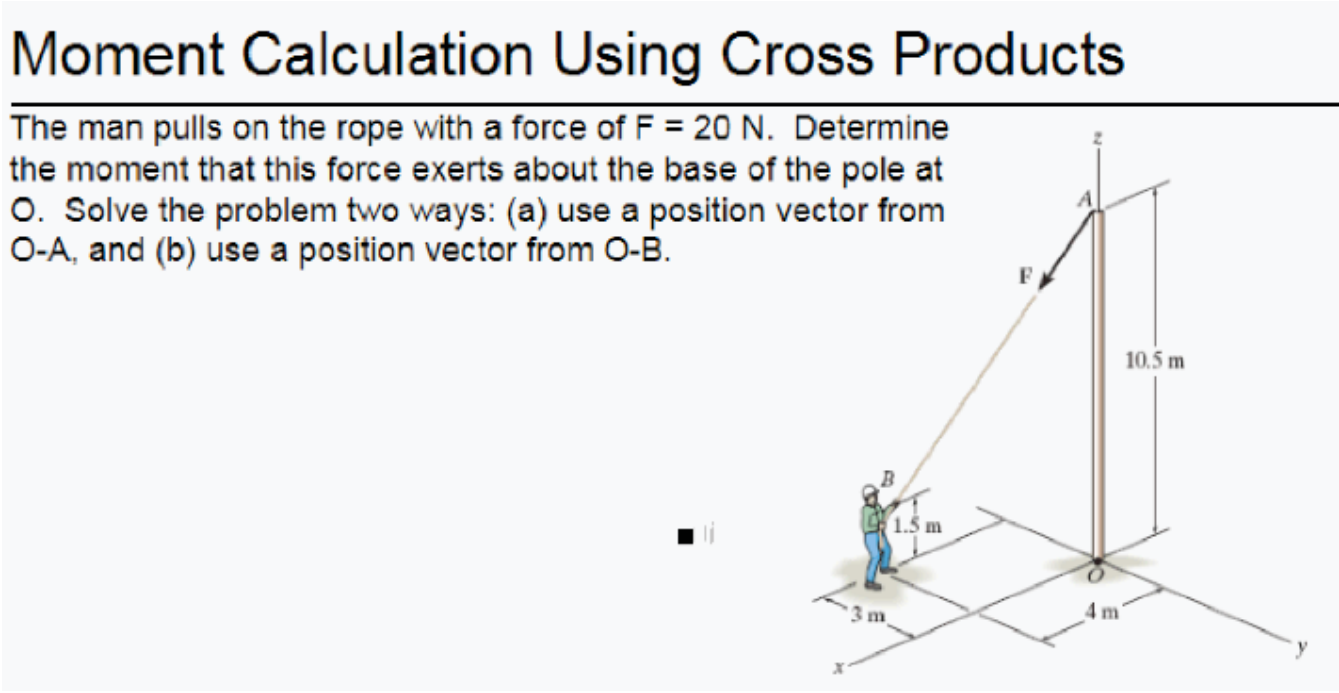

Figure P2.3: Problem 2.3

Problem 2.4

Torque to Loosen a Lug Nut

The lug nut on the automobile wheel is to be removed using the wrench and the vertical force of F = 30 N. If the torque required to loosen the lug nut is 14 N-m *around the x-axis* is this force sufficient? If the 30 N force can be applied anywhere on the wrench, will it be possible to loosen the lug nut?

