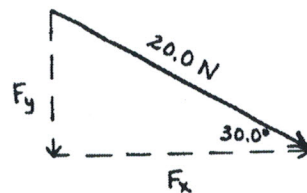


**Example 5:** Ralph is mowing the back yard with a push mower that he pushes downward with a force of 20.0 N at an angle of 30.0° to the horizontal. What are the horizontal and vertical components of the force exerted by Ralph?

**Solution:** Begin solving by drawing a diagram of the situation, labeling the horizontal and vertical components of the force.



**Horizontal component:** The hypotenuse in this exercise is the 20.0-N force. The horizontal component is the one going in the x direction. This is the side adjacent to the 30.0° angle so you use the equation for the cosine of an angle.

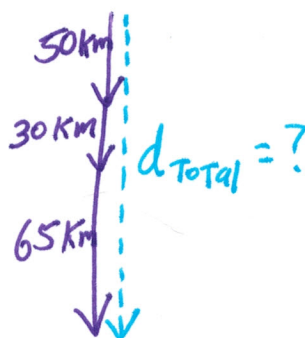
$$\cos \theta = \frac{F_x}{F} \quad F_x = F \cos \theta = (20.0 \text{ N}) \cos 30.0^\circ = 17.3 \text{ N}$$

**Vertical component:** Again, the 20.0-N force is the hypotenuse of the triangle. The vertical component is the one going in the y direction. This is the side opposite the 30.0° angle so you use the equation for the sine of an angle.

$$\sin \theta = \frac{F_y}{F} \quad F_y = F \sin \theta = (20.0 \text{ N}) \sin 30.0^\circ = 10.0 \text{ N}$$

### Practice Exercises

**Exercise 1:** Some Antarctic explorers heading due south toward the pole travel 50. km during the first day. A sudden snowstorm slows their progress and they move only 30. km on the second day. With plenty of rest, they travel the final 65 km the last day and reach the pole. What was the explorers' displacement?



$$50 \text{ km} + 30 \text{ km} + 65 \text{ km} =$$

$$\boxed{145 \text{ km}}$$

Answer: 145 km

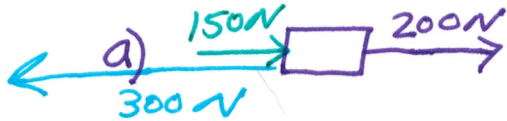
**Exercise 2:** Erica and Tory are out fishing on the lake on a hot summer day when they both decide to go for a swim. Erica dives off the front of the boat with a force of 45 N, while Tory dives off the back with a force of 60 N. a) Draw a vector diagram of the situation. b) Find the resultant force on the boat.



b)  $-45\text{ N} + 60\text{ N} = \boxed{15\text{ N}}$

Answer: b. 15 N

**Exercise 3:** Young thoroughbreds are sometimes reluctant to enter the starting gate for their first race. Astro Turf is one such horse, and it takes two strong men to get him set for the race. Derek pulls Astro Turf's bridle from the front with a force of 200 N and Dan pushes him from behind with a force of 150 N, while the horse pushes back against the ground with a force of 300 N. a) Draw a vector diagram of the situation. b) What is the resultant force on Astro Turf?



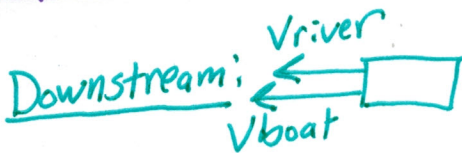
b)  $200\text{ N} + 150\text{ N} + -300\text{ N} = \boxed{50\text{ N}}$

Answer: b. 50 N

**Exercise 4:** Shareen finds that when she drives her motorboat upstream she can travel with a speed of only 8 m/s, while she moves with a speed of 12 m/s when she heads downstream. What is the current of the river on which Shareen is traveling?



$V_{\text{boat}} - V_{\text{river}} = 8\text{ m/s}$  (going up the river)



$-V_{\text{boat}} - V_{\text{river}} = -12\text{ m/s}$  (going down the river)

Answer: 2 m/s

$V_{\text{boat}} - V_{\text{river}} = 8\text{ m/s}$   
 $-V_{\text{boat}} - V_{\text{river}} = -12\text{ m/s}$

$$\frac{-2V_{\text{river}}}{-2} = \frac{-4\text{ m/s}}{-2} \rightarrow V_{\text{river}} = \boxed{2\text{ m/s}}$$

**Exercise 5:** Rochelle is flying to New York for her big Broadway debut. If the plane heads out of Los Angeles with a velocity of 220. m/s in a northeast direction, relative to the ground, and encounters a wind blowing head-on at 45 m/s, what is the resultant velocity of the plane, relative to the ground?



$$220 \text{ m/s} - 45 \text{ m/s} = \boxed{175 \text{ m/s}}$$

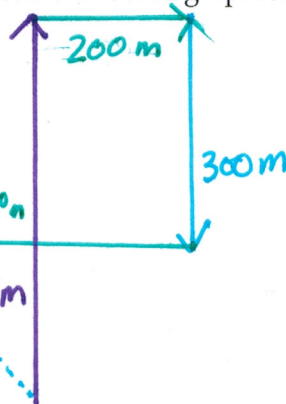
Answer: 175 m/s

**Exercise 6:** While Dexter is on a camping trip with his boy scout troop, the scout leader hands each boy a compass and map. The directions on Dexter's map read as follows: "Walk 500.0 m north, 200.0 m east, 300.0 m south, and 400.0 m west." If he follows the map, what is Dexter's displacement? Solve graphically.

