Force Vectors

Vectors

Vector Quantities

Have both a **magnitude** and **direction**

Examples: Position, force, moment

Vector Notation

Vectors are given a variable, such as A or B

Handwritten notation usually includes an **arrow**, such as $\vec{A}\ or\ \vec{B}$

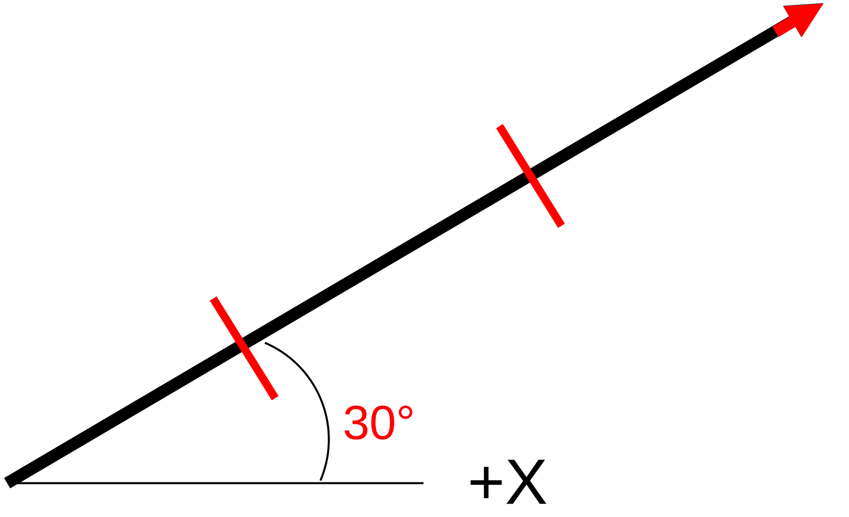
Illustrating Vectors

Vectors are represented by arrows.

Include **magnitude**, **direction**, and **sense**.

Magnitude: The length of the line segment

Magnitude = 3



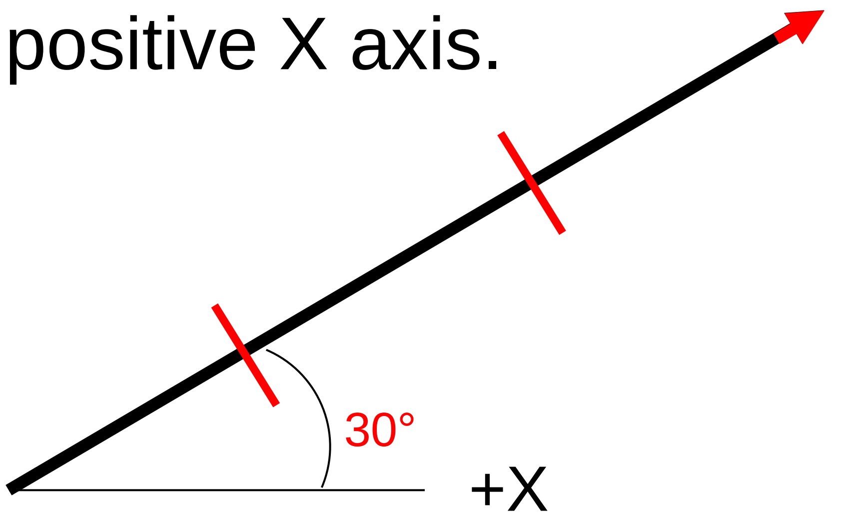
Illustrating Vectors

Vectors are represented by arrows.

Include **magnitude**, **direction**, and **sense**

Direction: The angle between a **reference** axis and the arrow’s line of action.

Direction = **30°** counterclockwise from the positive X axis.



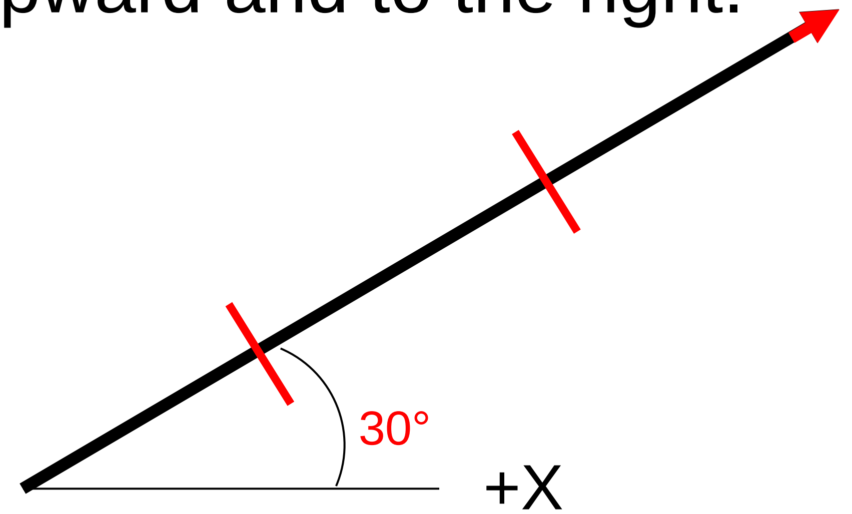
Illustrating Vectors

Vectors are represented by arrows

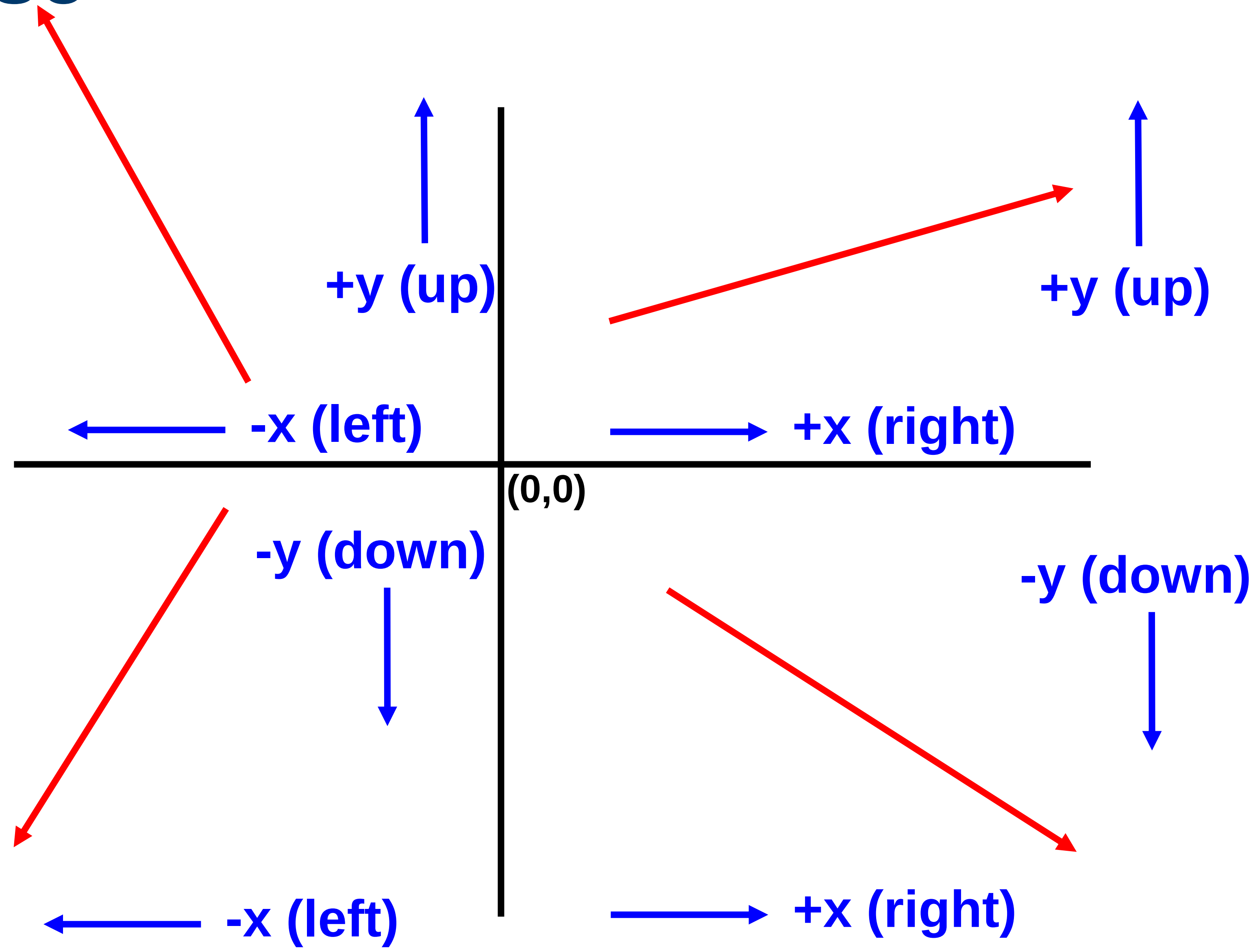
Include **magnitude**, **direction**, and **sense**

Sense: Indicated by the direction of the **tip** of the arrow.

