Zarema Balgabekova

1-14

Given:

$\rho = 5.26 \frac{slug}{ft^3}$

ρ in SI units - ?

Solution:

$1 slug = 14.59 kg \qquad 1 ft = 0.3048 m$

$$\rho = 5.26 \frac{slug}{ft^3} = 5.26 \frac{slug}{ft^3} \left(\frac{14.59 kg}{1 slug}\right)\left(\frac{(1 ft)^3}{(0.3048 m)^3}\right)$$

$$= 2710 \frac{kg}{m^3}$$

<u>Answer</u>: $\rho = 2710 \frac{kg}{m^3}$

1-16

Given:

$m_1 = 8 kg$

$m_2 = 12 kg$

$r = 800 mm = 0.8 m$

F_g - ?

W_1, W_2 - ?

Solution:

$$F_g = G \frac{m_1 m_2}{r^2} = \frac{66.73 \cdot 10^{-12} \cdot 8 \cdot 12}{(0.8)^2} = 10^4 \cdot 10^{-12} =$$

$$10^{-8} N = 10.0 nN$$

$$W_1 = m_1 g = 8 \cdot 9.81 = 78.5 N$$

$$W_2 = m_2 g = 12 \cdot 9.81 = 118 N$$

Therefore, F_g is much smaller than W_1 and W_2

<u>Answer</u>: $F_g = 10.0 nN$

$F_g << W_1 = 78.5 N$

$F_g << W_2 = 118 N$

2-14.

Given:

$F_{hor} = 400$ lb

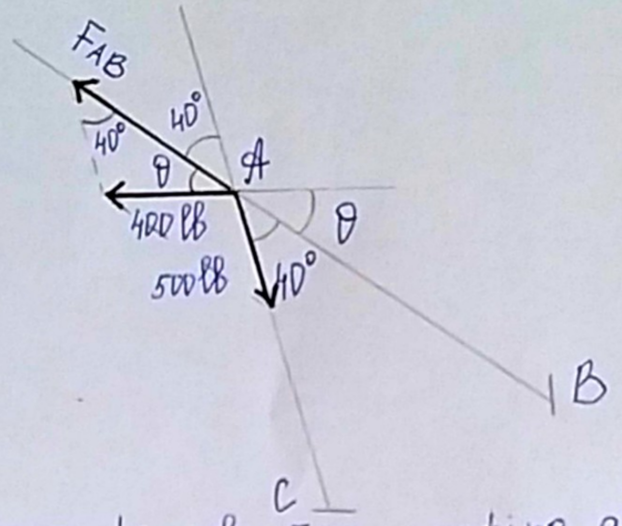
$F_{AC} = 500$ lb

$\varphi = 40°$

θ - ? $(0° \leq \theta \leq 90°)$

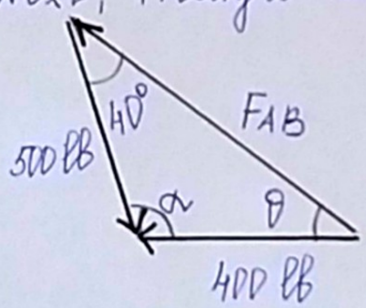
F_{AB} - ?

Solution:



The components of Fhor acting along AC and AB were obtained using Parallelogram law

Next, Triangle law can be used



Sine law:

$$\frac{500}{\sin\theta} = \frac{400}{\sin 40°} = \frac{F_{AB}}{\sin\alpha}$$

$$\theta = \sin^{-1}\left(\frac{500 \cdot \sin 40°}{400}\right) = 53.5°$$

$$\alpha = 180° - (40° + 53.5°) = 86.5°$$

$$F_{AB} = \frac{400 \sin 86.5°}{\sin 40°} = 621 \text{ lb} = 621 \cancel{\text{lb}} \left(\frac{4.448 \text{ N}}{1 \cancel{\text{lb}}}\right)$$

$$= 2762 \text{ N} = 2.76 \text{ kN}$$

Answer: $\theta = 53.5°$

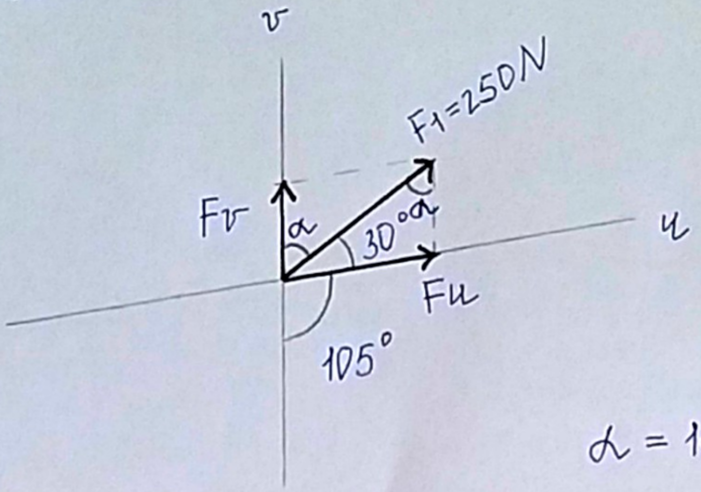
$F_{AB} = 621$ lb $= 2.76$ kN

2-16 Given:

$F_1 = 250\ N$

F_u, F_v - ?

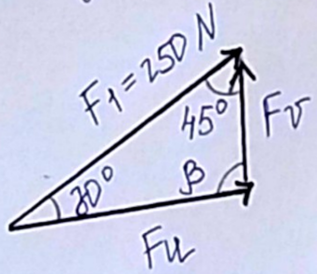
Solution:



$\alpha = 180° - (30° + 105°) = 45°$

F_1 was resolved into components F_v and F_u using Parallelogram law.