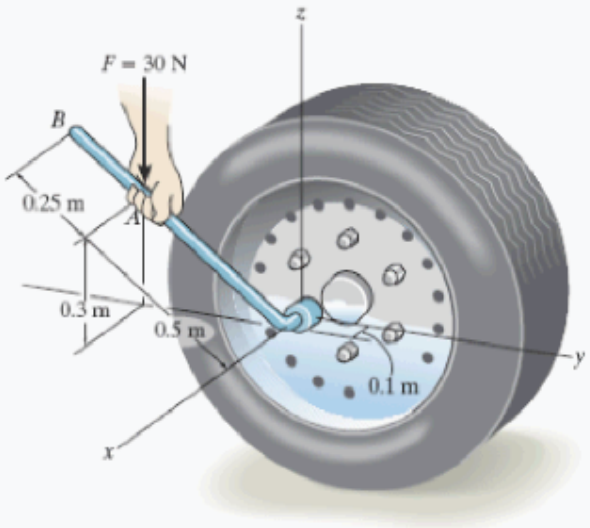

Figure P2.4: Problem 2.4

Problem 2.5

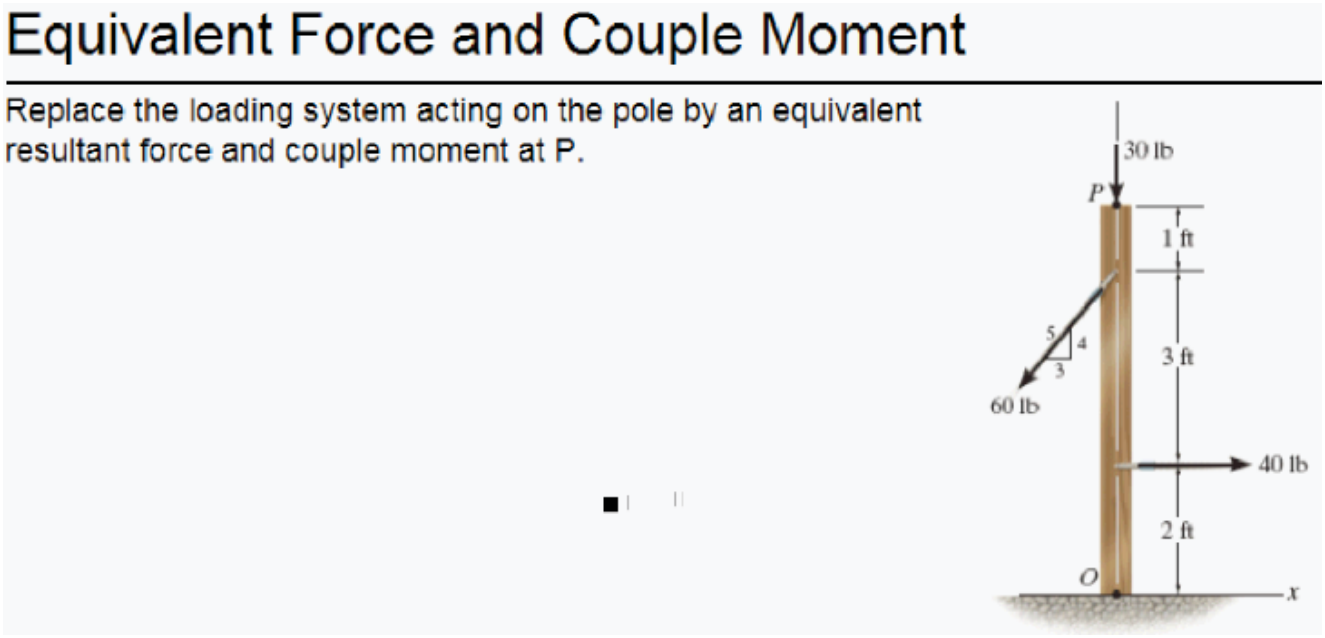

Figure P2.5: Problem 2.5

Problem 2.6

a) Determine the resultant of the forces $\mathbf{F}_1 = F_{1x}\,\mathbf{\imath} + F_{1y}\,\mathbf{J} + F_{1z}\,\mathbf{k}$, $\mathbf{F}_2 = F_{2x}\,\mathbf{\imath} + F_{2y}\,\mathbf{J} + F_{2z}\,\mathbf{k}$, and $\mathbf{F}_3 = F_{3x}\,\mathbf{\imath} + F_{3y}\,\mathbf{J} + F_{3z}\,\mathbf{k}$, which are concurrent at the point $P(x_P,\, y_P,\, z_P)$, where $F_{1x} = 2$, $F_{1y} = 3.5$, $F_{1z} = -3$, $F_{2x} = -1.5$, $F_{2y} = 4.5$, $F_{2z} = -3$, $F_{3x} = 7$, $F_{3y} = -6$, $F_{3z} = 5$, $x_P = 1$, $y_P = 2$, and $z_P = 3$. b) Find the total moment of the given forces about the origin $O(0,\, 0,\, 0)$. The units for the forces are in Newtons and for the coordinates are given in meters.