Sense = Upward and to the right.



Sense



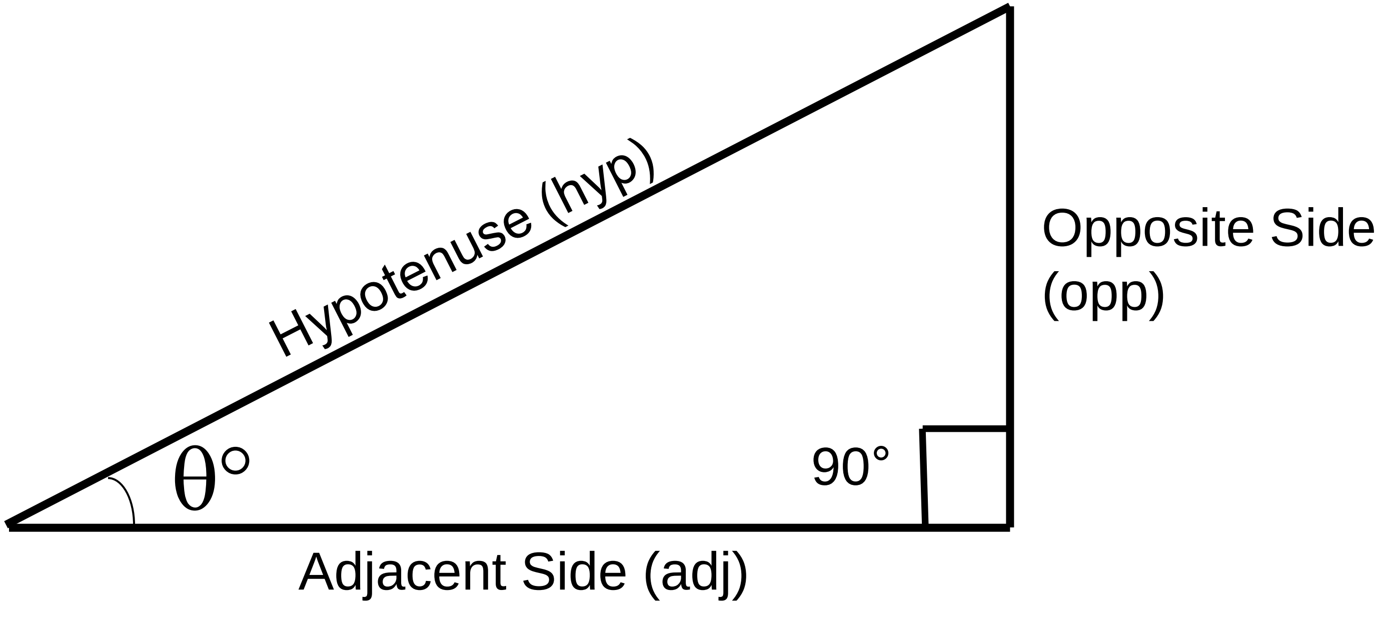
Trigonometry Review

Right Triangle

A triangle with a **90°** angle.