Triangle Rule:



Sine law:

$$\frac{250}{\sin\beta} = \frac{F_u}{\sin 45°} = \frac{F_v}{\sin 30°}$$

$$\beta = 180° - (30° + 45°) = 105°$$

$$F_u = \frac{250 \cdot \sin 45°}{\sin 105°} = 183\ N$$

$$F_v = \frac{250 \cdot \sin 30°}{\sin 105°} = 129\ N$$

Answer: $F_u = 183\ N$

$F_v = 129\ N$

2-31

Given.

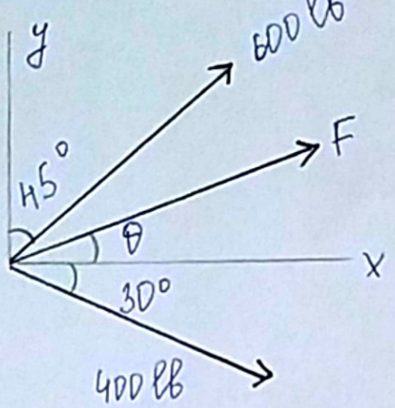
$F_R = 900$ lb

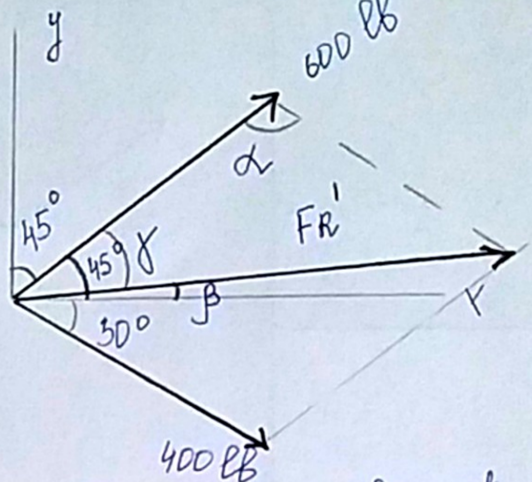
$F = F_{min}$

θ - ?

F - ?

Solution:

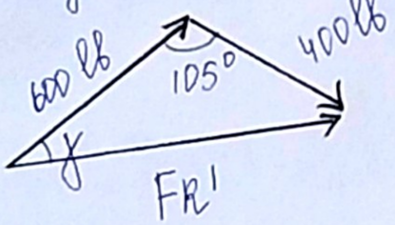




Resultant force of two known forces was found using Parallelogram law

$\alpha = 180° - (45° + 30°) = 105°$

Triangle Rule.



Cosine law:

$F_R' = \sqrt{600^2 + 400^2 - 2\,600\,400\cos 105°} =$

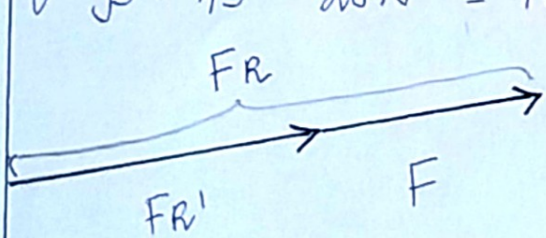
803 lb

$F = F_{min}$, therefore, F acts along the same line as F_R' and $\theta = \beta$

Sine law: $\dfrac{400}{\sin\gamma} = \dfrac{803}{\sin 105°}$ $\gamma = \sin^{-1}\left(\dfrac{400 \sin 105°}{803}\right) =$

$28.8°$

$\theta = \beta = 45° - 28.8° = 16.2°$



$F_R = F_R' + F$

$F = F_R - F_R' = 900 - 803 =$

97 lb $= 431$ N

Answer: $\theta = 16.2°$

$F = 97$ lb $= 431$ N

2-46

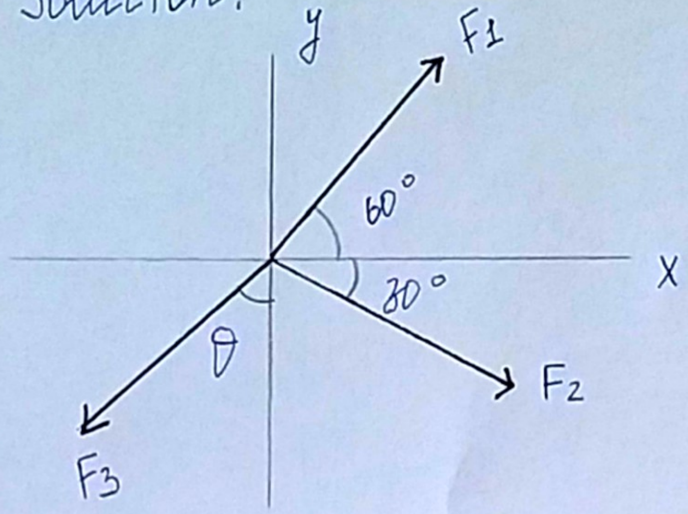
Given:

