Problem Set 1

Problem 1.1 Force Vector Resultant

The riveted brackets supports two forces. Determine the angle θ so that the resultant force is directed along the negative x-axis. What is the magnitude of the resultant force?

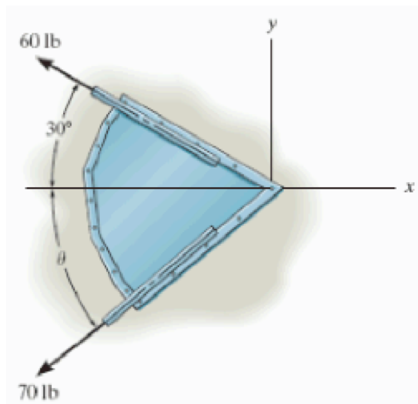

Figure P1.1: Problem 1.1

Problem 1.2 Force Magnitude Minimization

The boat is to be pulled onto the shore using two ropes. If the resultant force is to be 80 lbs. directed along the keel $a - a$ 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 minimum.

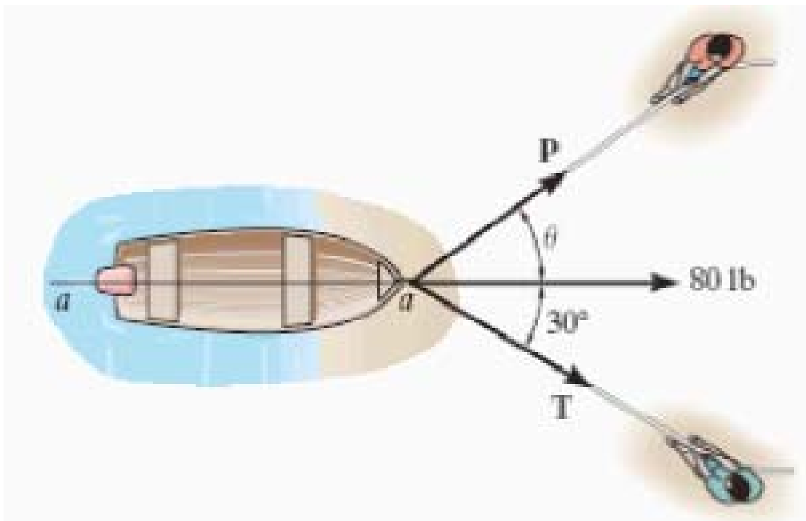

Figure P1.2: Problem 1.2

Problem 1.3 Force Vector Addition

Determine the magnitude of the resultant vector $\mathbf{F}_R = \mathbf{F}_1 + \mathbf{F}_2$ and its direction, measured counterclockwise from the positive x-axis.

