

BCN 2405 – Structures I  
Assignment: Homework #1  
**SOLUTIONS**

**Purpose:** This homework assignment will strengthen learning objectives from chapter 1, 2, and 3 of the text. The learning objectives from chapter 1 included reviewing and discussing trigonometric functions and formulas and calculating trigonometry problems. Geometric properties of shapes were also discussed. The learning objectives from Chapter 2 included explaining and discussing the concept of a force and of equilibrium. Chapter 3 included reinforcing the concepts of forces in equilibrium.

**Skills:** The purpose of this assignment is to help you practice the following skills that are essential to your success in this course.

- Understanding basic trigonometric functions and formulas and how they are used to solve triangles.
- Analyzing concurrent force systems and becoming (or re-familiarizing) yourself with vector addition through the rectangular component method.
- Understanding the equations of static equilibrium and how they can be applied to solve for unknown forces in static force systems.
- Understanding how to construct free body diagrams.

**Knowledge:** This assignment will also help you become more familiar with the following important content knowledge in the field of construction management:

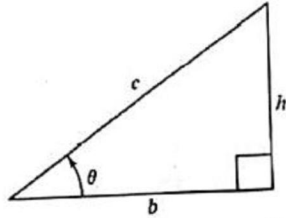
1. Understanding how to analyze structural systems.
2. Applying disciplinary knowledge from construction management, but in the context of structural analysis

**Task:** Complete the problems from the text that are located on the following pages. Problem 1.15, 1.16, 1.18, 1.20, 1.22, 1.28, 2.4, 2.5, 2.6, 2.19, 2.20, 2.22, 3.1, 3.9, 3.10, 3.11, 3.12, and 3.18

**Criteria for Success:** Please print this document and complete the problems on the following pages. Please scan your completed document and submit your solutions online on the Canvas website in one cohesive word or pdf file. Please name your file LASTNAME\_FIRSTNAME\_BCN 2405\_HW#1.

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**SOLUTIONS**

Problem 1.15



PROB. 1.15

$$a) c^2 = b^2 + h^2 \Rightarrow c^2 = (950)^2 + (475)^2$$
$$\sqrt{c^2} = \sqrt{1128125} \Rightarrow \boxed{c = 1092 \text{ mm}}$$

$$\tan \theta = \frac{h}{b} \Rightarrow \theta = \arctan\left(\frac{475}{950}\right) = 26.6^\circ$$

$$\boxed{\sin 26.6^\circ = 0.447}$$
$$\boxed{\cos 26.6^\circ = 0.894}$$

$$b) c^2 = b^2 + h^2 \Rightarrow c^2 = (8)^2 + (6)^2$$
$$\sqrt{c^2} = \sqrt{100} \Rightarrow \boxed{c = 10 \text{ ft}}$$

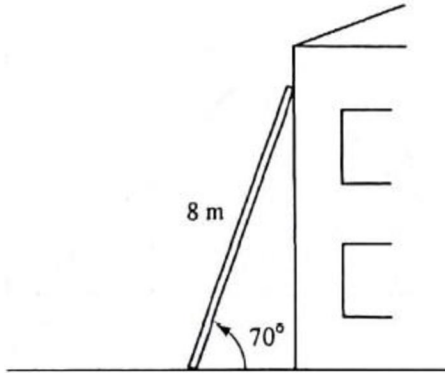
$$\tan \theta = \frac{h}{b} \Rightarrow \theta = \arctan\left(\frac{6}{8}\right) = 36.86^\circ$$

$$\boxed{\sin 36.86^\circ = 0.6}$$
$$\boxed{\cos 36.86^\circ = 0.8}$$

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Problem 1.16

In the figure, an 8-m ladder is leaning against a house at an angle of  $70^\circ$  with the ground. Determine (a) the distance of the bottom of the ladder from the house, and (b) the distance of the top of the ladder from the ground.



PROB. 1.16

$$a) \frac{d}{8} = \cos 70^\circ \Rightarrow d = 8 \cos 70^\circ = \underline{2.74 \text{ m} = d}$$

$$b) \frac{h}{8} = \sin 70^\circ \Rightarrow h = 8 \sin 70^\circ = \underline{7.52 \text{ m} = h}$$

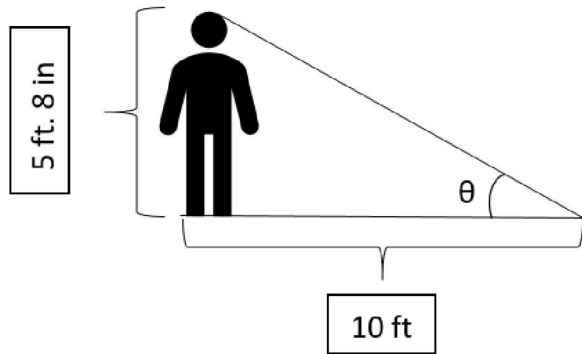
$$2.74^2 + 7.52^2 = 8^2$$

$$64 = 64 \checkmark$$

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Problem 1.18

A man 5 ft 8 in. tall casts a shadow 10 ft long. Determine the angle of elevation of the sun above the ground.