$F_R = 0$

$F_2 = \frac{2}{3} F_1$

$F_3 - ?$

Solution:



$$F_{Rx} = \sum F_x = 0$$

$$F_1 \cos 60° + F_2 \cos 30° - F_3 \sin\theta = 0$$

$$\frac{F_1}{2} + \left(\frac{\cancel{2}}{3} F_1\right) \cdot \frac{\sqrt{3}}{\cancel{2}} = F_3 \sin\theta$$

$$1.077 F_1 = F_3 \sin\theta \qquad [1]$$

$$F_{Ry} = \sum F_y = 0$$

$$F_1 \sin 60° - F_2 \sin 30° - F_3 \cos\theta = 0$$

$$\frac{\sqrt{3}}{2} F_1 - \left(\frac{\cancel{2}}{3} F_1\right) \frac{1}{\cancel{2}} = F_3 \cos\theta$$

$$0.5327 F_1 = F_3 \cos\theta \qquad [2]$$

[1] : [2] $\qquad \tan\theta = 2.02$

$$\theta = \tan^{-1}(2.02) = 63.7°$$

[1] $\qquad F_3 = \dfrac{1.077 F_1}{\sin 63.7°} = 1.2 F_1$

__Answer__. $F_3 = 1.2 F_1$

2-57

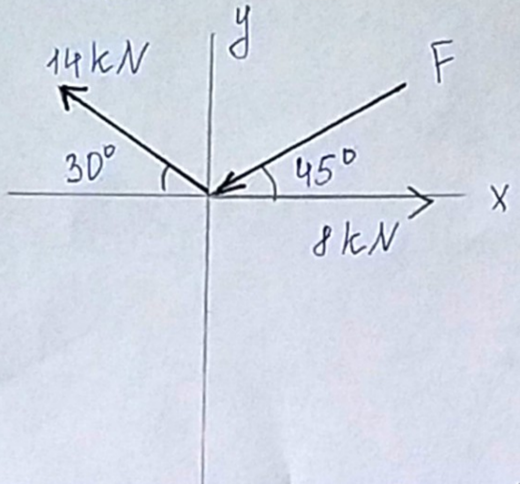
Given.

F_R as small as possible

F - ?

F_R - ?

Solution:



$$F_{Rx} = \sum F_x = 8 - F\cos45° - 14\cos30° =$$

$$-4.124 - F\cos45°$$

$$F_{Ry} = \sum F_y = 14\sin30° - F\sin45° = 7 - F\sin45°$$

$$F_R^2 = F_{Rx}^2 + F_{Ry}^2 = (-4.124 - F\cos45°)^2 + (7 - F\sin45°)^2$$

F_R is the smallest when $\frac{dF_R}{dF} = 0$

$$2F_R\frac{dF_R}{dF} = 2(-4.124 - F\cos45°)(-\cos45°) + 2(7 - F\sin45°)(-\sin45°) = 0$$

$$5.83 + F - 9.90 + F = 0$$

$$2F = 4.07$$

$$F = 2.04 \text{ kN}$$

$$F_R = \sqrt{(-4.124 - 2.04\cos45°)^2 + (7 - 2.04\sin45°)^2} = 7.87 \text{ kN}$$

Answer: $F = 2.04$ kN

$F_R = 7.87$ kN

2-71

Given

$\alpha = 120°$

$\beta < 90°$

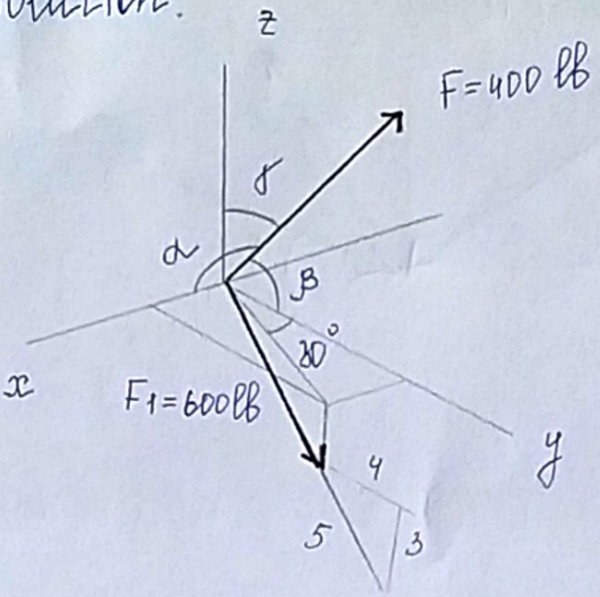
$\gamma = 60°$

$F = 400$ lb

F_R - ?

$\alpha_R, \beta_R, \gamma_R$ - ?

Solution:



$$\cos^2\alpha + \cos^2\beta + \cos^2\gamma = 1$$

$$\cos\beta = \pm\sqrt{1-\cos^2 120° - \cos^2 60°}$$

$$\cos\beta = \pm\frac{\sqrt{2}}{2}$$

$$\beta = 45° \quad (\beta < 90°)$$

$$\vec{F} = 400\cos 120°\,\hat{i} + 400\cos 45°\,\hat{j} + 400\cos 60°\,\hat{k} =$$

$$\{-200\hat{i} + 283\hat{j} + 200\hat{k}\} \text{ lb}$$

$$\vec{F_1} = 600\cdot\frac{4}{5}\sin 30°\,\hat{i} + 600\,\frac{4}{5}\cos 30°\,\hat{j} - 600\,\frac{3}{5}\,\hat{k} =$$

$$\{240\hat{i} + 416\hat{j} - 360\hat{k}\} \text{ lb}$$

$$\vec{F_R} = \vec{F_1} + \vec{F} = \{40\hat{i} + 699\hat{j} - 160\hat{k}\} \text{ lb}$$

$$F_R = \sqrt{40^2 + 699^2 + (-160)^2} = 718 \text{ lb} = 718 \cancel{\text{lb}}\left(\frac{4.448 N}{1 \cancel{\text{lb}}}\right) =$$

$$3194 N = 3.19 kN$$

$\cos\alpha_R = \frac{40}{718}$ $\quad \alpha_R = 86.8°$

$\cos\beta_R = \frac{699}{718}$ $\quad \beta_R = 13.2°$

$\cos\gamma_R = -\frac{160}{718}$ $\quad \gamma_R = 103°$

Answer: $F_R = 718$ lb $= 3.19$ kN; $\alpha_R = 86.8°$, $\beta_R = 13.2°$, $\gamma_R = 103°$

