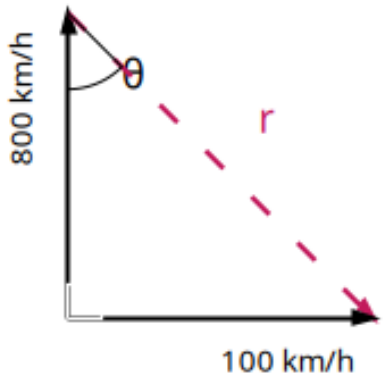
4.4 Applications of Vector Addition Worksheet with solutions

This document was composed and formatted by Annie Bernatchez.

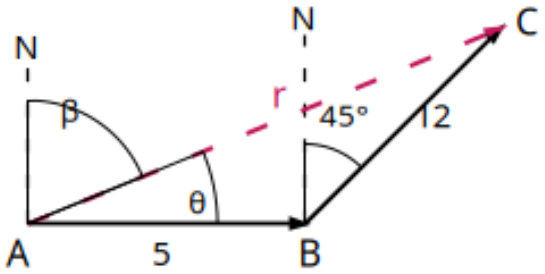
The course material originated from www.jensenmath.ca

1) The velocity of an airplane is 800 km/h north. A wind is blowing due east at 100 km/h. Determine the velocity of the airplane relative to the ground.

$\lvert\vec{v}_{ground}\rvert^2 = 800^2 + 100^2$ $\lvert\vec{v}_{ground}\rvert \approx 806.2$ km/h $\tan\theta = \frac{100}{800}$ $\theta \approx 7.1°$	

The ground velocity is 806.2 km/h at a quadrant bearing of $N7.1°E$.

2) A particle is displaced 5 units to the east and then displaced 12 units in a direction $N45°E$. Find the magnitude and direction of the resultant displacement.

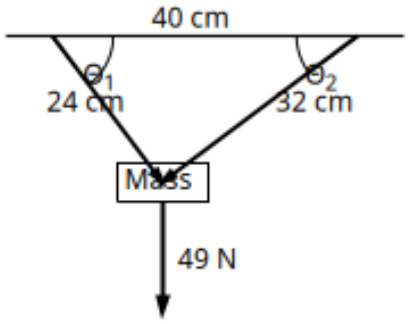
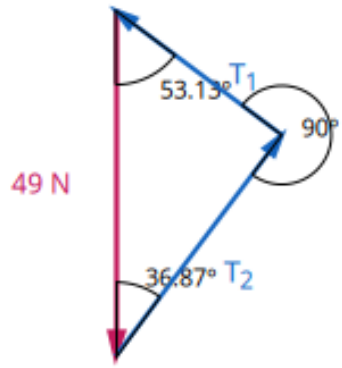


$\lvert\vec{r}\rvert^2 = 5^2 + 12^2 - 2(5)(12)\cos(135°)$ $\lvert\vec{r}\rvert \approx 15.93$ units $\cos\theta = \frac{12^2 - 5^2 - 15.93^2}{-2(5)(15.93)}$	$\theta \approx 32.2°$ $\beta = 90 - 32.2°$ $\beta \approx 57.8°$

The resultant is 15.93 units at a quadrant bearing of $N57.8°E$.

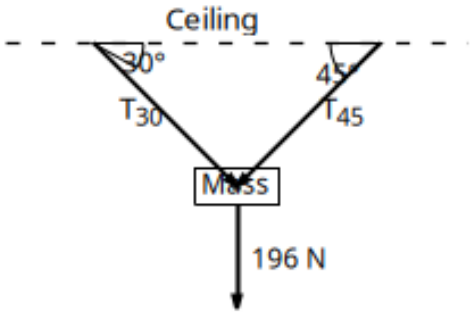
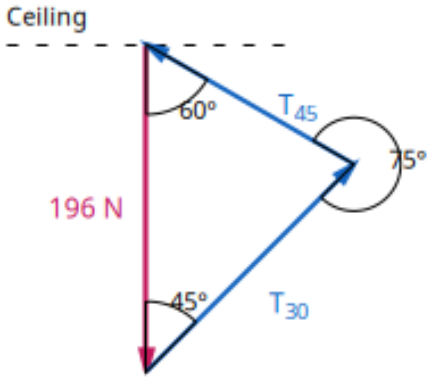
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3) A mass of 5 kg is suspended by two strings, 24 cm and 32 cm long, from two points that are 40 cm apart and at the same level. Determine the tension in each of the strings.