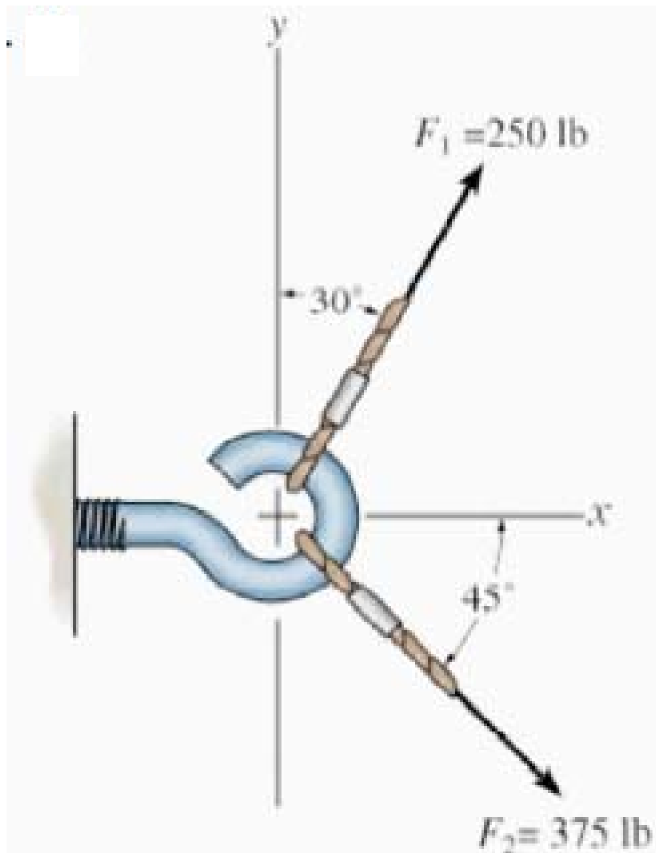

Figure P1.3: Problem 1.3

Problem 1.4 Addition of Coplanar Force Systems

Determine the magnitude of the resultant force and its direction, measured clockwise from the positive x-axis.

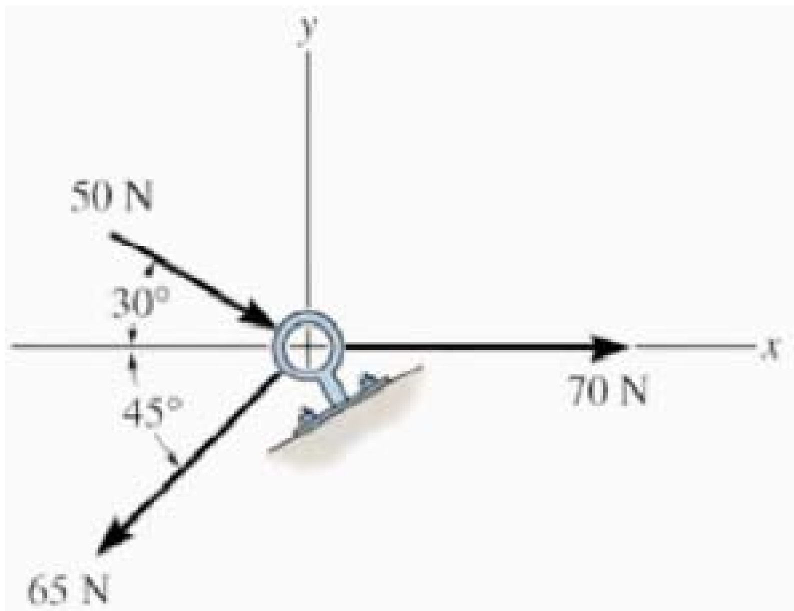

Figure P1.4: Problem 1.4

Problem 1.5 Force Resultant in 3-D

The beam is subjected to the two force shown. Express each force in Cartesian vector form and determine the magnitude and coordinate direction angles of the resultant force.