Sum of all interior angles = **180°**

Pythagorean Theorem: **$A^2 + B^2 = C^2$**



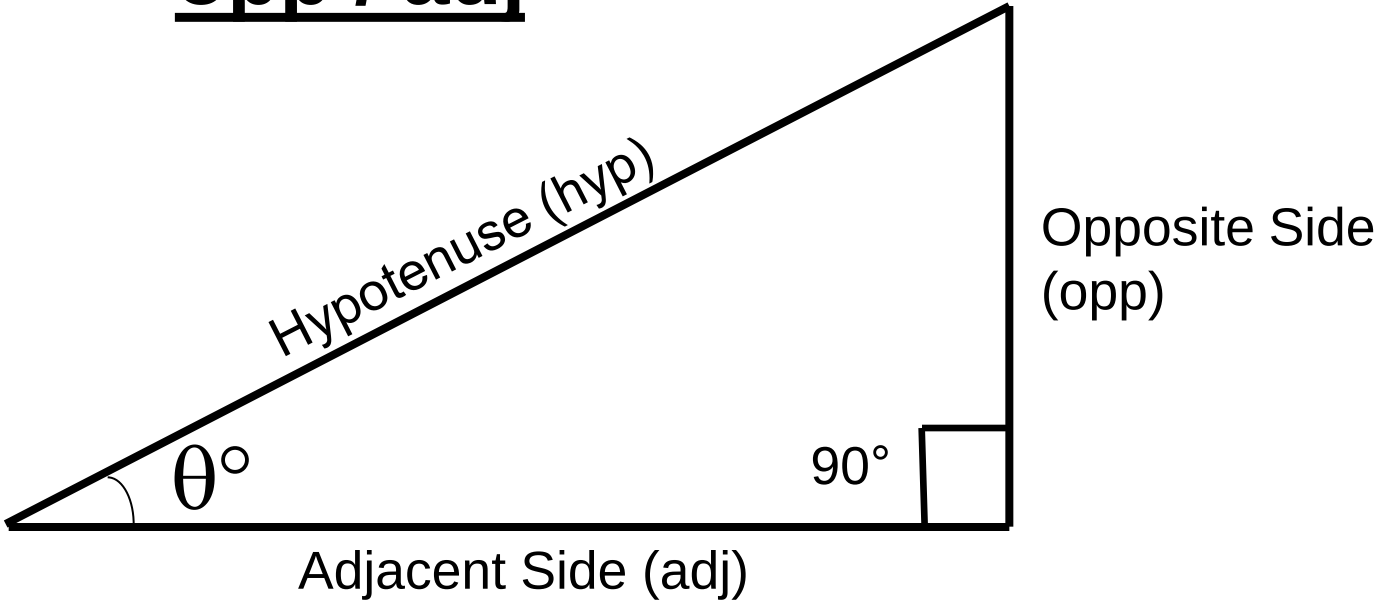
Trigonometry Review

Trigonometric Functions ***soh cah toa***

sin θ° = **opp / hyp**

cos θ° = **adj / hyp**

tan θ° = **opp / adj**

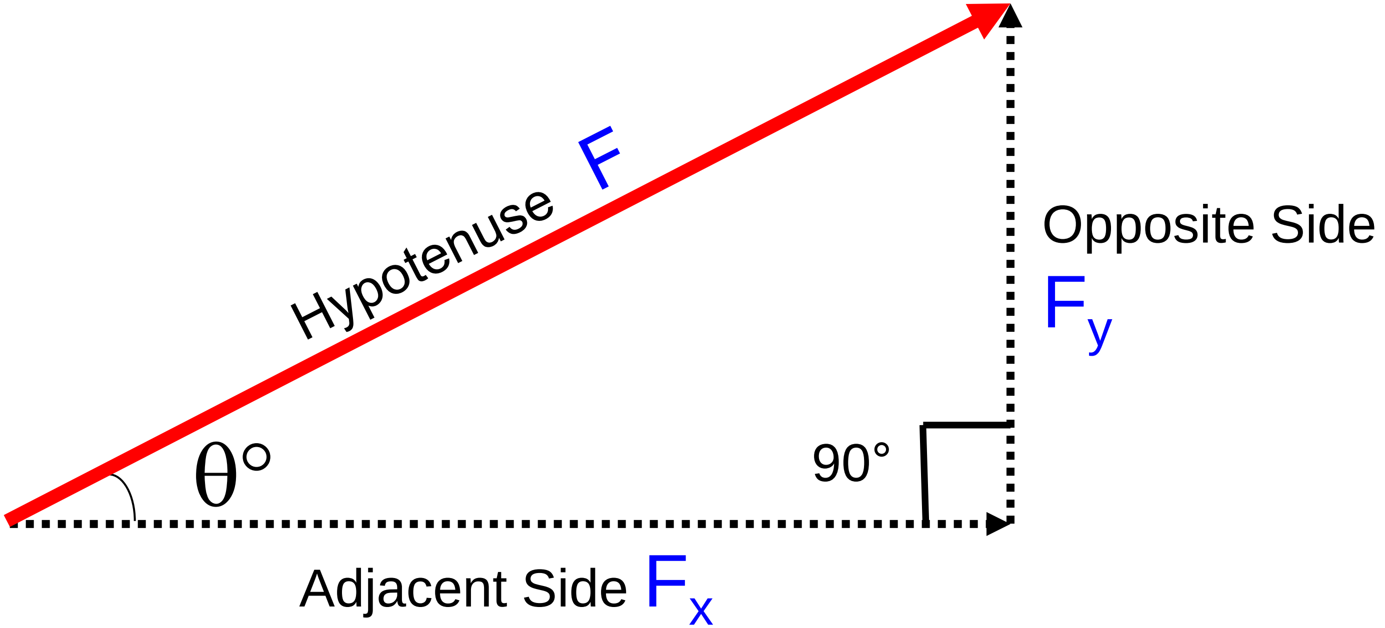


Trigonometry Application

The **hypotenuse** is the *Magnitude* of the Force, F.

The **adjacent side** is the x-component, F_x.

The **opposite side** is the y-component, F_y.