2-80

Given:

$F_3 = 9\ kN$

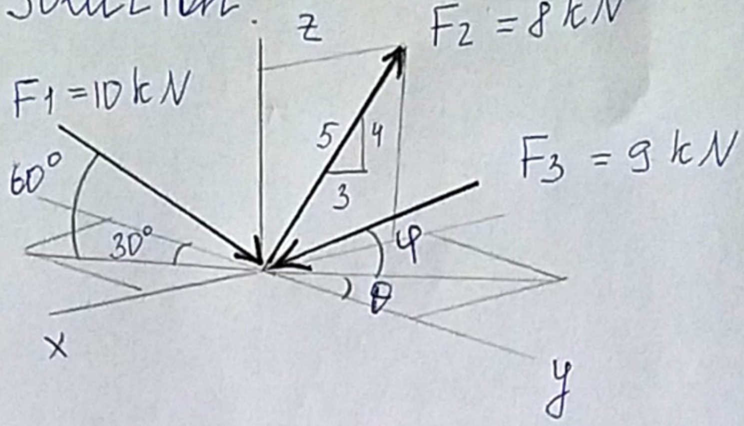
$\theta = 30^\circ$

$\varphi = 45^\circ$

$F_R - ?$

$\alpha_R, \beta_R, \gamma_R - ?$

Solution:



$$\vec{F_1} = -10\cos60^\circ\sin30^\circ\hat{i} + 10\cos60^\circ\cos30^\circ\hat{j} - 10\cdot\sin60^\circ\hat{k}$$

$$= \{-2.50\hat{i} + 4.33\hat{j} - 8.66\hat{k}\}\ kN$$

$$\vec{F_2} = -8\ \frac{3}{5}\hat{i} + 8\ \frac{4}{5}\hat{k} = \{-4.8\hat{i} + 6.4\hat{k}\}\ kN$$

$$\vec{F_3} = 9\cos45^\circ\sin30^\circ\hat{i} - 9\cos45^\circ\cos30^\circ\hat{j} - 9\cdot\sin45^\circ\hat{k}$$

$$= \{3.18\hat{i} - 5.51\hat{j} - 6.36\hat{k}\}\ kN$$

$$\vec{F_R} = \vec{F_1} + \vec{F_2} + \vec{F_3} = \{-4.12\hat{i} - 1.18\hat{j} - 8.62\hat{k}\}\ kN$$

$$F_R = \sqrt{(-4.12)^2 + (-1.18)^2 + (-8.62)^2} = 9.63\ kN$$

$$\cos\alpha_R = \frac{-4.12}{9.63} \qquad \alpha_R = 115^\circ$$

$$\cos\beta_R = \frac{-1.18}{9.63} \qquad \beta_R = 97^\circ$$

$$\cos\gamma_R = \frac{-8.62}{9.63} \qquad \gamma_R = 154^\circ$$

Answer. $F_R = 9.63\ kN$

$\alpha_R = 115^\circ,\ \beta_R = 97^\circ,\ \gamma_R = 154^\circ$

2-104.

Given:

$F_B = 520 N$

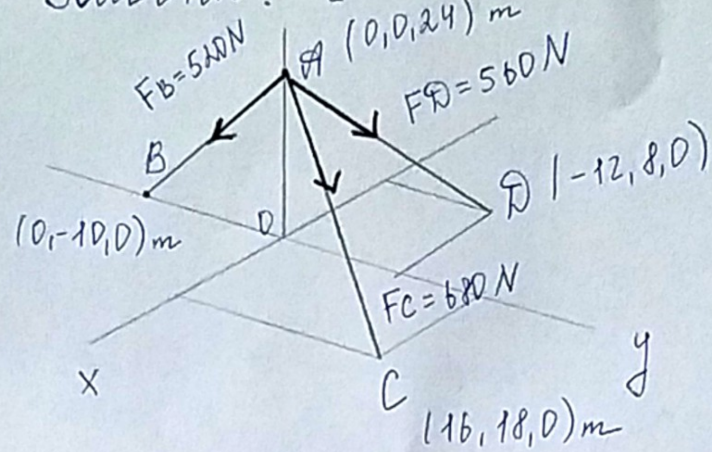
$F_C = 680 N$

$F_D = 560 N$

F_R - ?

$\alpha_R, \beta_R, \gamma_R$ - ?

Solution:



$\vec{r}_{AB} = r_B - r_A = \{-10\hat{j} - 24\hat{k}\}$ m

$r_{AB} = \sqrt{(-10)^2 + (-24)^2} = 26$ m

$\hat{u}_{AB} = \frac{\vec{r}_{AB}}{r_{AB}} = \frac{-10\hat{j} - 24\hat{k}}{26} = -0.385\hat{j} - 0.923\hat{k}$

$\vec{F}_B = F_B \hat{u}_{AB} = 520(-0.385\hat{j} - 0.923\hat{k}) =$

$\{-200\hat{j} - 480\hat{k}\}$ N

$\vec{r}_{AC} = r_C - r_A = \{16\hat{i} + 18\hat{j} - 24\hat{k}\}$ m

$r_{AC} = \sqrt{16^2 + 18^2 + (-24)^2} = 34$ m

$\hat{u}_{AC} = \frac{\vec{r}_{AC}}{r_{AC}} = \frac{16\hat{i} + 18\hat{j} - 24\hat{k}}{34} = 0.471\hat{i} + 0.529\hat{j} - 0.706\hat{k}$

$\vec{F}_C = F_C \hat{u}_{AC} = 680(0.471\hat{i} + 0.529\hat{j} - 0.706\hat{k}) =$

