Relative Velocities

Frame of reference

A set of coordinates used to measure the velocity of an object

When adding vectors, always add tip to tail. The general equation for relative velocity vectors is

$$\vec{v}_{og} = \vec{v}_{om} + \vec{v}_{mg}$$

$\vec{v}_{og}$ = Velocity of the object relative to the ground

$\vec{v}_{om}$ = Velocity of the object relative to the medium

$\vec{v}_{mg}$ = Velocity of the medium relative to the ground

Typical Objects: footballs, airplanes, ships, swimmers, newspapers

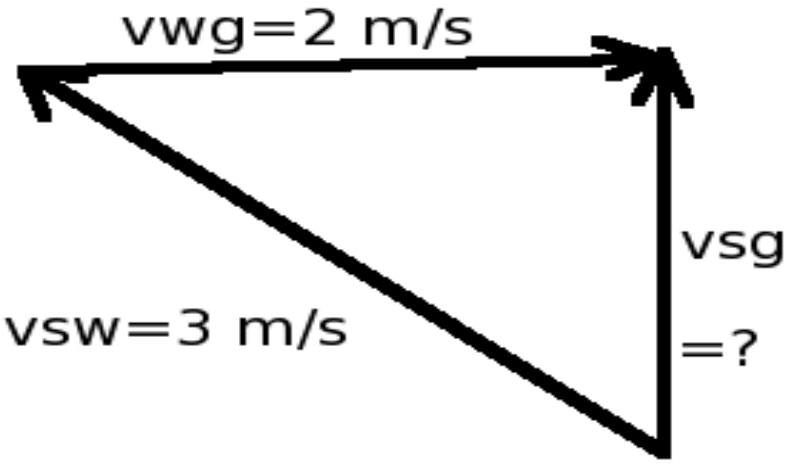
Typical Media: quarterbacks, air, water, newspaper delivery personnel

Examples:

1. Iggy is swimming across the St. Lawrence River, where the current is 2 m/s [E]. He is able to swim with a speed of 3 m/s in still water.

a) What must his heading be in order to progress directly across to the other side (North)? What is his velocity relative to the ground in this case?

b) If his heading is directly North, what will his velocity be relative to the ground and how far down river does he end up?



$$a)\ \vec{v}_{sg} = \vec{v}_{sw} + \vec{v}_{wg}$$

$$\sin\theta = \frac{2}{3}$$

$$\theta = 42^{o}$$

Therefore heading is [N 42º W].

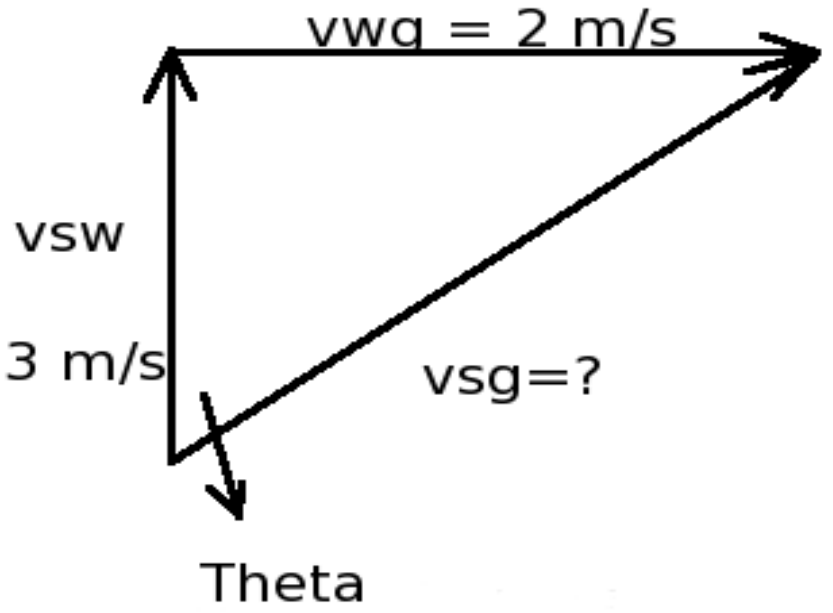
$$\tan 42^{o} = \frac{2}{v_{sg}} \qquad \vec{v}_{sg} = 2.22\,m/s\ [N]$$

