Relative motion:
- All motion is relative.
- This means that one must specify a specific frame of reference when speaking of an objects motion.

Ex: You are sitting on a train that is traveling at 150km/h [E]. Relative to the train, you are at rest. Relative to the Earth, however, you are travelling at 150km/h [E]. It even becomes more apparent when you move the reference frame off the surface of the Earth. Relative to a fixed point in orbit, you are moving at a speed of approximately 1500km/h and hurtling through space at approximately 108,000km/h!

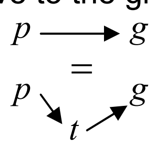
Because of the complexity of relative motion, it is important to define an appropriate notation.

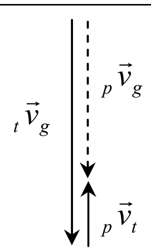
${}_y\vec{v}_t = 0km/h$ → your velocity relative to the train
${}_y\vec{v}_E = 150km/h[E]$ → your velocity relative to the Earth
${}_y\vec{v}_o = 1500km/h[E]$ → your velocity relative to a fixed point in orbit
${}_y\vec{v}_S = 108000km/h[CCW]$ → your velocity relative to the sun

<u>Relative motion follows the rules of vector addition</u>.

Ex1: Passenger on a train, traveling at 150km/h [S], walks to the back of the train at 3.0km/h. What is the passenger's velocity relative to the ground?

${}_p\vec{v}_g = {}_p\vec{v}_t + {}_t\vec{v}_g$ Notice the pattern



<table>
<tr><td><u>Given</u>
${}_t\vec{v}_g = 150km/h[S]$
${}_p\vec{v}_t = 3.0km/h[N]$
</td><td><u>RTF</u>
The resultant, ${}_p\vec{v}_g$</td><td><u>Formulae</u>
${}_p\vec{v}_g = {}_p\vec{v}_t + {}_t\vec{v}_g$</td></tr>
<tr><td colspan="3"><u>Solution</u>
Let N be positive
${}_p\vec{v}_g = {}_p\vec{v}_t + {}_t\vec{v}_g$
${}_pv_g = ({}_pv_t) - ({}_tv_g)$
${}_pv_g = (3.0) - (150)$
${}_pv_g = -147km/h$
$\therefore {}_p\vec{v}_g = 147km/h[S]$</td></tr>
</table>

Notice that $_p\vec{v}_g$ **is** the resultant. This is a very important distinction because as you notice, the resultant is not the longest vector necessarily. The resultant is always on the **left side** of the vector equation.

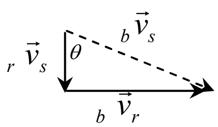
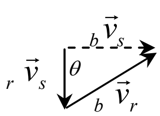
River crossing questions

Ex2: A boy can swim at maximum speed of 2.0m/s. He dives into a river with a current of 1.0m/s [S].

a) What is the boy's velocity w.r.t the shore if he orients his body due east?
b) What is the boy's velocity w.r.t the shore if he actually wants to swim due east?

Given	**RTF**	**Formulae**
$_bv_r = 2.0m/s$ $_r\vec{v}_s = 1m/s[S]$	a) $_b\vec{v}_s$ if orientation is due east b) $_b\vec{v}_s$ if actual path is due east	$_b\vec{v}_s = _b\vec{v}_r + _r\vec{v}_s$

Solution

a) 	$_b\vec{v}_s = _b\vec{v}_r + _r\vec{v}_s$ **Find** $\lvert _b\vec{v}_s \rvert$ $\lvert _b\vec{v}_s \rvert = \sqrt{(_bv_r)^2 + (_rv_s)^2}$ $_bv_s = \sqrt{(2.0)^2 + (1.0)^2}$ $_bv_s = 2.2m/s$	**Find** θ $\tan\theta = \frac{opp}{adj}$ $\tan\theta = \frac{_bv_r}{_rv_s}$ $\tan\theta = \frac{2.0}{1.0}$ $\theta = 63^0$	$\therefore _b\vec{v}_s = 2.2m/s[S63^0E]$
b) 	$_b\vec{v}_s = _b\vec{v}_r + _r\vec{v}_s$ **Find** $\lvert _b\vec{v}_s \rvert$ $(_bv_r)^2 = (_bv_s)^2 + (_rv_s)^2$ $(_bv_s)^2 = (_bv_r)^2 - (_rv_s)^2$ $_bv_s = \sqrt{(_bv_r)^2 - (_rv_s)^2}$ $_bv_s = \sqrt{(2.0)^2 - (1.0)^2}$ $_bv_s = 1.73m/s$	$\therefore _b\vec{v}_s = 1.73m/s[E]$	