$$b = 10 \text{ ft} \left( \frac{12 \text{ in}}{\text{ft}} \right) = 120 \text{ in}$$

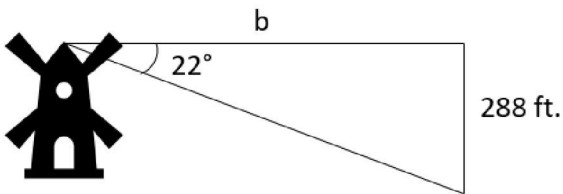
$$h = 5 \text{ ft } 8 \text{ in} \left( \frac{12 \text{ in}}{\text{ft}} \right) = 68 \text{ in}$$

$$\tan \theta = \frac{h}{b} = \frac{68}{120} \Rightarrow \theta = \arctan \left( \frac{68}{120} \right) = \boxed{29.53^\circ = \theta}$$

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**SOLUTIONS**

Problem 1.20

The angle of depression of a ship from the top of a 288-ft-high lighthouse is  $22^\circ$ . Determine how far the ship is from the lighthouse.



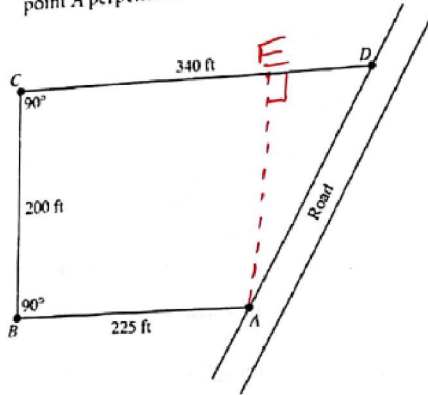
$$\tan 22^\circ = \frac{288}{b} \Rightarrow b = \frac{288}{\tan 22^\circ} = 712.8 = 713 \text{ ft}$$

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**SOLUTIONS**

Problem 1.22

Problem 1.22

A building lot has the dimensions shown in the figure. Find the amount of road frontage (distance  $AD$ ) for this lot. (Hint: First construct an imaginary line from point  $A$  perpendicular to lot line  $CD$ .)



PROB. 1.22

$$AE = BC = 200 \text{ ft}$$

$$ED = 340 - 225 = 115 \text{ ft}$$

Triangle AED

$$(AD)^2 = (200 \text{ ft})^2 + (115 \text{ ft})^2$$

$$\sqrt{(AD)^2} = \sqrt{53225} \Rightarrow \boxed{AD = 230.7 \text{ ft}}$$

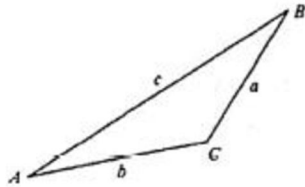
This is the amount of  
Road frontage

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**SOLUTIONS**

Problem 1.28

Problem 1.28

- Determine, for the triangle shown, the missing sides and angles with the following sides and angles given.
- $a = 7$  in.,  $B = 40^\circ$ , and  $C = 30^\circ$
  - $a = 3$  m,  $b = 6$  m, and  $C = 48^\circ$
  - $a = 8$  ft,  $b = 7$  ft, and  $A = 60^\circ$
  - $a = 4$  m,  $b = 7$  m, and  $c = 9$  m