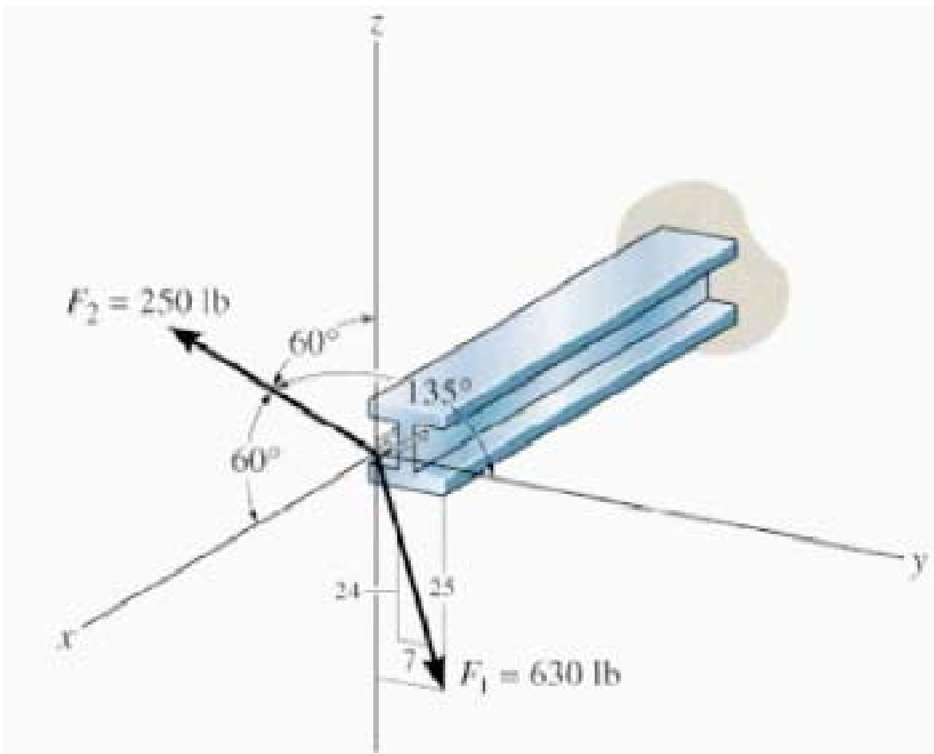

Figure P1.5: Problem 1.5

Problem 1.6 Force Vector Coordinate Angles

Determine the magnitude and coordinate direction angles of $\mathbf{F}_3$ so that the resultant of the three forces is zero.

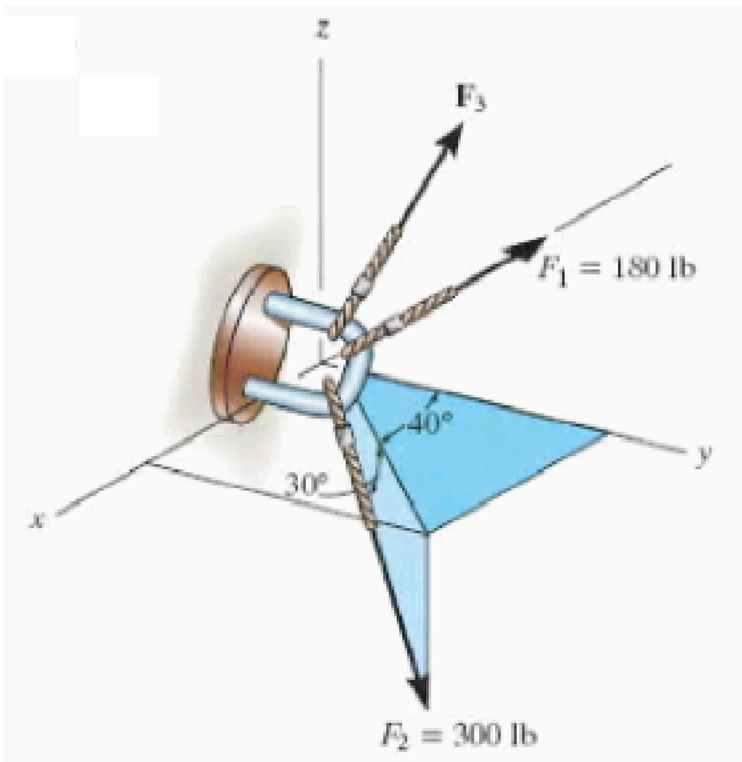

Figure P1.6: Problem 1.6

Problem 1.7 Force Directed Along a Line

The window is held open by the cable AB. Determine the length of the cable and express the 30 N force acting at A along the cable as a Cartesian vector.