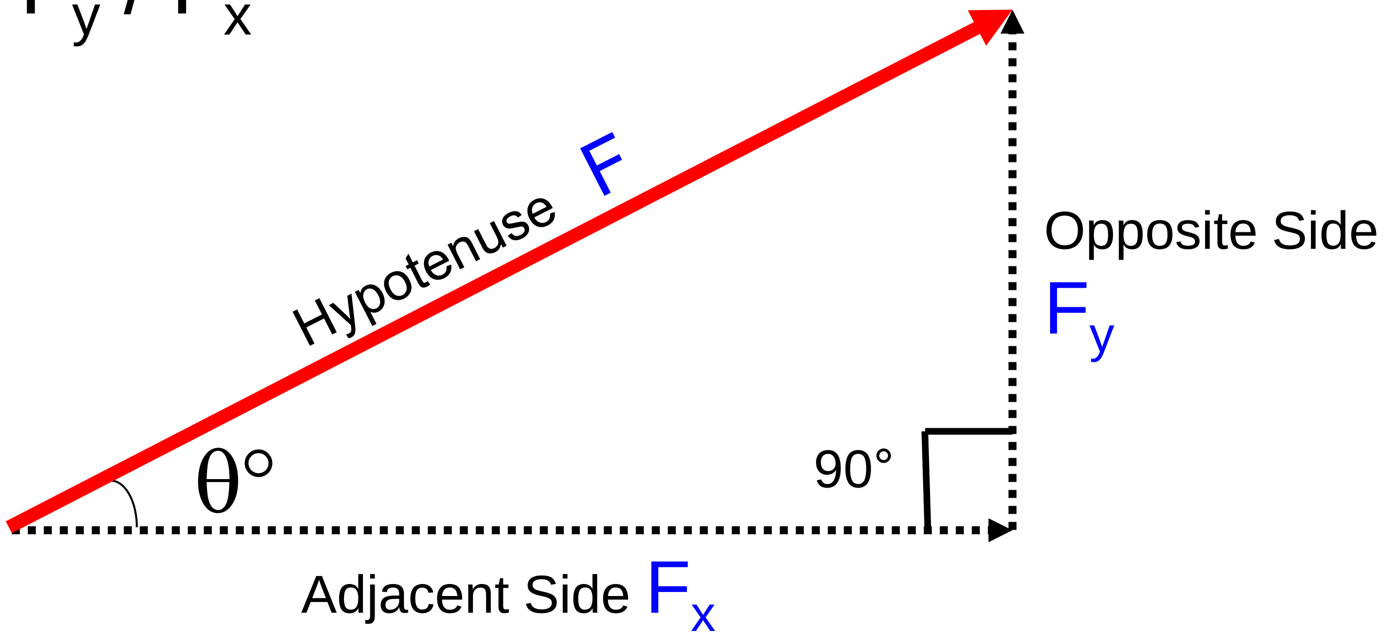


Trigonometry Application

$\sin\theta° = F_y / F$ → $F_y = \underline{\mathbf{F \sin\theta°}}$

$\cos\theta° = F_x / F$ → $F_x = \underline{\mathbf{F \cos\theta°}}$

$\tan\theta° = F_y / F_x$



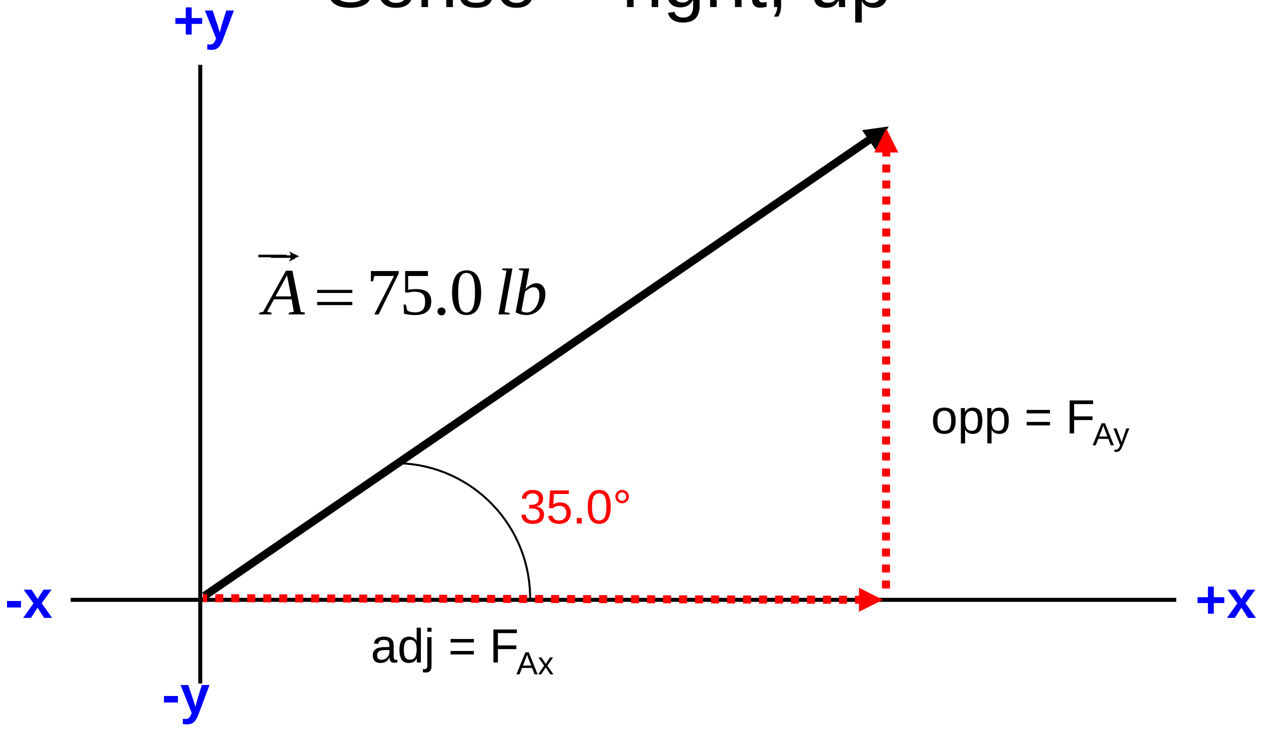
Vector X and Y Components

Vector $\vec{A}$

Magnitude = 75.0 lb

Direction = 35.0° from the horizontal

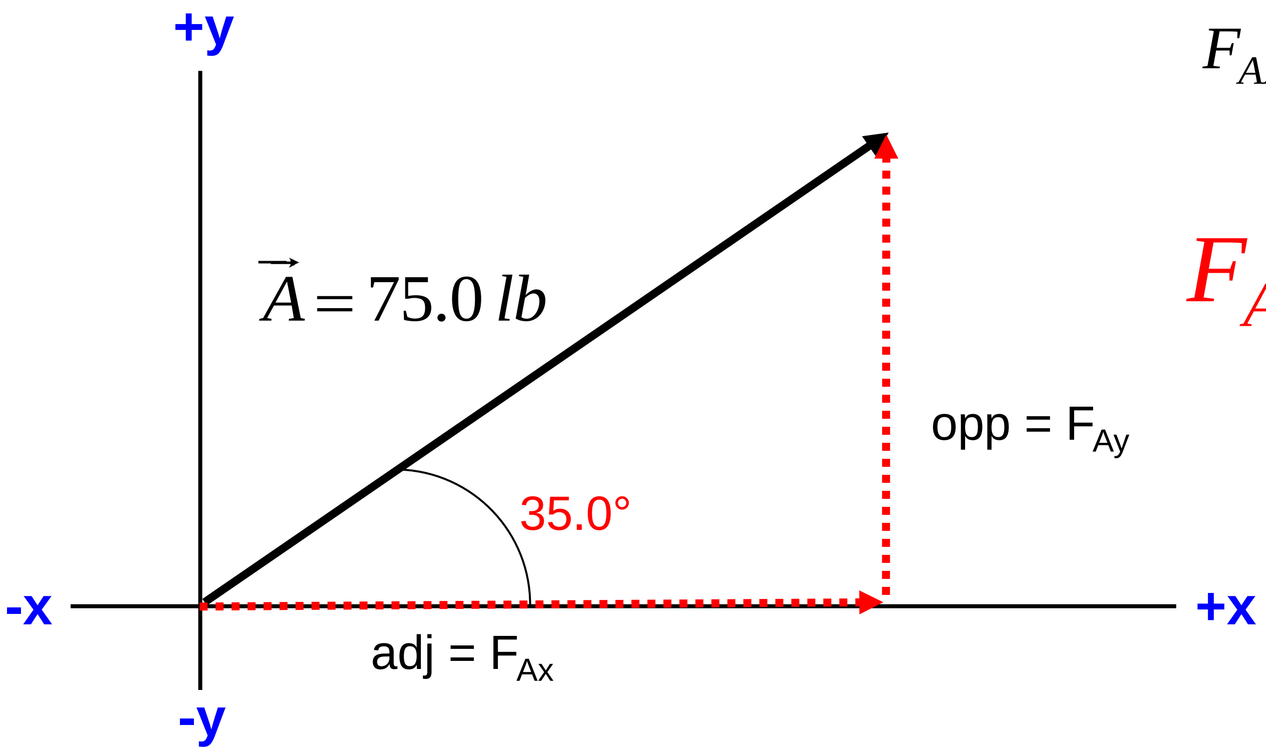
Sense = right, up



Vector X and Y Components

Solve for F_{AX}

$$\cos\theta = \frac{adj}{hyp} \qquad \cos\theta = \frac{F_{AX}}{\vec{A}} \qquad \cos 35.0^\circ = \frac{F_{AX}}{75.0\ lb}$$



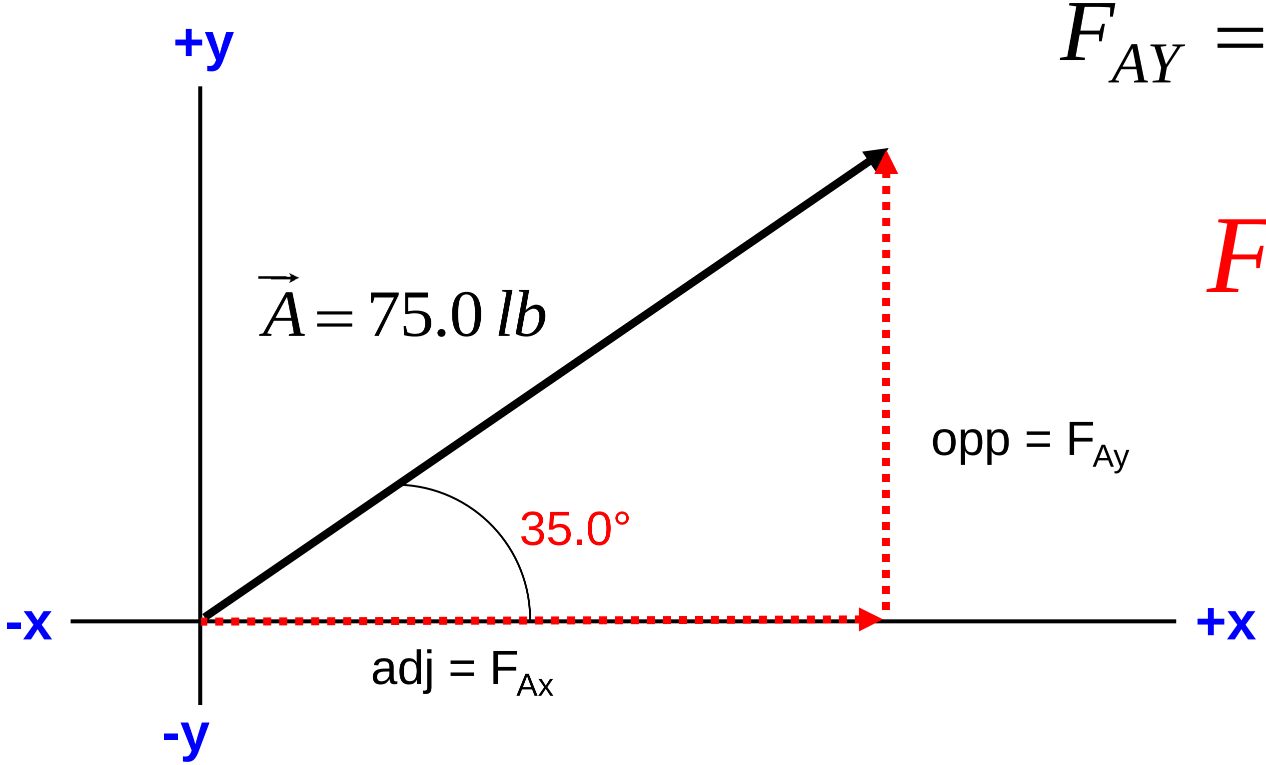
$$F_{AX} = 75.0\ lb \cos 35.0^\circ$$

$$F_{AX} = 61.4\ lb$$

Vector X and Y Components

Solve for F_{AY}

$$\sin\theta = \frac{opp}{hyp} \qquad \sin\theta = \frac{F_{AY}}{\vec{A}} \qquad \sin 35.0^\circ = \frac{F_{AY}}{75.0\ lb}$$



