Lesson 1.5: Relative Velocity

Unit 1: Kinematics, Vectors, and Mathematics

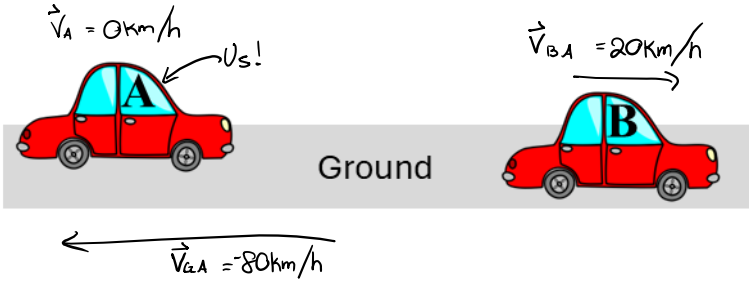
Think of all the times you've been in motion in your life? Can you remember the fastest you've ever went? What were you doing when you were going this velocity?

Velocity is always _____ to a frame of reference.

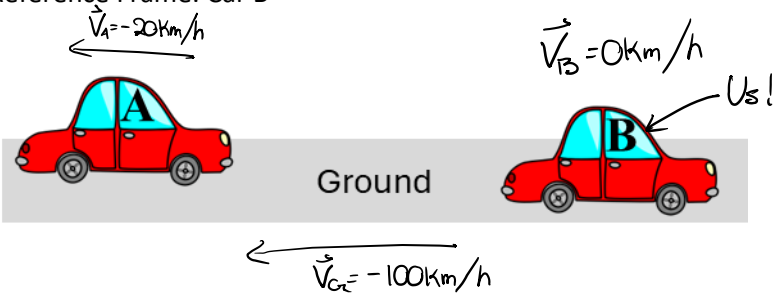
V_{AB} = velocity of A relative to B.

Reference Frame: The Ground

Reference Frame: Car A



Reference Frame: Car B



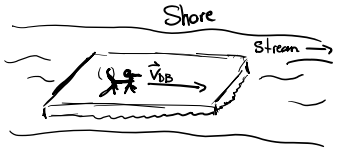
Velocity of A relative to B:

$$\vec{V}_{AB} = \vec{V}_{AG} - \vec{V}_{BG}$$
$$= 80\text{Km/h} - 100\text{Km/h}$$
$$= -20\text{Km/h}$$

Velocity of B relative to A:

$$\vec{V}_{BA} = \vec{V}_{BG} - \vec{V}_{AG}$$
$$= 100\text{Km/h} - 80\text{Km/h}$$
$$= +20\text{ Km/h}$$

Scenario 1: A barge floats down a river at 2.0 m/s. A dog on the barge walks in the downstream direction at 1.0 m/s relative to the log. Find the velocity of the dog relative to the shore.



$\vec{V}_{BS} = +2.0\,m/s$

$\vec{V}_{DB} = +1.0\,m/s$

$\vec{V}_{DS} = ?$

$\vec{V}_{DB} = \vec{V}_{DS} - \vec{V}_{BS}$

$\therefore \vec{V}_{DS} = \vec{V}_{DB} + \vec{V}_{BS}$ ← rearrange.

$\vec{V}_{DS} = 1.0 + 2.0 = \boxed{+2.0\,m/s}$

*Our frame of reference is from the shore! (for all scenarios).

Scenario 2: What if the dog was walking the in the direction opposite to the current (-1.0 m/s)?

$\vec{V}_{BS} = +2.0\,m/s$

$\vec{V}_{DB} = -1.0\,m/s$ (negative.)

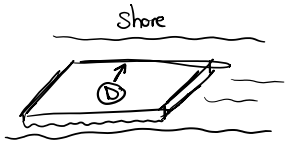
$\vec{V}_{DS} = ?$

$\vec{V}_{DS} = \vec{V}_{DB} + \vec{V}_{BS}$

$= (-1.0) + (2.0)$

$= +1.0\,m/s$

Scenario 3: What if the dog walks perpendicular to the movement of the barge?



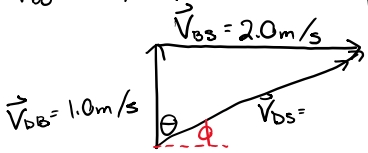
$\vec{V}_{BS} = 2.0\,m/s$ →

$\vec{V}_{DB} = 1.0\,m/s$ ↑

} add the vectors ↘

$\vec{V}_{DS} = \sqrt{1^2 + 2^2}$

$= 2.2\,m/s$



$\theta = \arctan\left(\frac{2}{1}\right) = 63°$

$\phi = 90 - 63 = 27°$

$\boxed{2.2\,m/s \quad 27° \text{ from shore}}$

Example 2: Bartholomew can swim 3.0 m/s. He heads north across a 75 m stream which has a current of 2.0 m/s east.

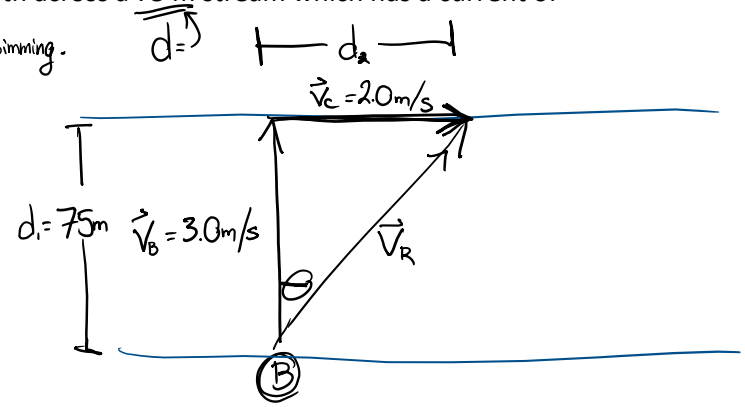
V_c = velocity of current. $\vec{V}_B$ = velocity of Bart swimming.

a) Find his resultant velocity relative to the ground.

$\vec{V}_R = \sqrt{V_s^2 + V_c^2}$ $\quad \theta = \arctan\left(\frac{2}{3}\right) = 34°$

$= \sqrt{3^2 + 2^2}$

$= 3.6\,m/s$ at $34°$ E of N or $56°$ from shore.



b) How long does it take him to cross?

$\vec{V}_B = \frac{\vec{d}_1}{t} \Rightarrow t = \frac{\vec{d}}{\vec{V}} = \frac{75m}{3.0m/s} = 25s$

*current does not effect time here.

c) How far downstream is he carried?

$d_2 = \vec{V}_c t$

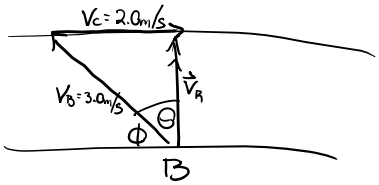
$= 2.0m/s\,(25s) = 50m$ east

d) If he wishes to end his swim directly across from his start, which direction should he swim?

$\theta = \arcsin\left(\frac{2}{3}\right)$

$= 42°$ W of N

or $48°$ upstream from shore.



Assignment: WS 1.5 – Relative Velocity Practice