PROB. 1.28

a)  $a = 7$  in.,  $B = 40^\circ$ ,  $C = 30^\circ$

$$A = 180^\circ - B - C = 110^\circ$$

$$\frac{b}{\sin 40^\circ} = \frac{c}{\sin 30^\circ} = \frac{7}{\sin 110^\circ}$$

$$b = \frac{7 \sin 40^\circ}{\sin 110^\circ} = 4.79 \text{ in.}$$

$$c = \frac{7 \sin 30^\circ}{\sin 110^\circ} = 3.72 \text{ in.}$$

b)  $a = 3$  m,  $b = 6$  m,  $C = 48^\circ$

$$c^2 = (6)^2 + (3)^2 - 2(6)(3) \cos 48^\circ$$

$$\sqrt{c^2} = \sqrt{20.911} \Rightarrow c = 4.57 \text{ m} = c$$

$$\frac{3}{\sin A} = \frac{4.57}{\sin 48^\circ}$$

$$\sin A = \frac{3 \sin 48^\circ}{4.57} \Rightarrow A = 29.2^\circ$$

$$B = 180^\circ - A - C \Rightarrow B = 102.8^\circ$$

c)  $a = 8$  ft,  $b = 7$  ft,  $A = 60^\circ$

$$\frac{7}{\sin B} = \frac{8}{\sin 60^\circ}$$

$$\sin B = \frac{7 \sin 60^\circ}{8} \Rightarrow B = 49.3^\circ$$

$$C = 180^\circ - A - B \Rightarrow C = 70.7^\circ$$

$$c^2 = (7)^2 + (8)^2 - 2(7)(8) \cos 70.7^\circ$$

$$c = 8.72 \text{ ft}$$

d)  $a = 4$  m,  $b = 7$  m,  $c = 9$  m

$$B = 180^\circ - A - C$$

$$(9)^2 = (7)^2 + (4)^2 - 2(7)(4) \cos C$$

$$B = 48.2^\circ$$

$$\cos C = -0.2857 \Rightarrow C = 106.6^\circ$$

$$(4)^2 = (7)^2 + (9)^2 - 2(7)(9) \cos A$$

$$\cos A = 0.9048 \Rightarrow A = 25.2^\circ$$

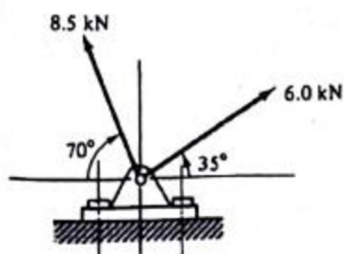
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**SOLUTIONS**

Problem 2.4

The bracket supports the two forces as shown. Obtain their resultant by the rectangular component method.

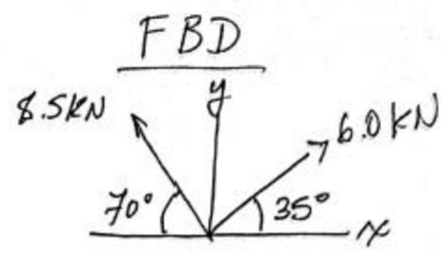
Problem 2.4

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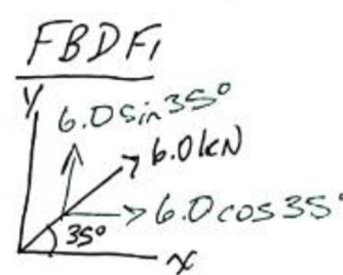


PROB. 2.4

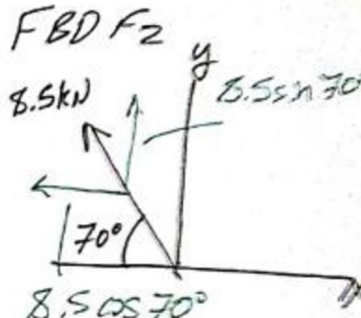
**FBD**



**FBD F1**



**FBD F2**



$F_1 = 6.0 \text{ kN}$   
 $F_2 = 8.5 \text{ kN}$

$F_{1x} = 6.0 \cos 35^\circ = +4.91 \text{ kN}$   
 $F_{2x} = 8.5 \cos 70^\circ = -2.91 \text{ kN}$

$F_{1y} = 6.0 \sin 35^\circ = +3.44 \text{ kN}$   
 $F_{2y} = 8.5 \sin 70^\circ = +7.99 \text{ kN}$

$\Sigma F_x = 4.91 - 2.91 = 2 \text{ kN}$   
 $\Sigma F_y = 3.44 + 7.99 = 11.43 \text{ kN}$

$R = \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2} = \sqrt{(2)^2 + (11.43)^2}$   
 $R = 11.6 \text{ kN}$

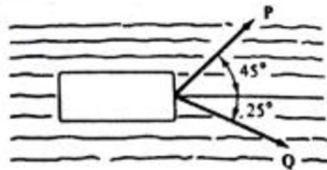
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**SOLUTIONS**

Problem 2.5

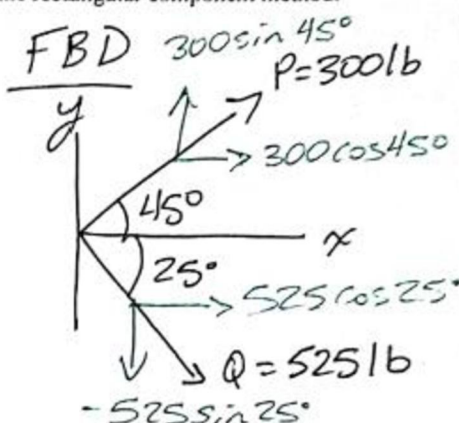
A barge is pulled by two ropes with tensions P and Q as shown. If P = 300 lb and Q = 525 lb, determine the resultant force applied on the barge by the rectangular component method.

Problem 2.5

A barge is pulled by two ropes with tensions P and Q as shown. If P = 300 lb and Q = 525 lb, determine the resultant force applied on the barge by the rectangular component method.