$$F_{AY} = 75.0\ lb \sin 35.0^\circ$$

$$F_{AY} = 43.0\ lb$$

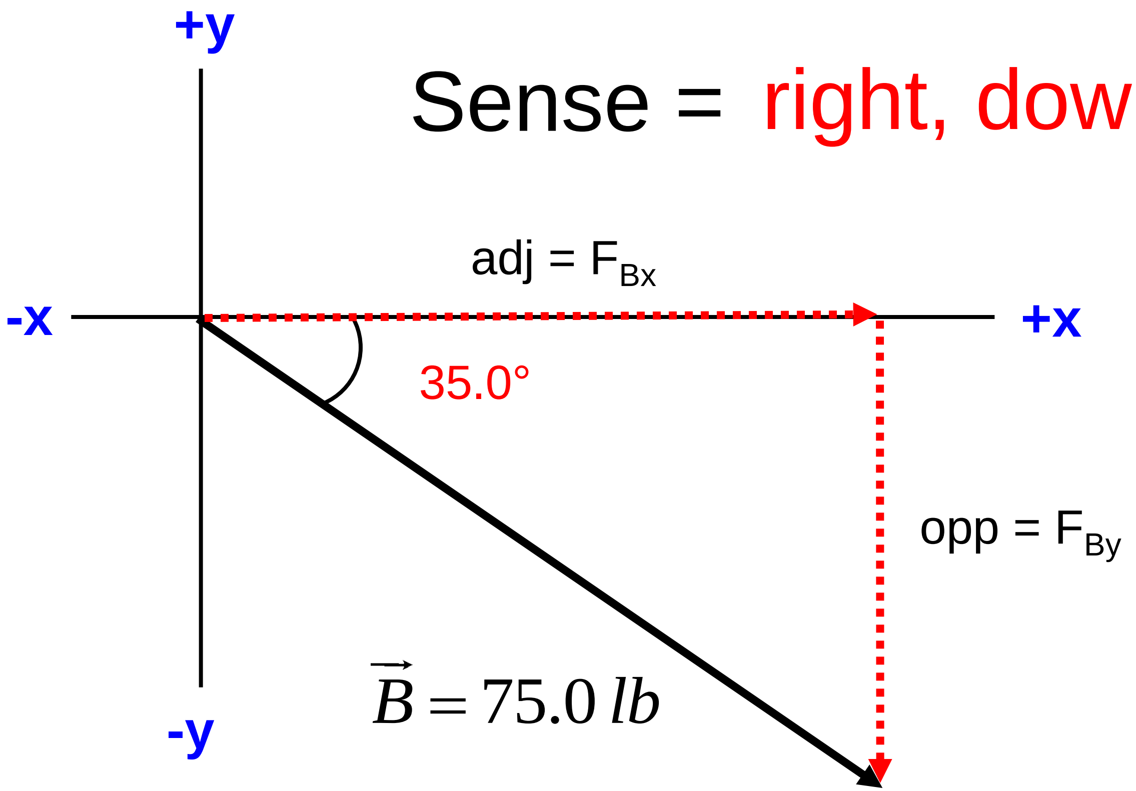
Vector X and Y Components – Your Turn

Vector $\vec{B}$

Magnitude = 75.0 lb

Direction = 35.0° from the horizontal

Sense = right, down



Vector X and Y Components – Your Turn

Solve for F_{BX}

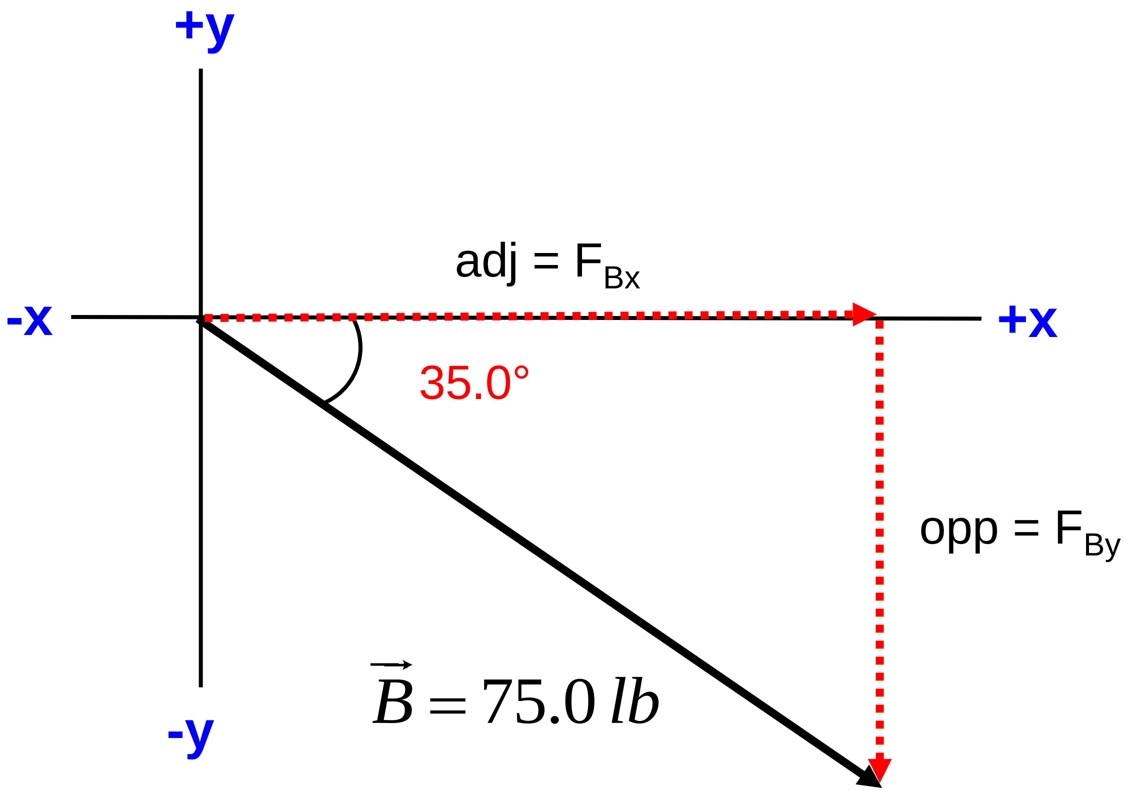
$$\cos\theta = \frac{adj}{hyp}$$

$$\cos\theta = \frac{F_{BX}}{\vec{B}}$$

$$\cos 35.0° = \frac{F_{BX}}{75.0\ lb}$$

$$F_{BX} = 75.0\ lb \cos 35.0°$$

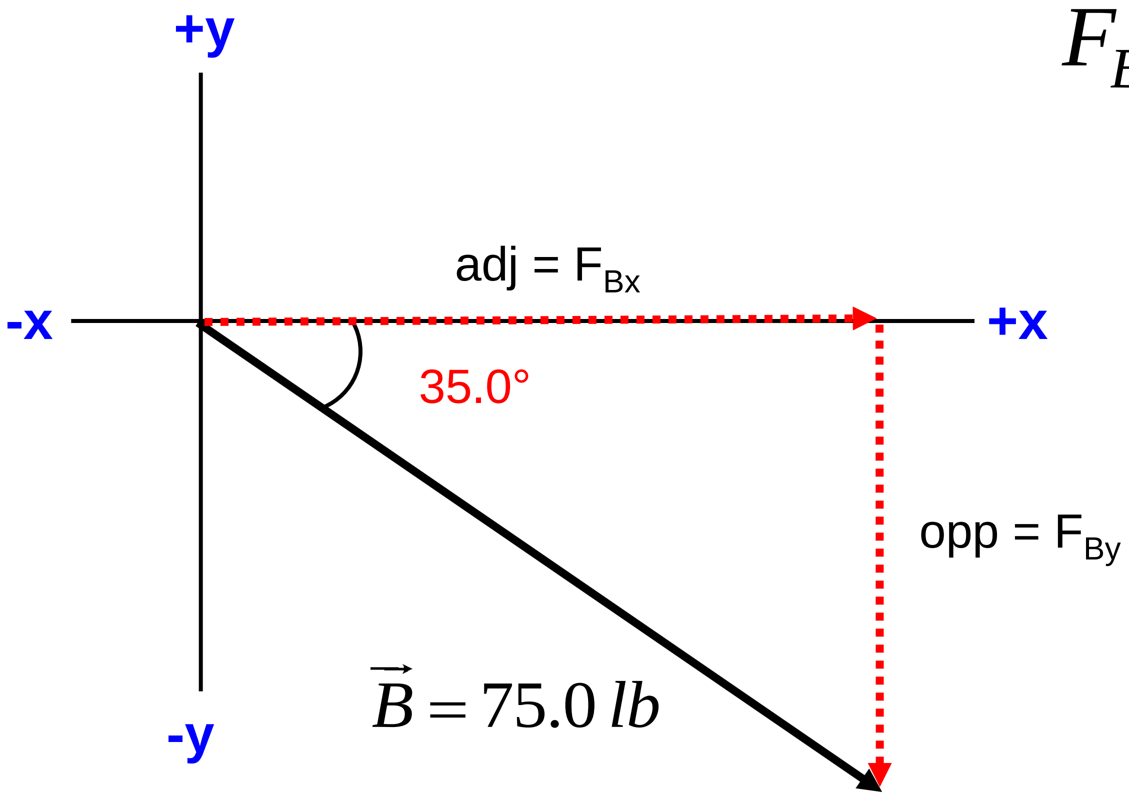
$$F_{BX} = 61.4\ lb$$



Vector X and Y Components – Your Turn

Solve for F_{BY}

$$\sin\theta = \frac{opp}{hyp} \qquad \sin\theta° = \frac{-F_{By}}{\vec{B}} \qquad \sin 35.0° = \frac{-F_{By}}{75.0\ lb}$$