$\{320\hat{i} + 360\hat{j} - 480\hat{k}\}$ N

$$\vec{r}_{AD} = r_D - r_A = \{-12\hat{i} + 8\hat{j} - 24\hat{k}\} m$$

$$r_{AD} = \sqrt{(-12)^2 + 8^2 + (-24)^2} = 28 m$$

$$\hat{u}_{AD} = \frac{\vec{r}_{AD}}{r_{AD}} = \frac{-12\hat{i} + 8\hat{j} - 24\hat{k}}{28} = -0.428\hat{i} + 0.286\hat{j} - 0.857\hat{k}$$

$$\vec{F}_D = F_D \hat{u}_{AD} = 560(-0.428\hat{i} + 0.286\hat{j} - 0.857\hat{k}) =$$

$$\{-240\hat{i} + 160\hat{j} - 480\hat{k}\} N$$

$$\vec{F}_R = \vec{F}_B + \vec{F}_C + \vec{F}_D = \{80\hat{i} + 320\hat{j} - 1440\hat{k}\} N$$

$$F_R = \sqrt{80^2 + 320^2 + (-1440)^2} = 1477 N$$

$$\cos\alpha_R = \frac{80}{1477} \qquad \alpha_R = 86.9^\circ$$

$$\cos\beta_R = \frac{320}{1477} \qquad \beta_R = 77.5^\circ$$

$$\cos\gamma_R = -\frac{1440}{1477} \qquad \gamma_R = 167^\circ$$

Answer: $F_R = 1477 N$

$\alpha_R = 86.9^\circ$, $\beta_R = 77.5^\circ$, $\gamma_R = 167^\circ$

2-115

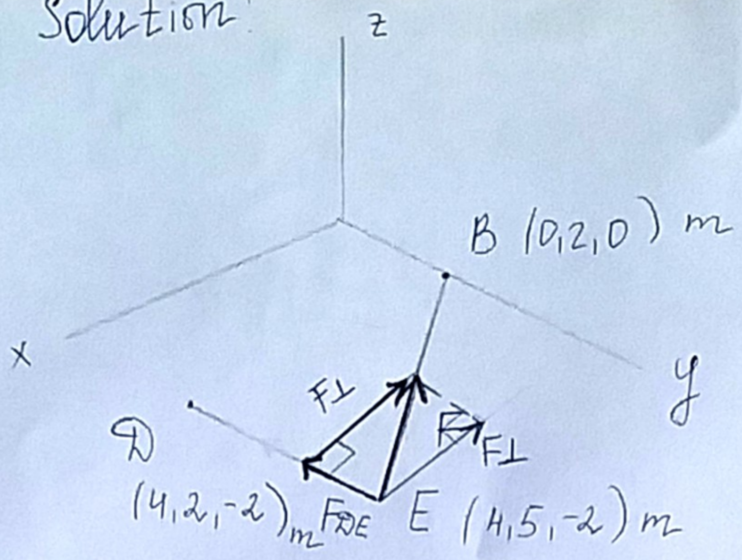
Given

$F = 600\,N$

F_{DE} - ?

$F_\perp$ - ?

Solution:



$$\vec{r}_{EB} = r_B - r_E = \{-4\hat{i} - 3\hat{j} + 2\hat{k}\}\,m$$

$$r_{EB} = \sqrt{(-4)^2 + (-3)^2 + 2^2} = 5.38\,m$$

$$\hat{u}_{EB} = \frac{\vec{r}_{EB}}{r_{EB}} = \frac{-4\hat{i} - 3\hat{j} + 2\hat{k}}{5.38} = -0.743\hat{i} - 0.558\hat{j} + 0.372\hat{k}$$

$$\vec{F} = \vec{F}_{EB} = F\hat{u}_{EB} = 600(-0.743\hat{i} - 0.558\hat{j} + 0.372\hat{k}) =$$

$$\{-446\hat{i} - 335\hat{j} + 223\hat{k}\}\,N$$

$$\vec{r}_{ED} = r_D - r_E = \{-3\hat{j}\}\,m$$

$$\hat{u}_{ED} = \frac{\vec{r}_{ED}}{r_{ED}} = \frac{-3\hat{j}}{3} = -\hat{j}$$

$$F_{DE} = \vec{F} \cdot \hat{u}_{ED} = (-446\hat{i} - 335\hat{j} + 223\hat{k}) \cdot (-\hat{j})$$

$$= 335\,N$$

Pythagorean theorem: $F_\perp = \sqrt{F^2 - F_{DE}^2} = \sqrt{600^2 - 335^2} = 498\,N$

Answer $F_{DE} = 335\,N$, $F_\perp = 498\,N$

2-116

Given.

$F_1 = 600\,N$

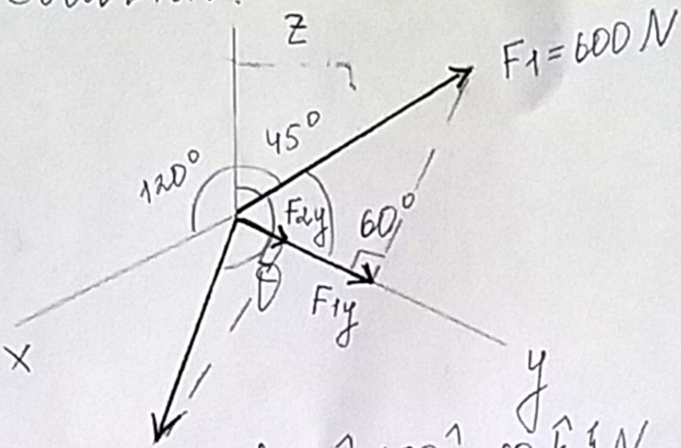
$\vec{F}_2 = \{120\hat{i} + 90\hat{j} - 80\hat{k}\}\,N$

θ - ?