PROB. 2.5 and PROB. 2.6



$$P_x = 300 \cos 45^\circ = 212.1316$$

$$P_y = 300 \sin 45^\circ = 212.1316$$

$$Q_x = 525 \cos 25^\circ = 475.8116$$

$$Q_y = 525 \sin 25^\circ = 221.8716$$

$$\sum F_x = 212.13 + 475.81 = 687.9416$$

$$\sum F_y = 212.13 - 221.87 = -9.7416$$

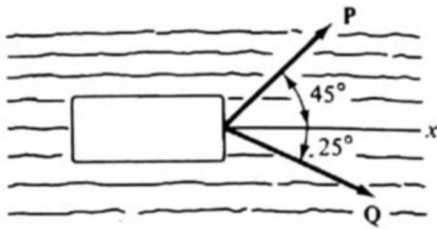
$$R = \sqrt{(\sum F_x)^2 + (\sum F_y)^2} = \sqrt{(687.94)^2 + (-9.74)^2}$$

R = 688 lb

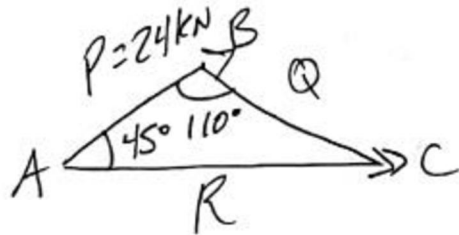
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**SOLUTIONS**

Problem 2.6

A barge is pulled by two ropes with tensions **P** and **Q**. The force  $P = 24 \text{ kN}$ , and the resultant of the two forces acts along the  $x$  axis. Determine the force **Q** and the resultant force applied on the barge by trigonometry.



PROB. 2.5 and PROB. 2.6



$$C = 180^\circ - 45^\circ - 110^\circ = 25^\circ$$

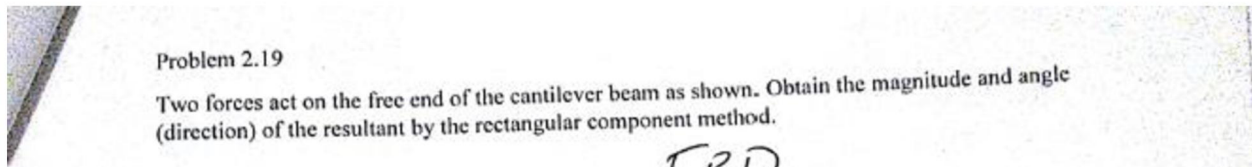
$$\frac{R}{\sin 110^\circ} = \frac{Q}{\sin 45^\circ} = \frac{24}{\sin 25^\circ}$$

$$R = \frac{24 \sin 110^\circ}{\sin 25^\circ} \Rightarrow \boxed{R = 53.4 \text{ kN}}$$

$$Q = \frac{24 \sin 45^\circ}{\sin 25^\circ} \Rightarrow \boxed{Q = 40.2 \text{ kN}}$$

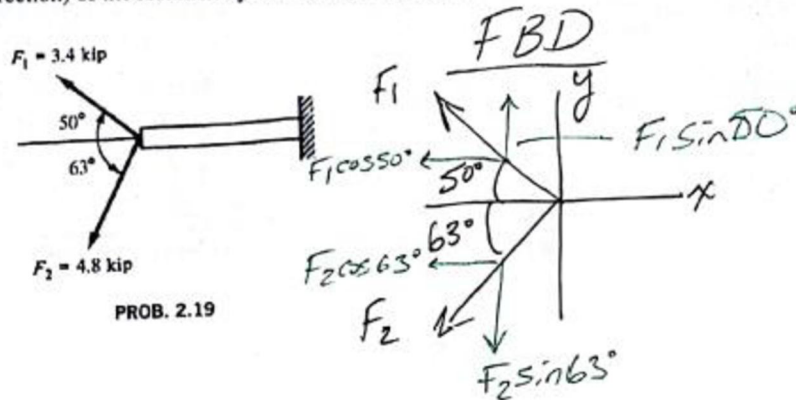
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**SOLUTIONS**

Problem 2.19



Problem 2.19

Two forces act on the free end of the cantilever beam as shown. Obtain the magnitude and angle (direction) of the resultant by the rectangular component method.



$$F_{1x} = 3.4 \cos 50^\circ = -2.18 \text{ k}$$

$$F_{1y} = 3.4 \sin 50^\circ = 2.6 \text{ k}$$

$$F_{2x} = 4.8 \cos 63^\circ = -2.17 \text{ k}$$

$$F_{2y} = 4.8 \sin 63^\circ = -4.27 \text{ k}$$

$$\Sigma F_x = -2.18 - 2.17 = -4.35 \text{ k}$$

$$\Sigma F_y = 2.6 - 4.27 = -1.67 \text{ k}$$

$$R = \sqrt{(-4.35)^2 + (-1.67)^2} = \boxed{4.65 \text{ k} = R}$$

$$\Theta = \arctan \left| \frac{\Sigma F_y}{\Sigma F_x} \right| = \left| \arctan \left| \frac{(-1.67)}{(-4.35)} \right| \right|$$