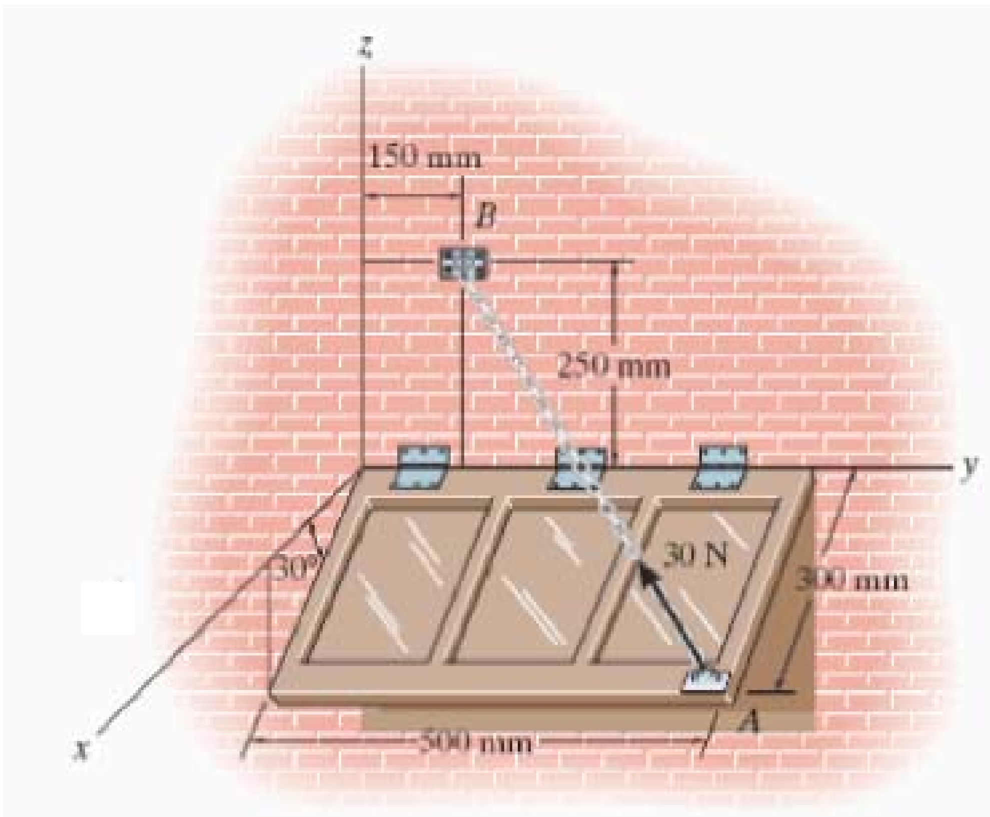

Figure P1.7: Problem 1.7

Problem 1.8 Force Directed Along a Structural Member

Determine the position (x, y, 0) for fixing cable BA so that the resultant of the forces exerted on the pole is directed along its axis, from B towards O, and has a magnitude of 1 kN. What is the magnitude of $\mathbf{F}_3$?