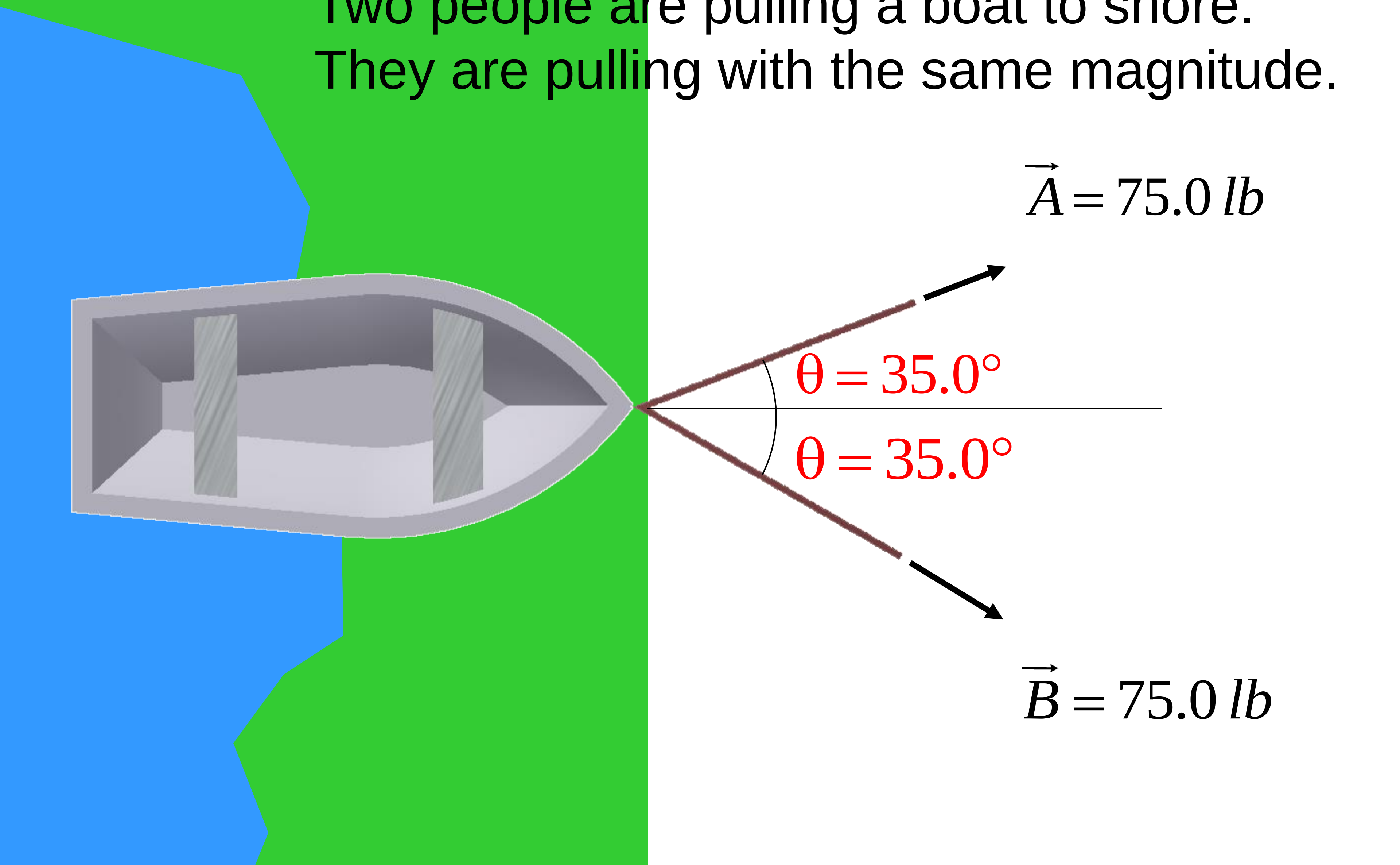


$$F_{By} = -75.0\ lb \sin 35.0°$$

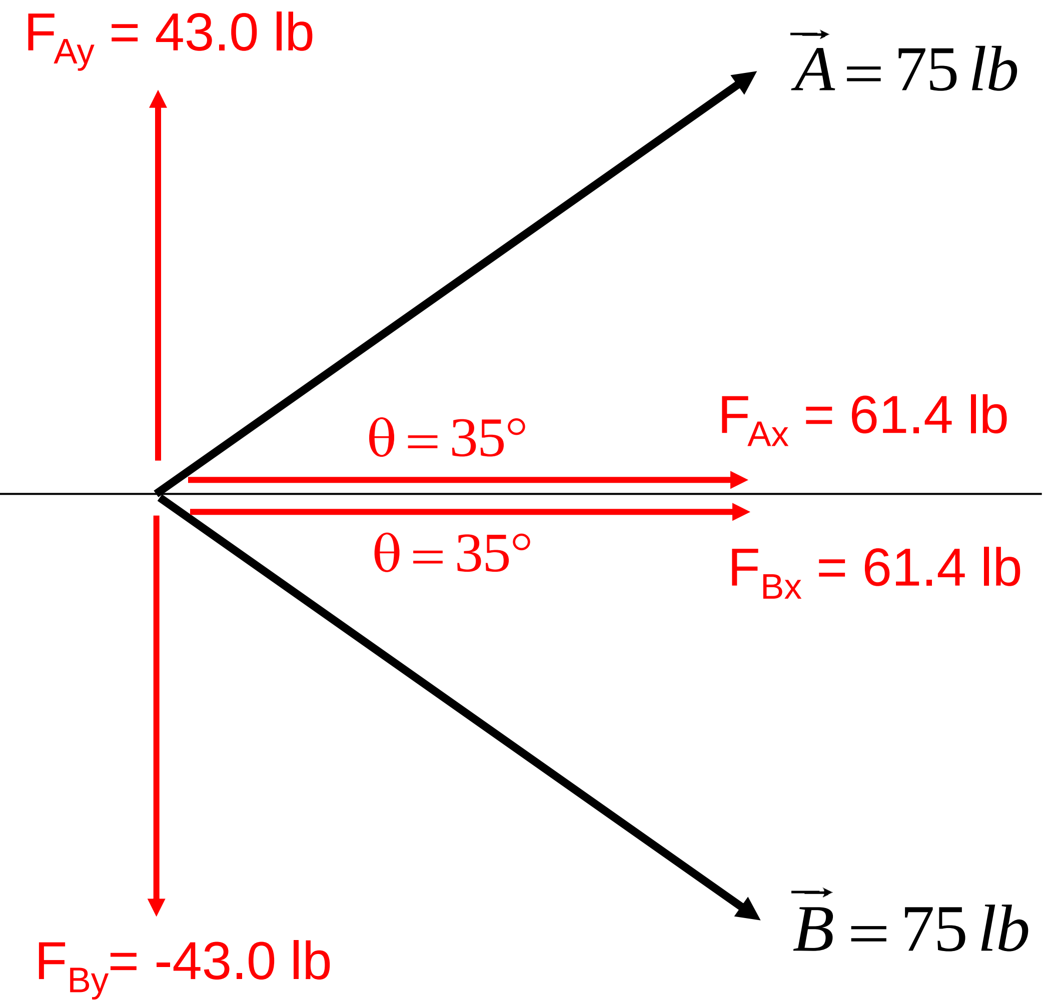
$$F_{By} = -43.0\ lb$$

Resultant Force

Two people are pulling a boat to shore. They are pulling with the same magnitude.