Drawn such that  
 $1 \text{ cm} = 100 \text{ m}$

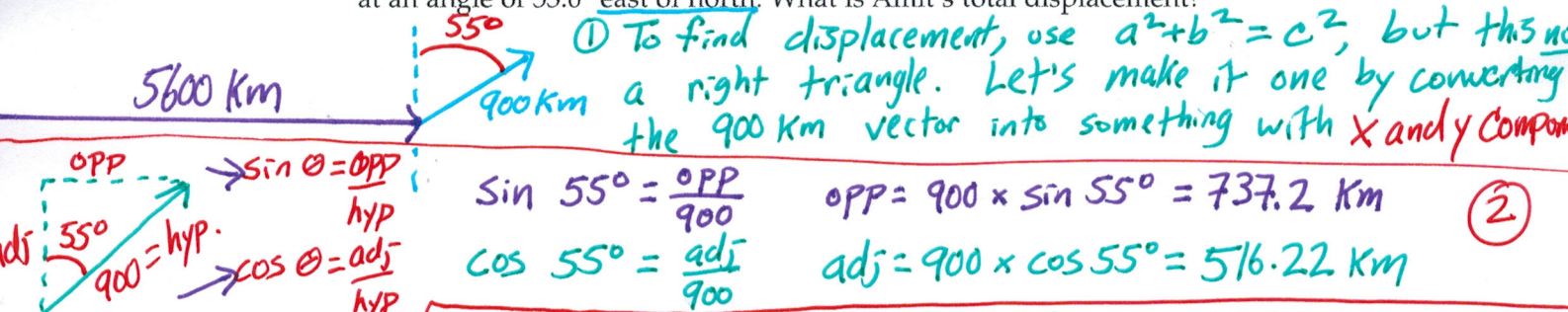
Displacement measures  
 $2.8 \text{ cm}$

$$2.8 \text{ cm} \times \frac{100 \text{ m}}{1 \text{ cm}} = \text{displacement. } 280 \text{ m}$$

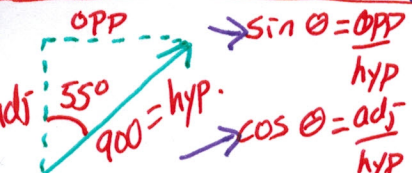


Answer: 280 m

**Exercise 7:** Amit flies due east from San Francisco to Washington, D.C., a displacement of 5600. km. He then flies from Washington to Boston, a displacement of 900. km at an angle of  $55.0^\circ$  east of north. What is Amit's total displacement?



① To find displacement, use  $a^2 + b^2 = c^2$ , but this needs a right triangle. Let's make it one by converting the 900 km vector into something with x and y components



$$\sin 55^\circ = \frac{\text{opp}}{900} \quad \text{opp} = 900 \times \sin 55^\circ = 737.2 \text{ km} \quad (2)$$

$$\cos 55^\circ = \frac{\text{adj}}{900} \quad \text{adj} = 900 \times \cos 55^\circ = 516.22 \text{ km}$$

$$6358.19 \text{ km} \quad (5600 + 737.2)^2 + (516.22)^2 = c^2$$

$$40160103.84 + 266483.08 = c^2$$

$$\sqrt{40426586.93} = c$$

Answer: 6358.19 km

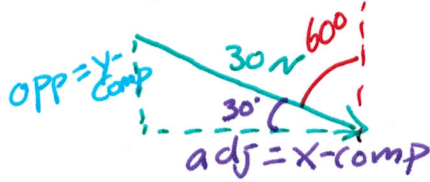
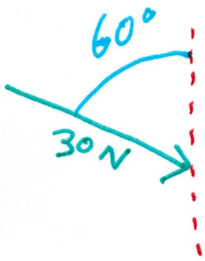
Triangle is now:

③



$$\boxed{c = 6358.19 \text{ km}}$$

**Exercise 8:** Marcie shovels snow after a storm by exerting a force of 30.0 N on her shovel at an angle of  $60.0^\circ$  to the vertical. What are the horizontal and vertical components of the force exerted by Marcie?



$$90^\circ - 60^\circ = 30^\circ$$

$$\sin \theta = \frac{\text{opp}}{\text{hyp}} \quad \sin 30^\circ = \frac{\text{opp}}{30}$$

$$\text{opp} = 30 \cdot \sin 30^\circ = \boxed{15 \text{ N}}$$

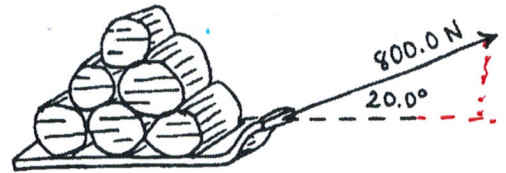
$$\cos \theta = \frac{\text{adj}}{\text{hyp}} \quad \cos 30^\circ = \frac{\text{adj}}{30}$$

Answer: 15 N

Answer: 25.98 N

$$\text{adj} = 30 \cdot \cos 30^\circ = \boxed{25.98 \text{ N}}$$

**Exercise 9:** Ivan pulls a sled loaded with logs to his cabin in the woods. If Ivan pulls with a force of 800. N in a direction  $20.0^\circ$  above the horizontal, what are the horizontal and vertical components of the force exerted by Ivan?



Answer: 273.62 N

Answer: 751.754 N

$$\sin \theta = \frac{\text{opp}}{\text{hyp}}$$

$$\sin 20^\circ = \frac{\text{opp}}{800}$$

$$\text{opp} = 800 \cdot \sin 20^\circ = \boxed{273.62 \text{ N}}$$

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

$$\cos 20^\circ = \frac{\text{adj}}{800}$$

$$\text{adj} = 800 \cdot \cos 20^\circ = \boxed{751.754 \text{ N}}$$