Problem 2.7

a) Determine the resultant of the three forces shown in Fig. P2.7. The force $\mathbf{F}_1$ acts along the x-axis, the force $\mathbf{F}_2$ acts along the z-axis, and the direction of the force $\mathbf{F}_3$ is given by the line O_3P_3, where $O_3 = O(x_{O_3},\, y_{O_3},\, z_{O_3})$ and $P_3 = P(x_{P_3},\, y_{P_3},\, z_{P_3})$. The application point of the forces $\mathbf{F}_1$ and $\mathbf{F}_2$ is the origin $O(0,\, 0,\, 0)$ of the reference frame as shown in Fig. P2.7. b) Find the total moment of the given forces about the point P_3. Numerical application: $|\mathbf{F}_1| = F_1 = 250$ N, $|\mathbf{F}_2| = F_2 = 300$ N, $|\mathbf{F}_3| = F_3 = 300$ N, $O_3 = O_3(1,\, 2,\, 3)$ and $P_3 = P_3(5,\, 7,\, 9)$. The coordinates are given in meters.

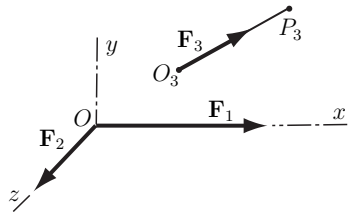

Figure P2.7: Problem 2.7

Problem 2.8

Replace the three forces $\mathbf{F}_1$, $\mathbf{F}_2$, and $\mathbf{F}_3$, shown in Fig. P2.8, by a resultant force, $\mathbf{R}$, through O and a couple. The force $\mathbf{F}_2$ acts along the x-axis, the force $\mathbf{F}_1$ is parallel to the y-axis, and the force $\mathbf{F}_3$ is parallel to the z-axis. The application point of the forces $\mathbf{F}_2$ is O, the application point of the forces $\mathbf{F}_1$ is B, and the application points of the force $\mathbf{F}_3$ is A. The distance between O and A is d_1 and the distance between A and B is d_2 as shown in Fig. P2.8. Numerical application: $|\mathbf{F}_1| = F_1 = 250$ N, $|\mathbf{F}_2| = F_2 = 300$ N, $|\mathbf{F}_3| = F_3 = 400$ N, $d_1 = 1.5$ m and $d_2 = 2$ m.

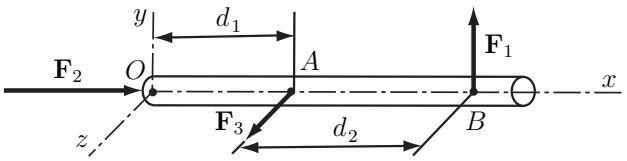

Figure P2.8: Problem P2.8

Problem 2.9

Determine the magnitude of the moments of the force **F** about the x, y, and z axes. Solve the problem a) using a Cartesian vector approach and b) using a scalar approach.