Resultant Force



List the forces according to **sense**.

Label right and up forces as **positive**, and label left and down forces as **negative**.

F_x

F_{Ax} = +61.4 lb

F_{Bx} = +61.4 lb

F_y

F_{Ay} = +43.0 lb

F_{By} = -43.0 lb

Resultant Force

F_x

$F_{Ax} = +61.4$ lb

$F_{Bx} = +61.4$ lb

F_y

$F_{Ay} = +43.0$ lb

$F_{By} = -43.0$ lb

Sum ($\sum$) the forces

$\sum F_x = F_{Ax} + F_{Bx}$

$\sum F_x = 61.4\underline{36}$ lb $+ 61.4\underline{36}$ lb

$\sum F_x = 122.9$ lb (right)

$\sum F_y = F_{Ay} + F_{By}$

$\sum F_y = 43.0\underline{18}$ lb $+ (-43.0\underline{18}$ lb$) = 0$

Magnitude is **122.9** lb.

Direction is **0°** from the x axis

Sense is **right**.

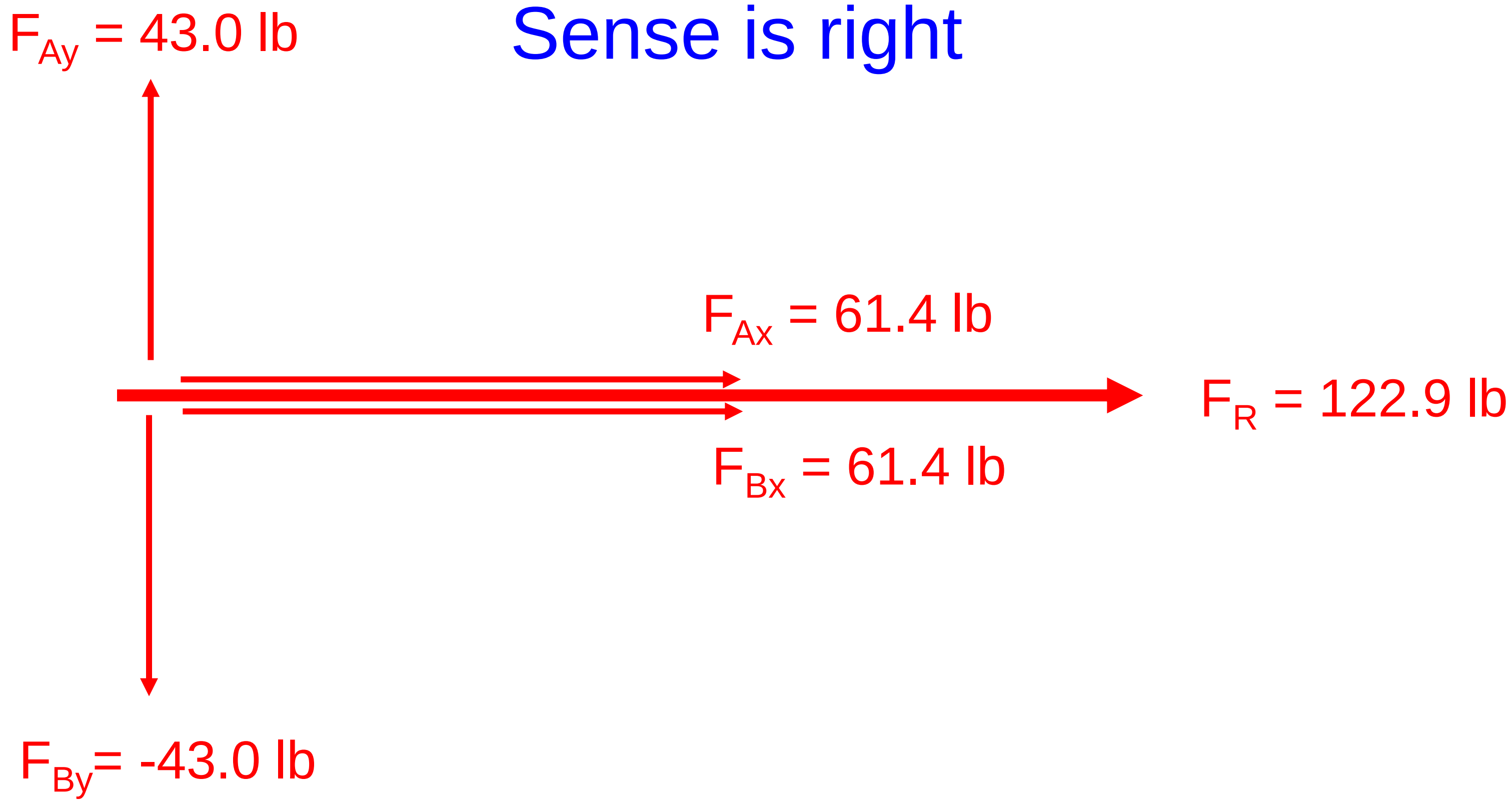
Resultant Force

Draw the resultant force (F_R)