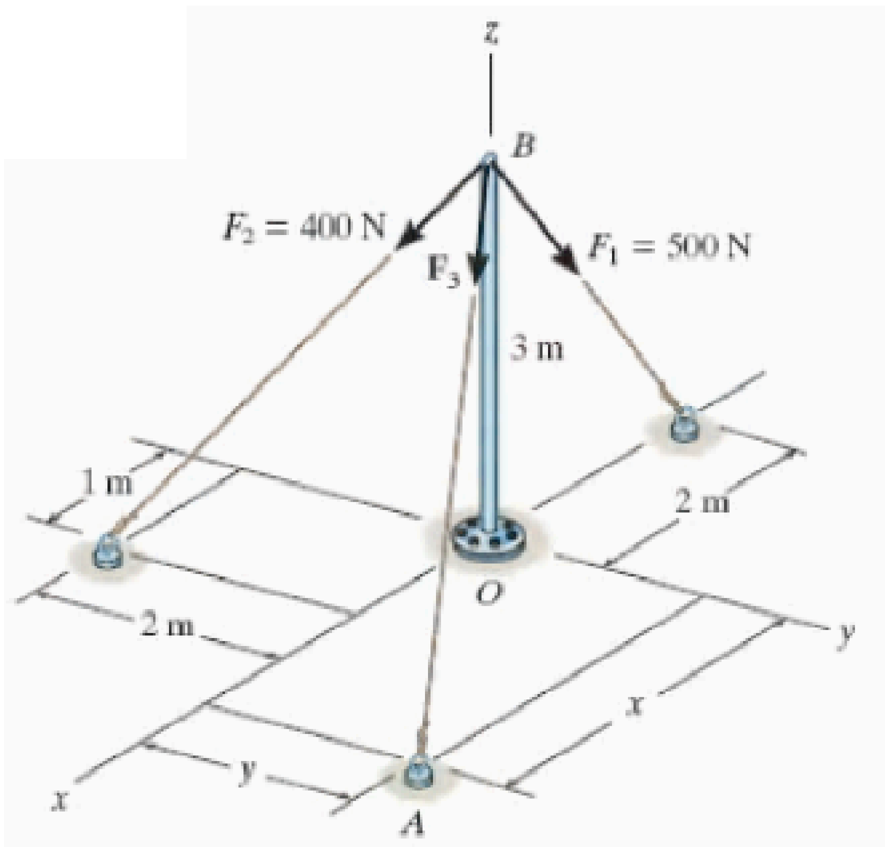

Figure P1.8: Problem 1.8

Problem 1.9 The cube in Fig. P1.9 has the sides equal to $l = 1$.
a) Find the direction cosines of the resultant $\mathbf{v} = \mathbf{v}_1 + \mathbf{v}_2 + \mathbf{v}_3 + \mathbf{v}_4$.
b) Determine the angle between the vectors $\mathbf{v}_2$ and $\mathbf{v}_3$.
c) Find the projection of the vector $\mathbf{v}_2$ on the vector $\mathbf{v}_4$.
d) Calculate $\mathbf{v}_2 \cdot \mathbf{v}_4$, $\mathbf{v}_2 \times \mathbf{v}_4$, $\mathbf{v}_1 \cdot (\mathbf{v}_2 \times \mathbf{v}_3)$, $(\mathbf{v}_2 \times \mathbf{v}_3) \times \mathbf{v}_4$, and $\mathbf{v}_2 \times (\mathbf{v}_3 \times \mathbf{v}_4)$.

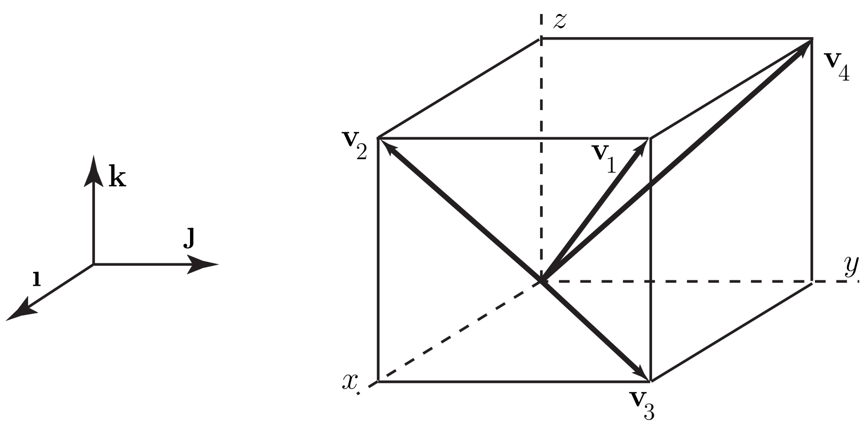

Figure P1.9: Problem 1.9

Solution

```
vector 1:
vector V=[ 1.000, 1.000, 1.000]
direction cosines=[ 0.577, 0.577, 0.577]

vector 2:
vector V=[ 1.000, 0.000, 1.000]
direction cosines=[ 0.707, 0.000, 0.707]

vector 3:
vector V=[ 1.000, 1.000, 0.000]
direction cosines=[ 0.707, 0.707, 0.000]

vector 4:
vector V=[ 0.000, 1.000, 1.000]
direction cosines=[ 0.000, 0.707, 0.707]
```

```
a)
R=V1+V2+V3+V4=[ 3.000, 3.000, 3.000]
|R|=   5.2
direction cosines=uR=R/|R|=[ 0.577, 0.577, 0.577]
b)
v2.v3 = |v2||v3| cos(phi23)
phi23 = 60 (deg)
c)
projection of v2 on v4 = v2.(v4/|v4|)
pr of v2 on v4 =  0.707
d)
v2.v4 = 1
v2 x v4 = [-1,-1,1]
v1.(v2 x v3) = 1
(v2 x v3) x v4 = [0,1,-1]
v2 x (v3 x v4) = [1,0,-1]
```