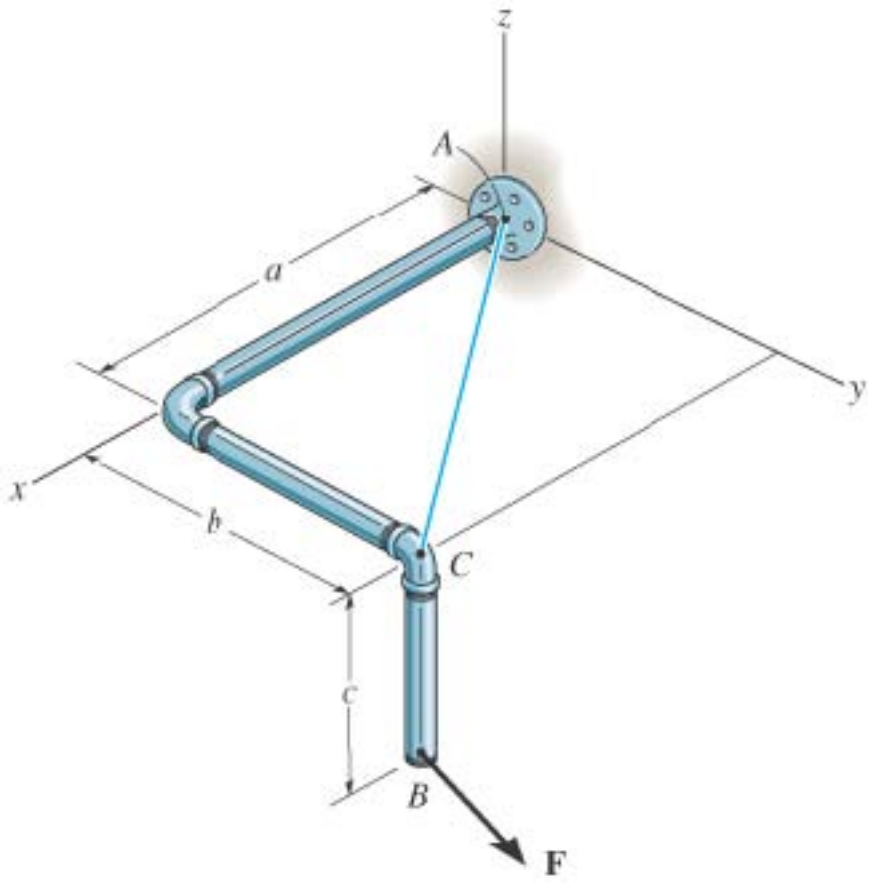

Figure P2.9: Problem 2.9

```
% input data
Fx = 4;  % lb
Fy = 12; % lb
Fz = -3; % lb
a = 4; % ft
b = 3; % ft
c = 2; % ft
```

Problem 2.10

Determine the moment of the force **F** about an axis extending between A and C. Express the result as a Cartesian vector.

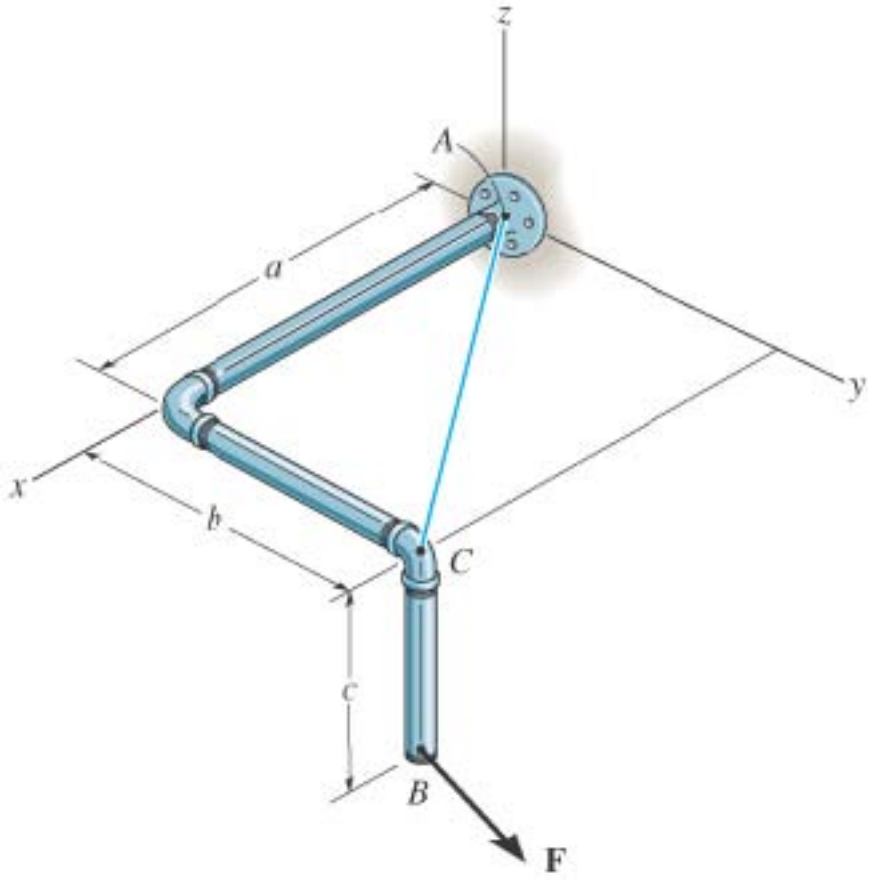

Figure P2.10: Problem 2.10

```
% input data
Fx = 4;  % lb
Fy = 12; % lb
Fz = -3; % lb
a = 4; % ft
b = 3; % ft
c = 2; % ft
```