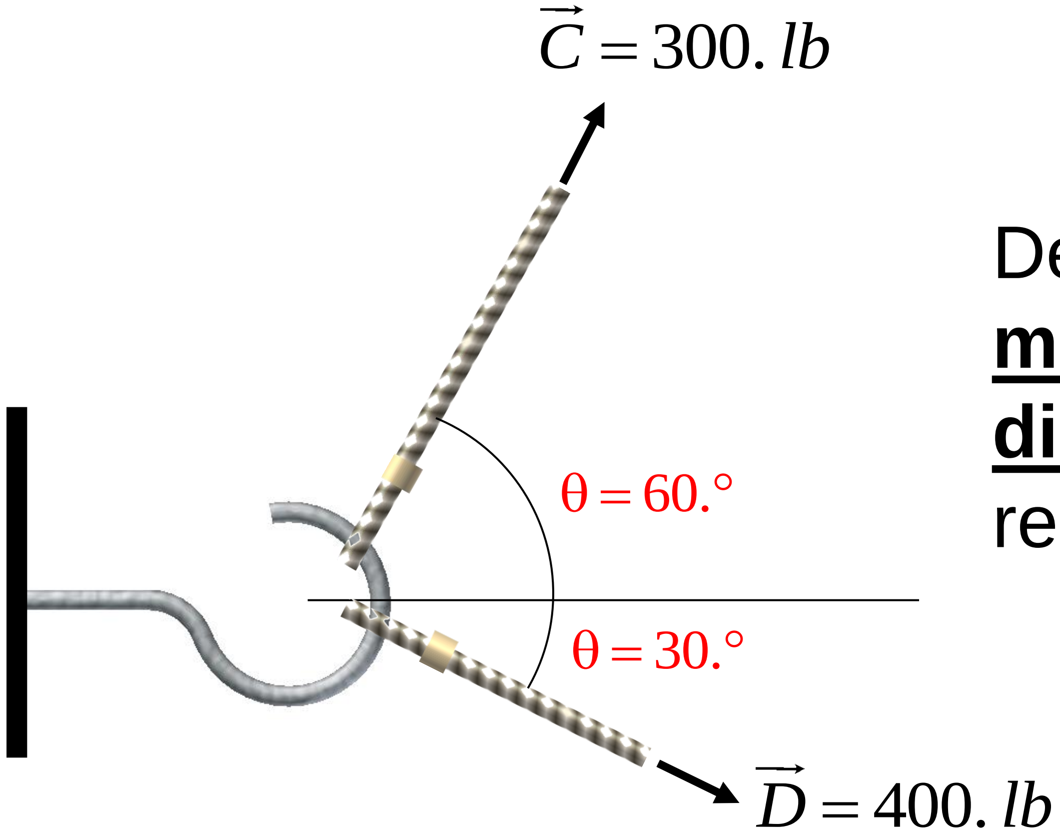
Magnitude is 123 lb

Direction is 0° from the x axis

Sense is right



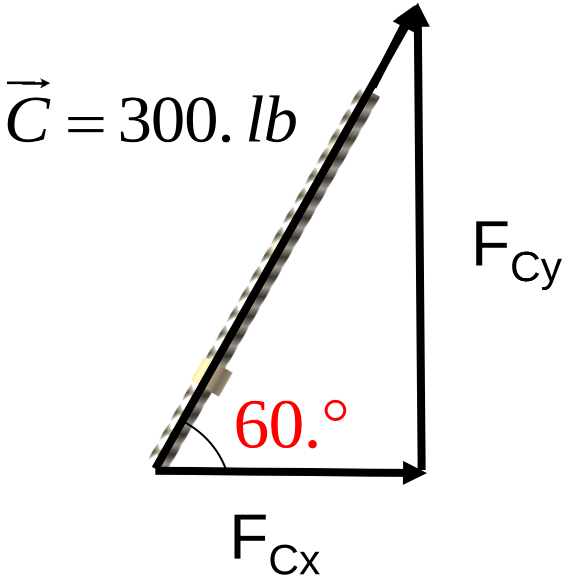
Resultant Force



Determine the **sense**, **magnitude**, and **direction** for the resultant force.

Resultant Force

Find the x and y components of vector C.



F_{Cx} = 300. lb cos60.°

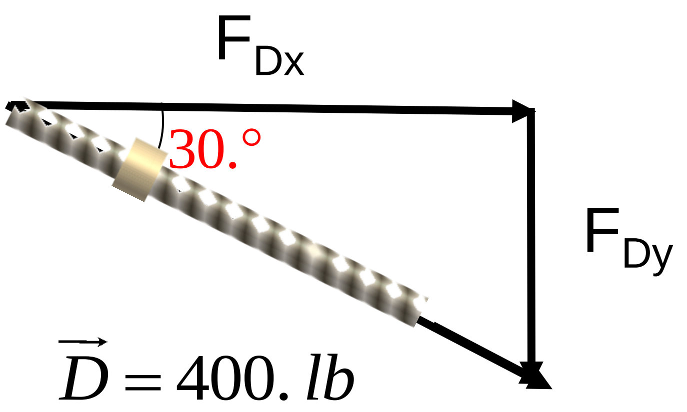
F_{Cx} = **150 lb**

F_{Cy} = 300. lb sin60.°

F_{Cy} = **260 lb**

Resultant Force

Find the x and y components of vector D.



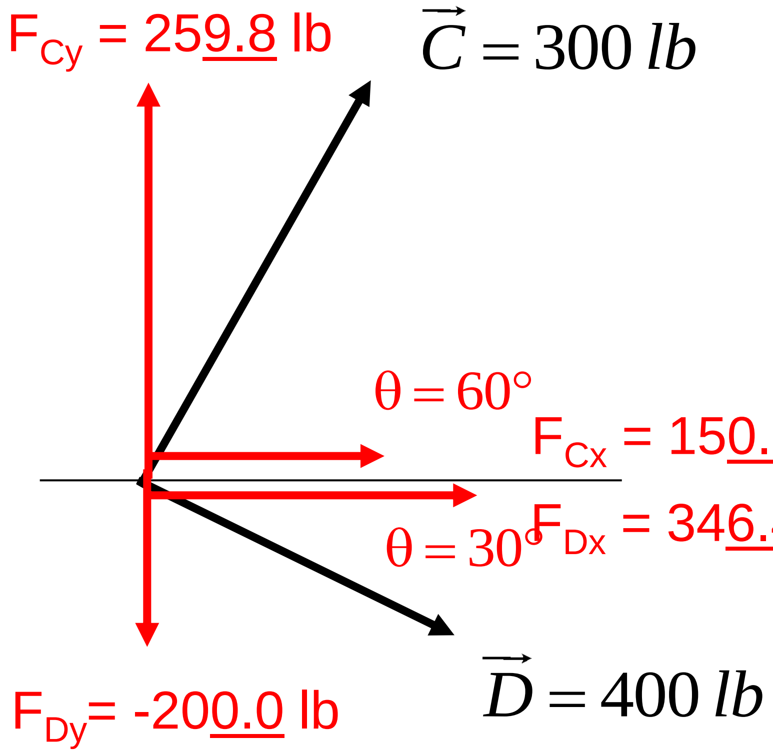
F_{Dx} = 400 lb cos30.°

F_{Dx} = **<u>350 lb</u>**

F_{Dy} = -400 lb sin30.°

F_{Dy} = **<u>-200 lb</u>**

Resultant Force



List the forces according to sense.

Label right and up forces as **positive**, and label left and down forces as **negative**.

F_x

F_{Cx} = +150.0 lb

F_{Dx} = +346.4 lb

F_y

F_{Cy} = +259.8 lb

F_{Dy} = -200.0 lb

Resultant Force

Sum ($\sum$) the forces

F_x

F_{Cx} = +150.0 lb

F_{Dx} = +346.4 lb

F_Y

F_{Cy} = +259.8 lb

F_{Dy} = -200.0 lb

$\sum F_x = F_{Cx} + F_{Dx}$

$\sum F_x$ = 150.0 lb + 346.4 lb = 496.4 lb (right)

$\sum F_y = F_{Cy} + F_{Dy}$

$\sum F_y$ = 259.8 lb + (-200.0 lb) = 59.8 lb (up)

Sense is **right** and **up**.

Resultant Force

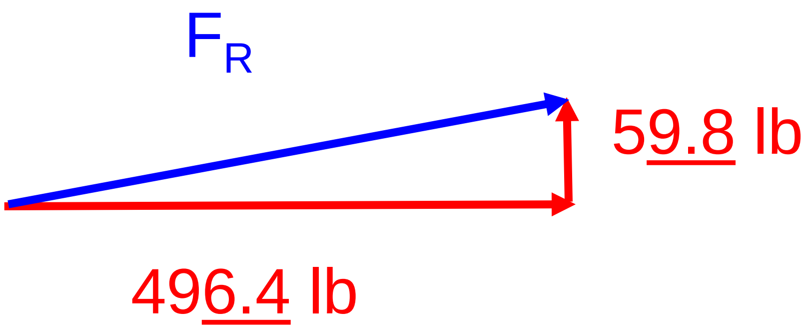
Draw the x and y components of the resultant force.

$\sum F_x$ = 496.4 lb (right) $\sum F_y$ = 59.8 (up)

Two ways to draw the X and Y components

Resultant Force

Solve for **magnitude**.



$a^2 + b^2 = c^2$

$(59.8 \text{ lb})^2 + (496.4 \text{ lb})^2 = F_R^2$

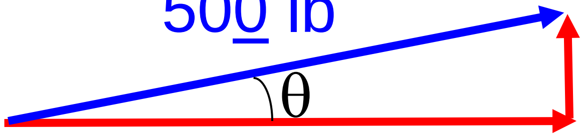
$$\sqrt{(59.8\ lb^2) + (496.4\ lb^2)} = F_R$$

$F_R = 500$ lb or $5.0\text{x}10^2$ lb

Magnitude is **$5.0\text{x}10^2$ lb (500 lbs)**

Resultant Force

Solve for **direction**.



$$\tan\theta = \frac{opp}{adj}$$

$$\tan\theta = \frac{59.8\ \cancel{lb}}{496.4\ \cancel{lb}}$$

$$\theta = \tan^{-1}\left(\frac{59.8}{496.4}\right)$$

$$\theta = 7^\circ$$

Direction is **7° counterclockwise** from the positive X axis.

Resultant Force

Draw the **resultant** force (F_R)

Magnitude is 500 lb.

Direction is 7° counterclockwise from the positive x axis.

Sense is right and up.