F_{1y} - ?

F_{2y} - ?

Solution:



$$\vec{F}_1 = 600\cos 120^\circ\hat{i} + 600\cos 60^\circ\hat{j} + 600\cos 45^\circ\hat{k} =$$

$$\{-300\hat{i} + 300\hat{j} + 424\hat{k}\}\,N$$

$$F_2 = \sqrt{120^2 + 90^2 + (-80)^2} = 170\,N$$

$$\theta = \cos^{-1}\left(\frac{\vec{F}_1 \cdot F_2}{F_1 F_2}\right) = \cos^{-1}\left(\frac{-300\,120 + 300\,90 + 424(-80)}{600\cdot 170}\right)$$

$$= \cos^{-1}\left(\frac{-42920}{102000}\right) = 115^\circ$$

$$F_{1y} = \vec{F}_1 \cdot \hat{u}_y = (-300\hat{i} + 300\hat{j} + 424\hat{k})\cdot(\hat{j}) =$$

$$300\,N$$

$$F_{2y} = \vec{F}_2 \cdot \hat{u}_y = (120\hat{i} + 90\hat{j} - 80\hat{k})\cdot(\hat{j}) =$$

$$90\,N$$

Answer. $\theta = 115^\circ$

$F_{1y} = 300\,N$, $F_{2y} = 90\,N$

3-13

Given:

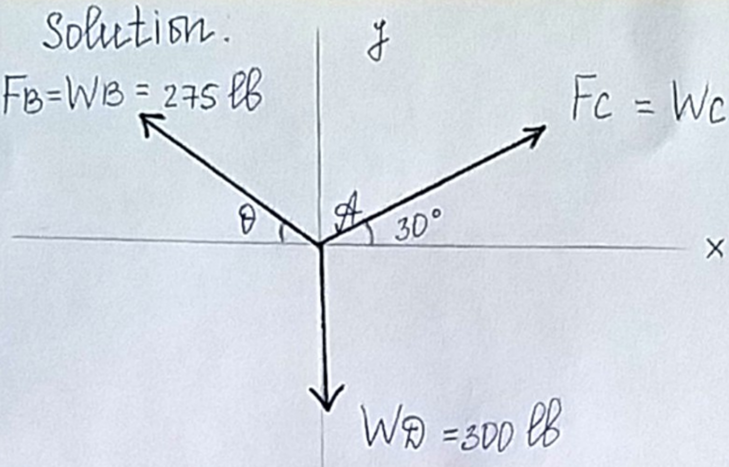
$W_D = 300$ lb

$W_B = 275$ lb

W_C - ?

θ - ?

Solution:



$\Sigma F_x = 0$ $\quad W_C \cos 30^\circ - W_B \cos\theta = 0$

$$W_C \cos 30^\circ = W_B \cos\theta$$

$$W_C = \frac{275 \cos\theta}{\cos 30^\circ} \text{ lb}$$

$\Sigma F_y = 0$ $\quad W_C \sin 30^\circ + W_B \sin\theta - W_D = 0$

$$W_C \sin 30^\circ + 275 \sin\theta = 300$$

$$\left(\frac{275 \cos\theta}{\cos 30^\circ}\right) \sin 30^\circ + 275 \sin\theta = 300$$

$$\frac{\cos\theta \sin 30^\circ}{\cos 30^\circ} + \sin\theta = \frac{12}{11}$$

$$\sin 30^\circ \cos\theta + \sin\theta \cdot \cos 30^\circ = \frac{12}{11} \cdot \cos 30^\circ$$

$$\sin(30^\circ + \theta) = \frac{6\sqrt{3}}{11}$$

$$30^\circ + \theta = \sin^{-1}\left(\frac{6\sqrt{3}}{11}\right)$$

$$30^\circ + \theta = 70.9^\circ$$

$$\theta = 40.9^\circ$$

$$W_C = \frac{275 \cos 40.9^\circ}{\cos 30^\circ} = 240 \text{ lb} = 1 \text{ kN}$$

Answer: $W_C = 240$ lb $= 1$ kN

$\theta = 40.9^\circ$

3-28

Given

$m_A = m_B = m$

$F_{el} = 20\,mN = 0.02\,N$

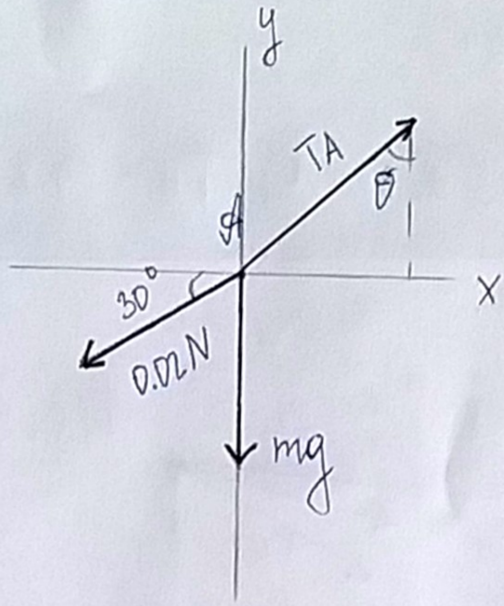
θ - ?