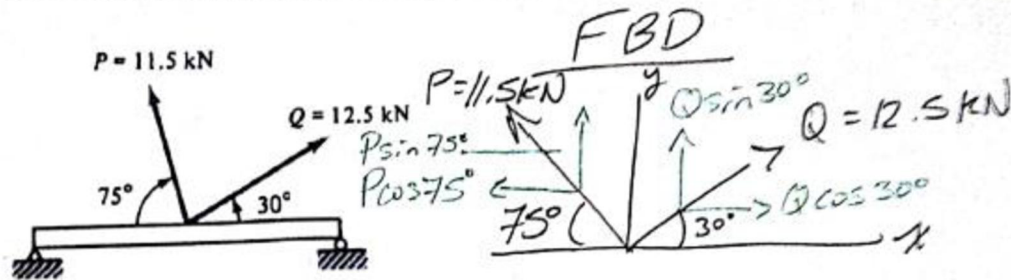
$$\boxed{\Theta = 21^\circ}$$

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**SOLUTIONS**

Problem 2.20

Problem 2.20

Two forces act in the center of the simply supported beam as shown. Find the magnitude and angle (direction) of the resultant by the rectangular component method.



$$P_x = 11.5 \cos 75^\circ = -2.97 \text{ kN}$$

$$P_y = 11.5 \sin 75^\circ = 11.11 \text{ kN}$$

$$Q_x = 12.5 \cos 30^\circ = 10.82 \text{ kN}$$

$$Q_y = 12.5 \sin 30^\circ = 6.25 \text{ kN}$$

$$\sum F_x = -2.97 + 10.82 = 7.85 \text{ kN}$$

$$\sum F_y = 11.11 + 6.25 = 17.36 \text{ kN}$$

$$R = \sqrt{(7.85)^2 + (17.36)^2} = \underline{\underline{19.05 \text{ kN} = R}}$$

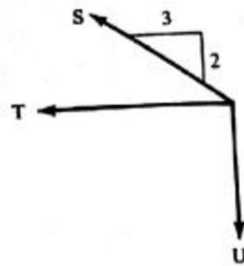
$$\theta = \arctan \left| \frac{17.36}{7.85} \right| = \underline{\underline{65.66^\circ = \theta}}$$

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**SOLUTIONS**

Problem 2.22

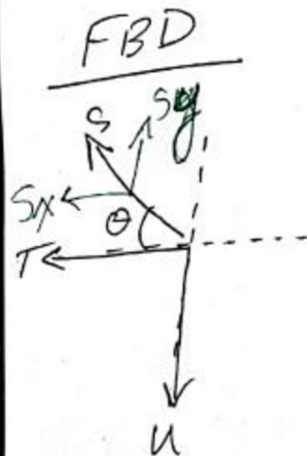
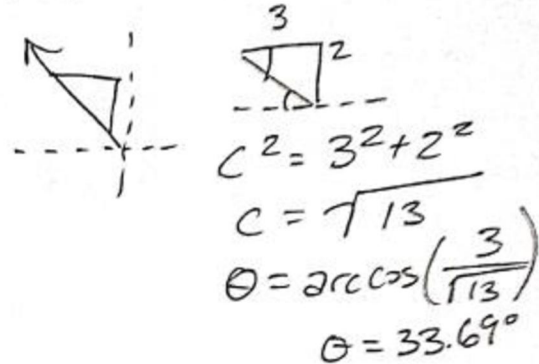
Problem 2.22

For the forces shown,  $S = 3.81$  kip,  $T = 4.73$  kip, and  $U = 3.65$  kip. Determine the magnitude and angle (direction) of the resultant.



PROB. 2.22

FBD of Force S



$$S_x = 3.81 \cos 33.69^\circ = -3.17k$$

$$S_y = 3.81 \sin 33.69^\circ = 2.11k$$

$$\Sigma F_x = S_x + T = -3.17 - 4.73 = -7.9k$$

$$\Sigma F_y = S_y + U = 2.11 - 3.65 = -1.53k$$

$$R = \sqrt{(-7.9)^2 + (-1.53)^2} = \boxed{8.05k = R}$$

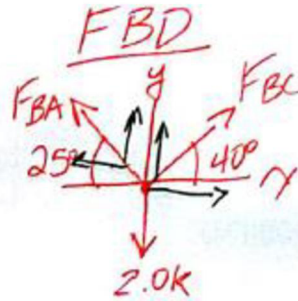
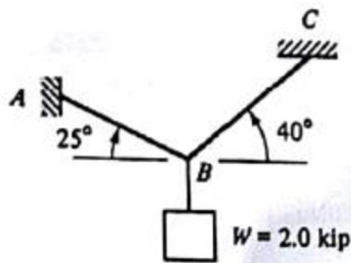
$$\theta = \arctan\left(\left|\frac{-1.53}{-7.9}\right|\right) = \boxed{\theta = 11.0^\circ}$$

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**SOLUTIONS**

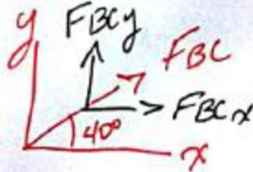
Problem 3.1

Problem 3.1

Solve for the tensile force in cable BA and cable BC that satisfies the conditions of static equilibrium using the rectangular component method.