b) $v_{sg}^2 = 2^2 + 3^2$

$v_{sg} = 3.6\ m/s$

$\tan\theta = \frac{2}{3}$

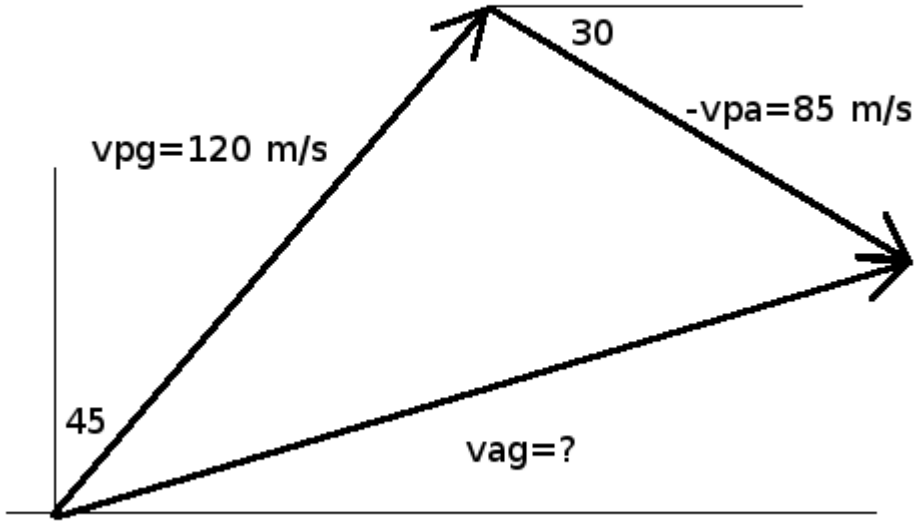
$\theta = 34^o$



$\vec{v}_{sg} = 3.6\ m/s\ [N\ 34^o\ E]$

2. Selma is flying her Sopwith Camel with a velocity of 120 m/s [NE] relative to the ground. The air speed of the plane is 85 m/s and its heading is [W30ºN]. What is the wind speed and direction?

$$a)\ \vec{v}_{pg} = \vec{v}_{pa} + \vec{v}_{ag}$$



$$so\ \vec{v}_{ag} = \vec{v}_{pg} - \vec{v}_{pa}$$

Using components:

$$v_{agx} = 120\cos 45^o + 85\cos 30^o$$

$$= 158.5 \ m/s$$

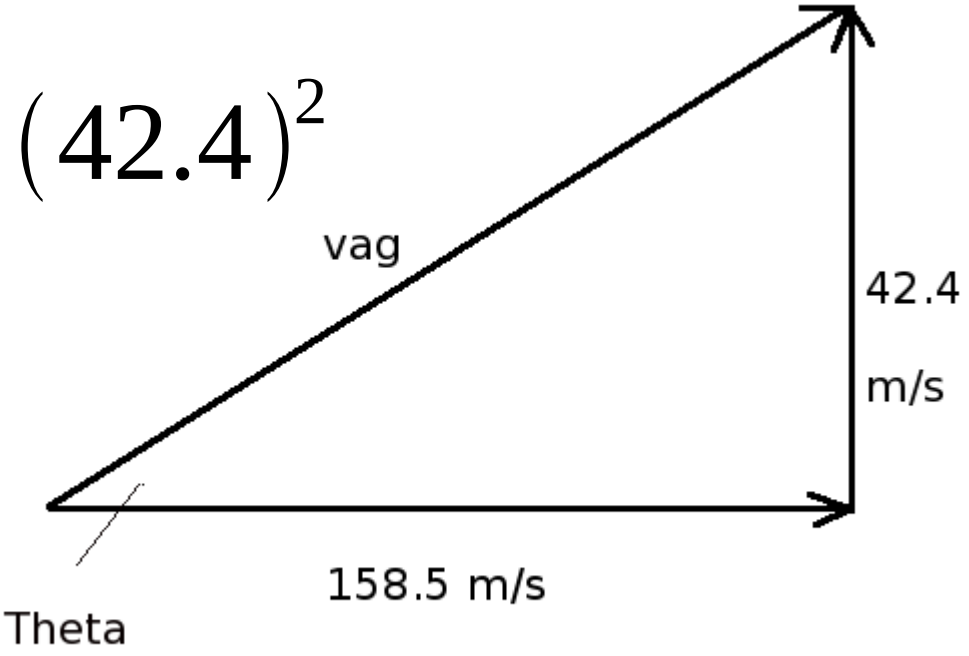
$$v_{agy} = 120\sin 45^o - 85\sin 30^o$$

$$= 42.4 \ m/s$$

$$(v_{ag})^2 = (158.5)^2 + (42.4)^2$$

$$= 164.1 \ m/s$$

$$\tan\theta = \frac{42.4}{158.5}$$



$$\theta = 15^{o}$$

$$\vec{v}_{ag} = 164.1\ m/s\ [E15^{o}N]$$