Problem 1.10 Figure P1.10 represents the vectors $\mathbf{v}_1$, $\mathbf{v}_2$, $\mathbf{v}_3$, and $\mathbf{v}_4$ acting on a cube with the side $l = 2$. The magnitude of the forces are $v_1 = V = 2$ and $v_2 = v_3 = v_4 = 2\,V$.

a) Find the resultant and the direction cosines of the resultant $\mathbf{v} = \mathbf{v}_1 + \mathbf{v}_2 + \mathbf{v}_3 + \mathbf{v}_4$.

b) Determine the angle between the vectors $\mathbf{v}_1$ and $\mathbf{v}_3$.

c) Find the projection of the vector $\mathbf{v}_4$ on the resultant vector $\mathbf{v}$.

d) Calculate $\mathbf{v}_2 \cdot \mathbf{v}$, $\mathbf{v}_1 \times \mathbf{v}_2$, and $\mathbf{v}_2 \times \mathbf{v}_4$.

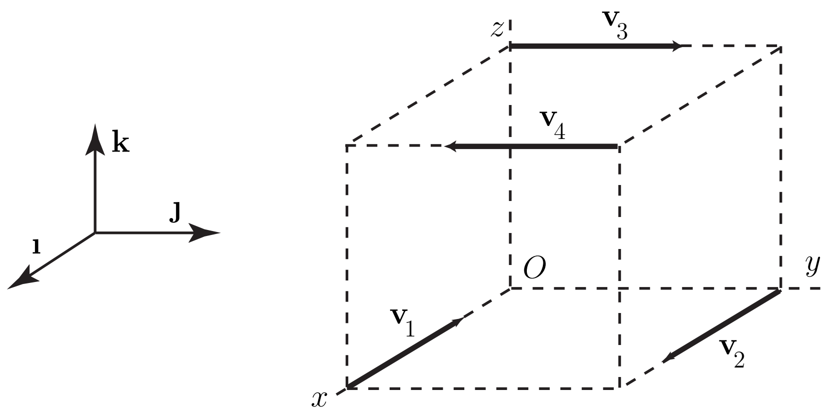

Figure P1.10: Problem 1.10

Solution

```
clear all; clc; close all
V = 2;
v1 = [-V 0 0];
v2 = [2*V 0 0];
v3 = [0 2*V 0];
v4 = [0 -2*V 0];

fprintf('a)\n')
v = v1+v2+v3+v4;
modv = norm(v);
fprintf('v=v1+v2+v3+v4=[%g,%g,%g]\n',v)
fprintf('|v|=%g\n',modv)
uv = v/modv;
fprintf('direction cosines=')
```

```
fprintf('uv=v/|v|=[%g,%g,%g]\n',uv)

fprintf('b)\n')
c13 = dot(v1,v3)/(norm(v1)*norm(v3));
phi13= acosd(c13);
fprintf('v1.v3 = |v1||v3| cos(phi13) \n')
fprintf('phi13 = %g (deg)\n',phi13)

fprintf('c)\n')
fprintf('projection of v4 on v = v4.(v/|v|)\n')
prv4v = dot(v4, uv);
fprintf('pr of v4 on v = %g \n',prv4v)

fprintf('d)\n')
fprintf('v2.v = %g \n',dot(v2,v))
fprintf('v1 x v2 = [%g,%g,%d] \n',cross(v1,v2))
fprintf('v2 x v4 = [%g,%g,%g] \n',cross(v2,v4))
```

```
a)
v=v1+v2+v3+v4=[2,0,0]
|v|=2
direction cosines=uv=v/|v|=[1,0,0]
b)
v1.v3 = |v1||v3| cos(phi13)
phi13 = 90 (deg)
c)
projection of v4 on v = v4.(v/|v|)
pr of v4 on v = 0
d)
v2.v = 8
v1 x v2 = [0,0,0]
v2 x v4 = [0,0,-16]
```