Unit 3 – 2D Kinematics
Section 3.3: Relative Velocity (Boat-River)

What's your velocity right now?

- depends on who's watching (perspective)
- in reality, something huge cause earth is hurtling through space

It would be stupid to use our *real* velocity every time we wanted to solve a problem. We can make our lives easier by working with relative **velocities.**

Example: In still water (e.g. on a lake), a student can paddle a canoe at 3 m/s.
If they are paddling down a river that flows at 7 m/s, what is their velocity relative to the shore?

7m/s + 3m/s = 10m/s

What is their velocity relative to the shore if they paddle *up* the river?

speed: 3m/s - 7m/s = -4m/s

Here's the equation we just used, without even knowing it...

"In still water" → Direction is called "Heading"

$$\vec{v}_{Boat/River} + \vec{v}_{River/Ground} = \vec{v}_{Boat/Ground}$$

"with respect to" / "as viewed from"

what river's doing

what's actually happening

B = Boat
R = River
G = Ground

Fun fact: This doesn't just work for $\vec{v}$, it works for $\vec{d}$ and $\vec{a}$ as well!

Example: A bullet whizzes past your head at 500 m/s north, fired from a car which soon whizzes past you at 50 m/s north. How fast was the bullet going, as viewed from the car?

B = bullet R = car G = ground

$\vec{v}_{B/R} = x$

$\vec{v}_{R/G} = 50\ m/s\ N$

$\vec{v}_{B/G} = 500\ m/s\ N$

$$\vec{v}_{B/R} + \vec{v}_{R/G} = \vec{v}_{B/G}$$

$$x + 50 = 500$$

$$x = 500 - 50$$

$$x = 450$$

2D Problems

Remember, for problems that are 2D (things not moving in a straight line) we use our equations with

arrows **instead of** numbers.

Example: You see an airplane fly overhead, moving at 90 m/s east. But the wind is blowing at 10 m/s north. What is the airplane's heading and airspeed (speed relative to the air)?

B = plane R = wind/air

$\vec{V}_{B/R} = ?$

$\vec{V}_{R/G} = 10\ m/s\ N$

$\vec{V}_{B/G} = 90\ m/s\ E$

$\vec{V}_{B/R} + \vec{V}_{R/G} = \vec{V}_{B/G}$

heading

$x = \sqrt{a^2 + b^2}$

$= \sqrt{90^2 + 10^2}$

$= \sqrt{8200}$

$= 90.6\ m/s$

airspeed

$\tan\theta = \frac{10}{90}$

$\theta = \tan^{-1}\left(\frac{10}{90}\right)$

$\theta = 6.34°$

$\vec{V}_{B/R} = 90.6\ m/s\ [6.34°\ S\ of\ E]$