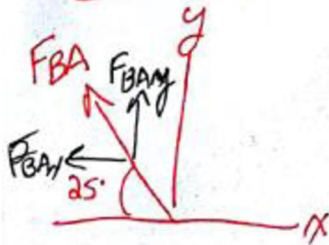
For FBC



$$F_{BCx} = F_{BC} \cos 40^\circ$$

$$F_{BCy} = F_{BC} \sin 40^\circ$$

For FBA



$$F_{BAy} = F_{BA} \sin 25^\circ$$

$$F_{BAx} = F_{BA} \cos 25^\circ$$

$$\textcircled{1} \sum F_x = 0 = F_{BC} \cos 40^\circ - F_{BA} \cos 25^\circ$$

$$\textcircled{2} \sum F_y = 0 = F_{BC} \sin 40^\circ + F_{BA} \sin 25^\circ - 2$$

From Eq. 1

$$F_{BC} \cos 40^\circ = F_{BA} \cos 25^\circ$$

$$F_{BC} = \frac{F_{BA} \cos 25^\circ}{\cos 40^\circ}$$

$$F_{BC} = F_{BA} (1.183)$$

From Eq. 2

$$0 = 1.183 F_{BA} \sin 40^\circ + F_{BA} \sin 25^\circ - 2$$

$$1.183 F_{BA} = 2 \Rightarrow \boxed{F_{BA} = 1.69 \text{ k}}$$

$$F_{BC} = 1.183 \cdot 1.69 = \boxed{2 \text{ k} = F_{BC}}$$

$$\sum F_x = 2 \cos 40^\circ - 1.69 \cos 25^\circ = 0$$

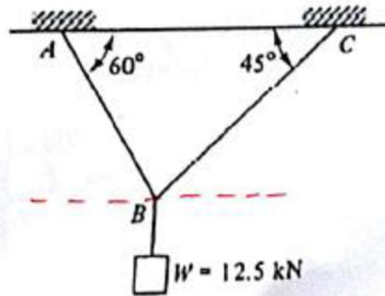
$$\sum F_y = 2 \sin 40^\circ + 1.69 \sin 25^\circ - 2 = 0$$

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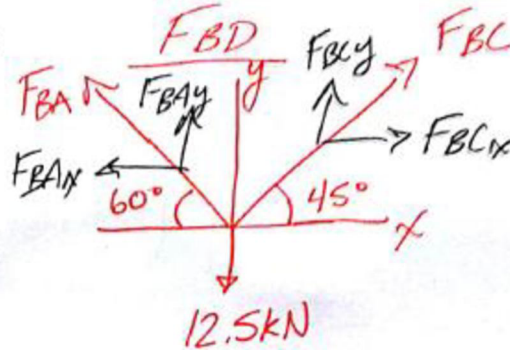
Problem 3.9

Problem 3.9

Solve for the tensile force in cable BA and cable BC that satisfies the conditions of static equilibrium using the rectangular component method.



PROB. 3.9



$$F_{BCx} = F_{BC} \cos 45^\circ$$

$$F_{BCy} = F_{BC} \sin 45^\circ$$

$$F_{BAx} = F_{BA} \cos 60^\circ$$

$$F_{BAy} = F_{BA} \sin 60^\circ$$

$$\textcircled{1} \sum F_x = 0 = F_{BC} \cos 45^\circ - F_{BA} \cos 60^\circ$$

$$\textcircled{2} \sum F_y = 0 = F_{BC} \sin 45^\circ + F_{BA} \sin 60^\circ - 12.5$$

From Eq. 1

$$F_{BC} \cos 45^\circ = F_{BA} \cos 60^\circ$$

$$F_{BC} = \frac{F_{BA} \cos 60^\circ}{\cos 45^\circ} = 0.707 F_{BA}$$

From Eq. 2

$$0.707 F_{BA} \sin 45^\circ + F_{BA} \sin 60^\circ - 12.5 = 0$$

$$\frac{1.365 F_{BA}}{1.365} = \frac{12.5}{1.365} \Rightarrow F_{BA} = 9.15 \text{ kN}$$

$$F_{BC} = 0.707 \cdot 9.15 = 6.46 \text{ kN} = F_{BC}$$

$$\sum F_x = 6.46 \cos 45^\circ - 9.15 \cos 60^\circ = 0 \checkmark$$

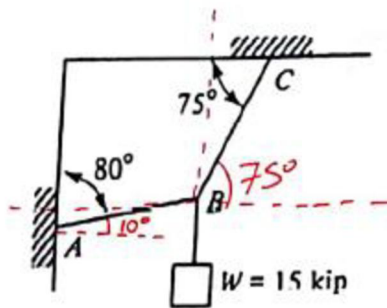
$$\sum F_y = 6.46 \sin 45^\circ + 9.15 \sin 60^\circ - 12.5 = 0 \checkmark$$

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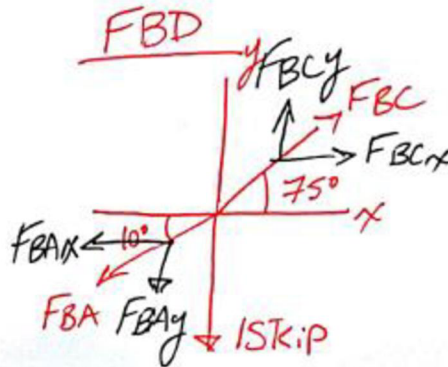
Problem 3.10

Problem 3.10

Solve for the tensile force in cable BA and cable BC that satisfies the conditions of static equilibrium using the rectangular component method.