Position Diagram	Vector Diagram
	

$\cos\Theta_1 = \frac{24^2 - 40^2 - 32^2}{-2(40)(32)}$ $\Theta_1 \approx 36.87°$ $\cos 53.13° = \frac{\lvert\vec{T_1}\rvert}{49}$ $\lvert\vec{T_1}\rvert \approx 29.4$ N (32 cm string)	$\cos\Theta_2 = \frac{32^2 - 24^2 - 40^2}{-2(24)(40)}$ $\Theta_2 \approx 53.13°$ $\sin 53.13° = \frac{\lvert\vec{T_2}\rvert}{49}$ $\lvert\vec{T_2}\rvert \approx 39.2$ N (24 cm string)

4) A mass of 20 kg is suspended from a ceiling by two lengths of rope that make angles of 30° and 45° with the ceiling. Determine the tension in each rope.

Position Diagram	Vector Diagram
	

$$\frac{196}{\sin 75} = \frac{\lvert\vec{T_{45}}\rvert}{\sin 60} = \frac{\lvert\vec{T_{30}}\rvert}{\sin 45}$$

$\lvert\vec{T_{45}}\rvert \approx 175.73$ N (45° rope); $\lvert\vec{T_{30}}\rvert \approx 143.48$ N (30° rope)

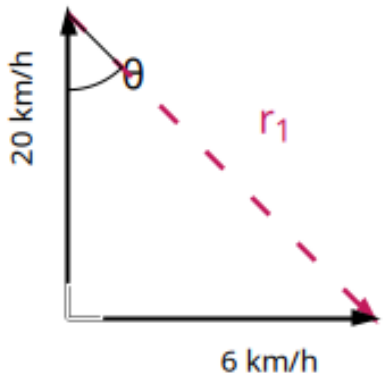
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5) A river is 2 km wide and flows at 6 km/h. Anna is driving a motorboat, which has a speed of 20 km/h in still water and she heads out from one bank in a direction perpendicular to the current. A marina lies directly across the river from the starting point on the opposite bank.

a) How far downstream from the marina will the current push the boat?

$\tan 16.7° = \frac{x}{2}$

$x \approx 0.6$ km



b) How long will it take for the boat to cross the river?

$$\cos 16.7° = \frac{20}{|\vec{r_1}|}$$

$|\vec{r_1}| \approx 20.9$ km/h

Time to cross $= \frac{2.1 \text{ km}}{20.9 \text{ km/h}} \approx 0.1$ hours (6 minutes)

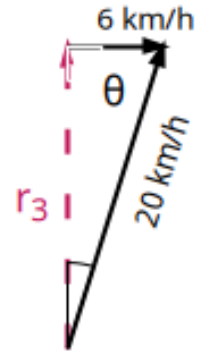
c) If Anna decides that she wants to end up directly across the river at the marina, in what direction should she head? What is the resultant velocity of the boat?

$\sin\theta = \frac{6}{20}$

$\theta \approx 17.5°$

$|\vec{r_3}|^2 = 20^2 - 6^2$

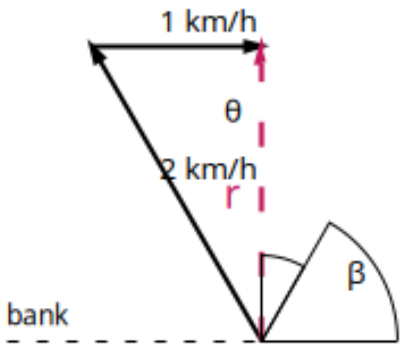
$|\vec{r_3}| \approx 19.1$ km/h



The boat needs to head out at an angle of 72.5° with the shore. The resultant velocity is 19.1 km/h.

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6) Adam can swim at the rate of 2 km/h in still water. At what angle to the bank of a river must he head if he wants to swim directly across the river and the current in the river moves at the rate of 1 km/h.

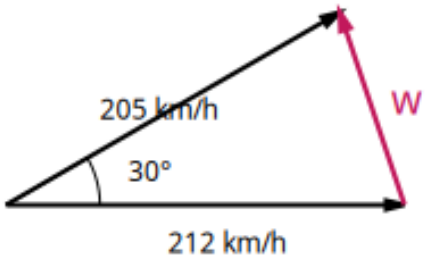


$$\sin\theta = \frac{1}{2}$$
$$\theta = 30°$$

Adam must head at 60° to the bank of the river.

7) An airplane is travelling $N60°E$ with a resultant ground speed of 205 km/h. The nose of the plane is actually pointing east with an airspeed of 212 km/h. Find the wind speed and direction.

$$|\vec{w}|^2 = 205^2 + 212^2 - 2(205)(212)\cos(30)$$
$$|\vec{w}| \approx 108.1 \text{ km/h}$$
$$\cos\theta = \frac{205^2 - 212^2 - 108.1^2}{-2(212)(108.1)}$$
$$\theta \approx 71.4°$$
$$\beta \approx 18.6°$$



The wind speed is 108.1 km/h at a quadrant bearing of $N18.6°W$.

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