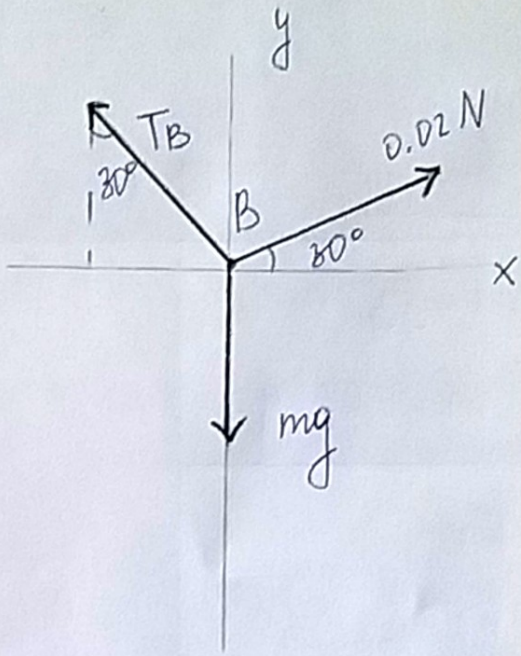
T_A - ?

T_B - ?

m - ?

Solution:





A. $\Sigma F_x = 0 \quad T_A \sin\theta - 0.02\cos 30° = 0$

$T_A \sin\theta = 0.0173 \qquad [1]$

$\Sigma F_y = 0 \quad T_A \cos\theta - 0.02 \sin 30° - mg = 0$

$T_A \cos\theta = mg + 0.01 \qquad [2]$

B: $\Sigma F_x = 0 \quad 0.02\cos 30° - T_B \sin 30° = 0$

$$T_B = \frac{0.02\cos 30°}{\sin 30°} = 0.0346\,N = 34.6\,mN$$

ΣF_y: $0.02\sin 30° + T_B \cos 30° - mg = 0$

$$m = \frac{0.02\sin 30° + 0.0346 \cdot \cos 30°}{9.81} = 4 \cdot 10^{-3}\,kg = 4g$$

[2] $\quad T_A \cos\theta = 4 \cdot 10^{-3}\, 9.81 + 0.01 = 0.0492$

[1]:[2] $\quad \tan\theta = \dfrac{0.0173}{0.0492} = \dfrac{173}{492} \qquad \theta = 19.4°$

[1] $T_A = \dfrac{0.0173}{\sin 19{,}4^\circ} = 0.0521\,N = 52.1\,mN$

<u>Answer</u>: $\theta = 19.4^\circ$, $T_A = 52.1\,mN$, $T_B = 34.6\,mN$, $m = 4g$

3-53 Given:

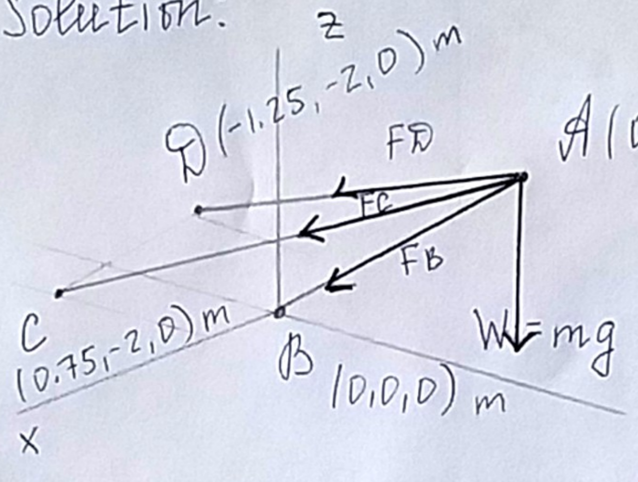
$m = 500\,kg$

$F_B - ?$

$F_C - ?$

$F_D - ?$

Solution:



$W = mg = 500 \cdot 9.81 = 4905\,N$

$$\vec{F_B} = F_B \hat{u}_{AB} = F_B \frac{\vec{r}_{AB}}{r_{AB}} = F_B \frac{-3\hat{j} - 2.5\hat{k}}{\sqrt{(-3)^2 + (-2.5)^2}} =$$

$$F_B(-0.768\hat{j} - 0.640\hat{k}) =$$

$$\{-0.768 F_B \hat{j} - 0.640 F_B \hat{k}\}\ N$$

$$\vec{F_C} = F_C \hat{u}_{AC} = F_C \frac{\vec{r}_{AC}}{r_{AC}} = F_C \frac{0.75\hat{i} - 5\hat{j} - 2.5\hat{k}}{\sqrt{0.75^2 + (-5)^2 + (-2.5)^2}} =$$

$$F_C(0.133\hat{i} - 0.886\hat{j} - 0.443\hat{k}) =$$

$$\{0.133 F_C \hat{i} - 0.886 F_C \hat{j} - 0.443 F_C \hat{k}\}\ N$$

$$\vec{F_D} = F_D \hat{u}_{AD} = F_D \frac{\vec{r}_{AD}}{r_{AD}} = F_D \frac{-1.25\hat{i} - 5\hat{j} - 2.5\hat{k}}{\sqrt{(-1.25)^2 + (-5)^2 + (-2.5)^2}} =$$

$$F_D(-0.218\hat{i} - 0.873\hat{j} - 0.436\hat{k}) =$$

$$\{-0.218 F_D \hat{i} - 0.873 F_D \hat{j} - 0.436 F_D \hat{k}\}\ N$$

$$W = -4905\hat{k}\ N$$

$$\sum \vec{F} = 0 \qquad \vec{F_B} + \vec{F_C} + \vec{F_D} + \vec{W} = 0$$

$$(-0.768 F_B \hat{j} - 0.640 F_B \hat{k}) + (0.133 F_C \hat{i} - 0.886 F_C \hat{j} - 0.443 F_C \hat{k}) +$$

$$(-0.218 F_D \hat{i} - 0.873 F_D \hat{j} - 0.436 F_D \hat{k}) + (-4905 \hat{k}) = 0$$

$$\sum F_x = 0 \qquad 0.133 F_C - 0.218 F_D = 0$$

$$F_C = 1.64 F_D \qquad [1]$$

$$\sum F_y = 0 \qquad -0.768 F_B - 0.886 F_C - 0.873 F_D = 0$$

$$F_B = \frac{-0.886(1.64 F_D) - 0.873 F_D}{0.768} = -3.03 F_D \qquad [2]$$

$$\sum F_z = 0 \qquad -0.640 F_B - 0.443 F_C - 0.436 F_D - 4905 = 0$$

$$0.640(-3.03 F_D) + 0.443(1.64 F_D) + 0.436 F_D = -4905$$

$$-0.777 F_D = -4905$$

$$F_D = 6313\,N = 6.31\,kN$$

$$[1] \qquad F_C = 1.64 \cdot 6313 = 10353\,N = 10.4\,kN$$

$$[2] \qquad F_B = -3.03 \cdot 6313 = -19128\,N = -19.1\,kN$$

(the direction of F_B have to be from B to A)