PROB. 3.10



$$F_{BCx} = F_{BC} \cos 75^\circ$$

$$F_{BCy} = F_{BC} \sin 75^\circ$$

$$F_{BAx} = F_{BA} \cos 10^\circ$$

$$F_{BAy} = F_{BA} \sin 10^\circ$$

$$\textcircled{1} \sum F_x = 0 = F_{BC} \cos 75^\circ - F_{BA} \cos 10^\circ$$

$$\textcircled{2} \sum F_y = 0 = F_{BC} \sin 75^\circ - F_{BA} \sin 10^\circ - 15$$

From Eq. 1

$$\frac{F_{BC} \cos 75^\circ}{\cos 75^\circ} = \frac{F_{BA} \cos 10^\circ}{\cos 75^\circ}$$

$$F_{BC} = 3.81 F_{BA}$$

From Eq. 2

$$3.81 F_{BA} \sin 75^\circ - F_{BA} \sin 10^\circ - 15 = 0$$

$$\frac{3.51 F_{BA}}{3.51} = \frac{15}{3.51} \Rightarrow F_{BA} = 4.27 \text{ k}$$

$$F_{BC} = 3.81 \cdot 4.27 = 16.27 \text{ k} = F_{BC}$$

$$\sum F_x = 16.27 \cos 75^\circ - 4.27 \cos 10^\circ = 0 \checkmark$$

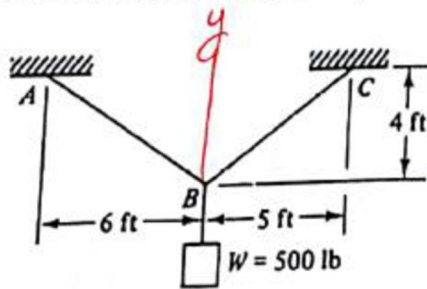
$$\sum F_y = 16.27 \sin 75^\circ - 4.27 \sin 10^\circ - 15 = 0 \checkmark$$

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Assignment: Homework #1  
**SOLUTIONS**

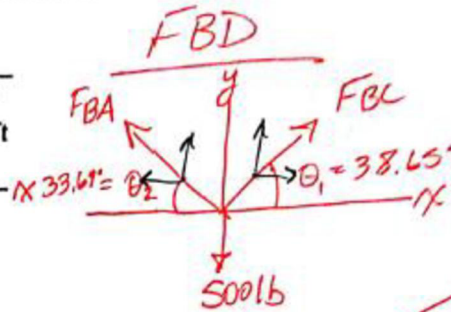
Problem 3.11

Problem 3.11

Solve for the tensile force in cable BA and cable BC that satisfies the conditions of static equilibrium using the rectangular component method.



PROB. 3.11



$$\theta_1 = \arctan(4/5) = 38.65^\circ$$

$$\theta_2 = \arctan(4/6) = 33.69^\circ$$

$$F_{BCx} = F_{BC} \cos 38.65^\circ$$

$$F_{BCy} = F_{BC} \sin 38.65^\circ$$

$$F_{BAx} = F_{BA} \cos 33.69^\circ$$

$$F_{BAy} = F_{BA} \sin 33.69^\circ$$

$$\textcircled{1} \sum F_x = F_{BC} \cos 38.65^\circ - F_{BA} \cos 33.69^\circ$$

$$\textcircled{2} \sum F_y = F_{BC} \sin 38.65^\circ + F_{BA} \sin 33.69^\circ - 500$$

From Eq. 1

$$\frac{F_{BC} \cos 38.65^\circ}{\cos 38.65^\circ} = \frac{F_{BA} \cos 33.69^\circ}{\cos 38.65^\circ}$$

$$F_{BC} = 1.065 F_{BA}$$

From Eq. 2

$$1.065 F_{BA} \sin 38.65^\circ + F_{BA} \sin 33.69^\circ - 500$$

$$\frac{1.219 F_{BA}}{1.219} = \frac{500}{1.219} \Rightarrow \boxed{F_{BA} = 409.8 \text{ lb}}$$

$$F_{BC} = 1.065 \cdot 409.8 = 436.416 = \boxed{F_{BC}}$$

$$\sum F_x = 436.41 \cos 38.65^\circ - 409.8 \cos 33.69^\circ = 0$$

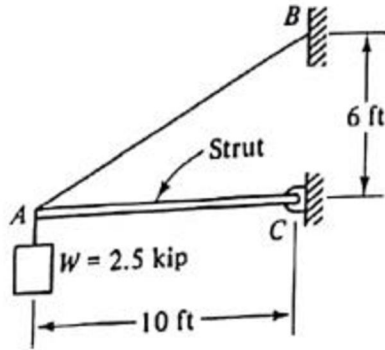
$$\sum F_y = 436.41 \sin 38.65^\circ + 409.8 \sin 33.69^\circ - 500 = 0$$

BCN 2405 – Structures I  
Assignment: Homework #1  
**SOLUTIONS**

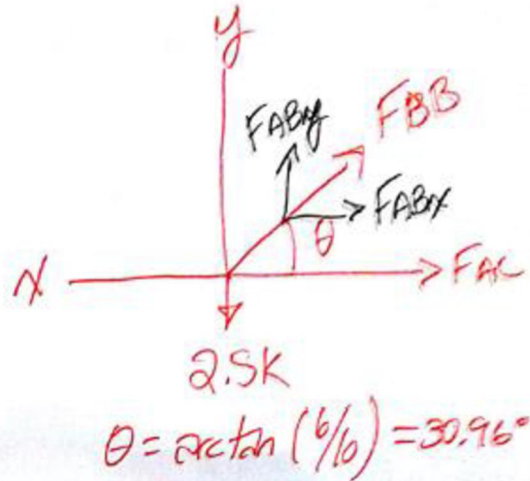
Problem 3.12

Problem 3.12

Determine the force in cable AB and the force in the strut AC by the method of rectangular components that satisfies the conditions of static equilibrium.



PROB. 3.12



$$F_{ABx} = F_{AB} \cos 30.96$$

$$F_{ABy} = F_{AB} \sin 30.96$$

$$\textcircled{1} \sum F_x = 0 = F_{AB} \cos 30.96 + F_{AC}$$

$$\textcircled{2} \sum F_y = 0 = F_{AB} \sin 30.96 - 2.5$$

From Eq. 2

$$\frac{F_{AB} \sin 30.96}{\sin 30.96} = \frac{2.5}{\sin 30.96}$$

$$\text{From Eq. 1} \quad \boxed{F_{AB} = 4.85 \text{ k}}$$

$$4.85 \cos 30.96 + F_{AC}$$

$$4.15 + F_{AC} = 0$$

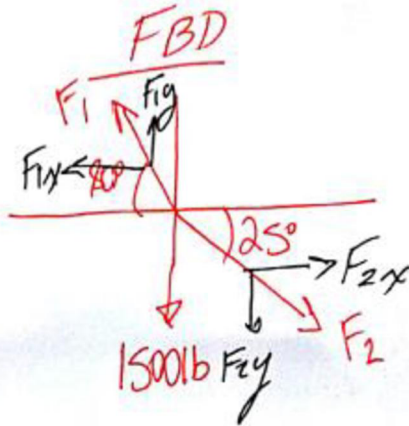
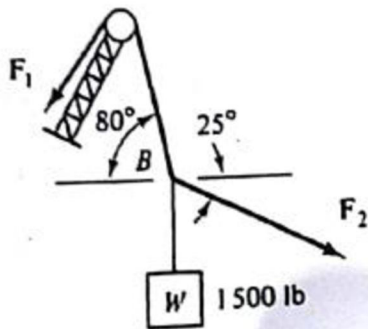
$$\boxed{F_{AC} = -4.15 \text{ k} = 4.15 \text{ k (C)}}$$

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Problem 3.18

Problem 3.18

Determine  $F_1$  and  $F_2$  that satisfies the conditions of static equilibrium using the method of rectangular components. Note that the pulley system depicted in the figure below is a frictionless pulley system.  $F_1$  is being transmitted throughout the length of the cable.



$$F_{1x} = F_1 \cos 80^\circ$$

$$F_{1y} = F_1 \sin 80^\circ$$

$$F_{2x} = F_2 \cos 25^\circ$$

$$F_{2y} = F_2 \sin 25^\circ$$

$$\textcircled{1} \sum F_x = 0 = -F_1 \cos 80^\circ + F_2 \cos 25^\circ$$

$$\textcircled{2} \sum F_y = 0 = F_1 \sin 80^\circ - F_2 \sin 25^\circ - 1500$$

From Eq. 1

$$\frac{F_1 \cos 80^\circ}{\cos 80^\circ} = \frac{F_2 \cos 25^\circ}{\cos 80^\circ}$$

From Eq. 2  $F_1 = 5.21 F_2$

$$5.21 F_2 \sin 80^\circ - F_2 \sin 25^\circ - 1500$$

$$\frac{4.708 F_2 = 1500}{4.708}$$

$$\frac{4.708}{4.708} F_2 = \frac{1500}{4.708}$$

$$F_1 = 5.21 \cdot 318.6 = 1659.91 \text{ lb}$$

$$F_2 = 318.6 \text{ lb}$$