<u>Answer</u>: $F_B = 19.1\,kN$, $F_C = 10.4\,kN$, $F_D = 6.31\,kN$

3-63

Given:

$T_{AB\,max} = T_{AC\,max} = 500\ lb$

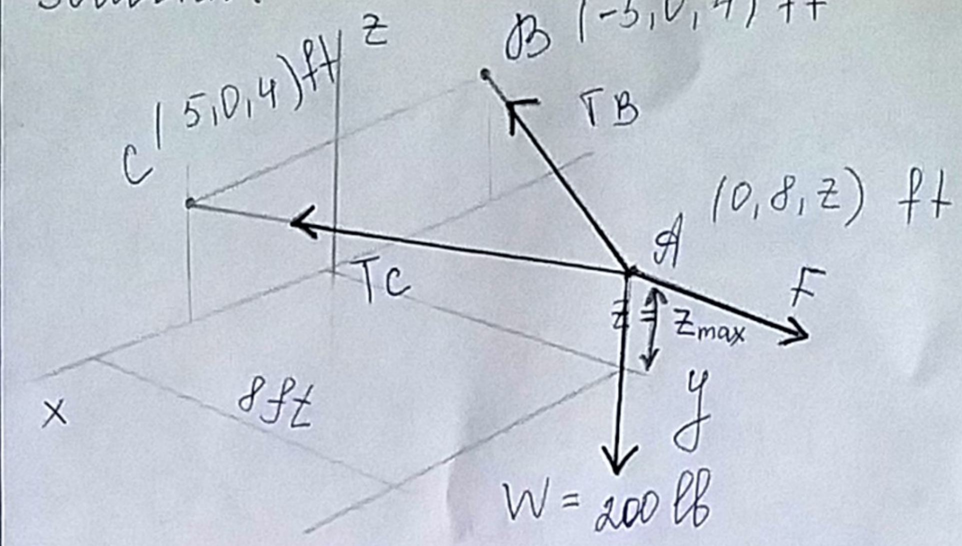
$W = 200\ lb$

$y = 8\ ft$

z_{max} - ?

F - ?

Solution:



$$\vec{W} = -200\hat{k}\ lb$$

$$\vec{F} = F\hat{j}$$

Due to symmetry, T_{AB} and T_{AC} are the same

$$\vec{T}_{AB\,max} = 500\hat{u}_{AB} = 500\frac{\vec{r}_{AB}}{r_{AB}} = 500\frac{-5\hat{i} - 8\hat{j} + (4-z)k}{\sqrt{(-5)^2 + (-8)^2 + (4-z)^2}}$$

$$= 500\left(\frac{-5\hat{i} - 8\hat{j} + (4-z)\hat{k}}{\sqrt{89 + (4-z)^2}}\right)$$

$$\vec{T}_{AC\,max} = 500\hat{u}_{AC} = 500\frac{\vec{r}_{AC}}{r_{AC}} = 500\frac{5\hat{i} - 8\hat{j} + (4-z)k}{\sqrt{89 + (4-z)^2}}$$

$$\sum\vec{F} = 0 \quad \vec{W} + \vec{F} + \vec{T}_{AB\,max} + \vec{T}_{AC\,max} = 0$$

$$(-200\hat{k}) + (F\hat{j}) + \left(500\frac{-5\hat{i} - 8\hat{j} + (4-z)\hat{k}}{\sqrt{89 + (4-z)^2}}\right) +$$

$$\left(500\frac{5\hat{i} - 8\hat{j} + (4-z)k}{\sqrt{89 + (4-z)^2}}\right) = 0$$

$\Sigma F_z = 0 \qquad -200 + \frac{500\cdot(4-z)}{\sqrt{89+(4-z)^2}} + \frac{500(4-z)}{\sqrt{89+(4-z)^2}} = 0$

$$\frac{1000(4-z)}{\sqrt{89+(4-z)^2}} = 200$$

$$5(4-z) = \sqrt{89+(4-z)^2}$$

$$25(4-z)^2 = 89+(4-z)^2$$

$$24(4-z)^2 = 89$$

$$(4-z)^2 = \frac{89}{24}$$

$4-z = 1.926 \qquad\qquad 4-z = -1.926$

$z = 2.07\,ft \qquad\qquad z = 5.93\,ft$

$$z_{max} = 2.07\,ft = 0.631\,m$$

(z-components of $T_{AB\,max}$ and $T_{AC\,max}$ are positive)

$\Sigma F_y = 0 \qquad F + \frac{500(-8)}{\sqrt{89+(4-2.07)^2}} + \frac{500(-8)}{\sqrt{89+(4-2.07)^2}} = 0$

$$F = \frac{8000}{9.63} = 831\,lb = 3696\,N = 3.7\,kN$$

<u>Answer</u>: $z_{max} = 2.07\,ft = 0.631\,m$

$F = 831\,lb = 3.7\,kN$