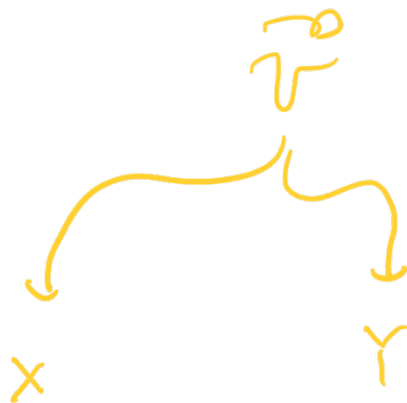


Physics 201 - Lecture 9

- test next Friday 😊
- three-week grades today!
(based only on first two assignments)
- A3 due next Wednesday

\vec{v} , \vec{x} , \vec{a} are vectors.



Relativity \rightarrow Einstein

!

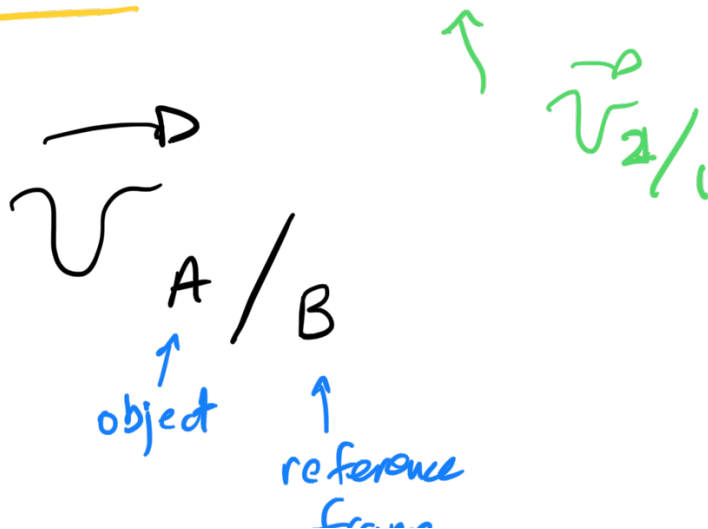
\downarrow

Galileo

Relative Motion of Multiple Objects.



What is the velocity of object 2
relative to object 1?



time

$$\vec{v}_{1/\text{Earth}} = v_1 \hat{i} \quad \checkmark$$

$$\vec{v}_{2/\text{Earth}} = -v_2 \hat{j}$$

$$\vec{v}_{1/2} \quad \checkmark = \vec{v}_{1/\text{Earth}} + \vec{v}_{\text{Earth}/2}$$

Diagram illustrating the addition of velocities. A blue arrow points from the first term to the second, and a red arrow points from the second term to the third. A red arrow labeled $-\vec{v}_{2/\text{Earth}}$ points upwards towards the second term. A red circle highlights the second term, and a question mark is above it.

① 3 reference frames.

②

A, B, C

$$\vec{v}_{B/C} = \vec{v}_{B/A} + \vec{v}_{A/C}$$

Diagram illustrating the addition of velocities. A blue arrow points from the first term to the second, and a red arrow points from the second term to the third.

$$\textcircled{3} \quad \vec{v}_{A/B} = - \vec{v}_{B/A}$$

$$\begin{aligned} \vec{v}_{1/2} &= \vec{v}_{1/\text{Earth}} - \vec{v}_{2/\text{Earth}} \\ &= v_1 \hat{i} - (-v_2 \hat{i}) \end{aligned}$$

$$\vec{v}_{1/2} = \underbrace{(v_1 + v_2)}_{120 \text{ mph}} \hat{i}$$

$$v_1 = 60 \text{ mph}$$

$$v_2 = 60 \text{ mph}$$

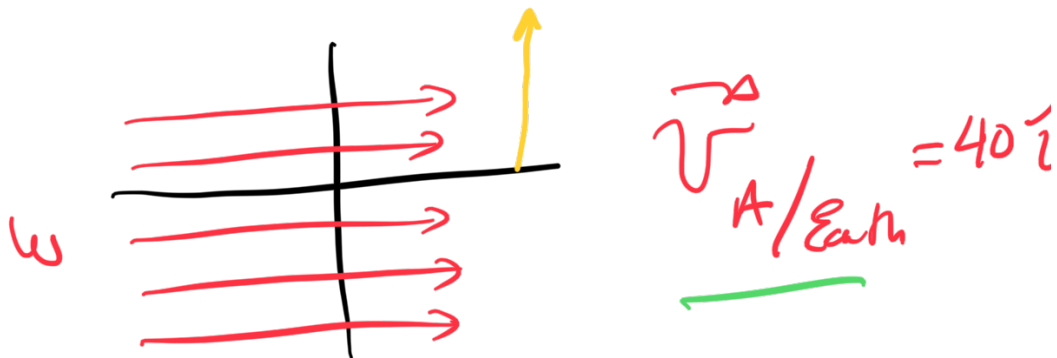
Airplane.

An airplane can fly at 200 mph "in still air".

1 \rightarrow 1 200 mph

$$|\vec{v}_{P/A}| = 200 \text{ mph}$$

Wind blowing from the West at 40 mph.



Plane sets its heading at North.

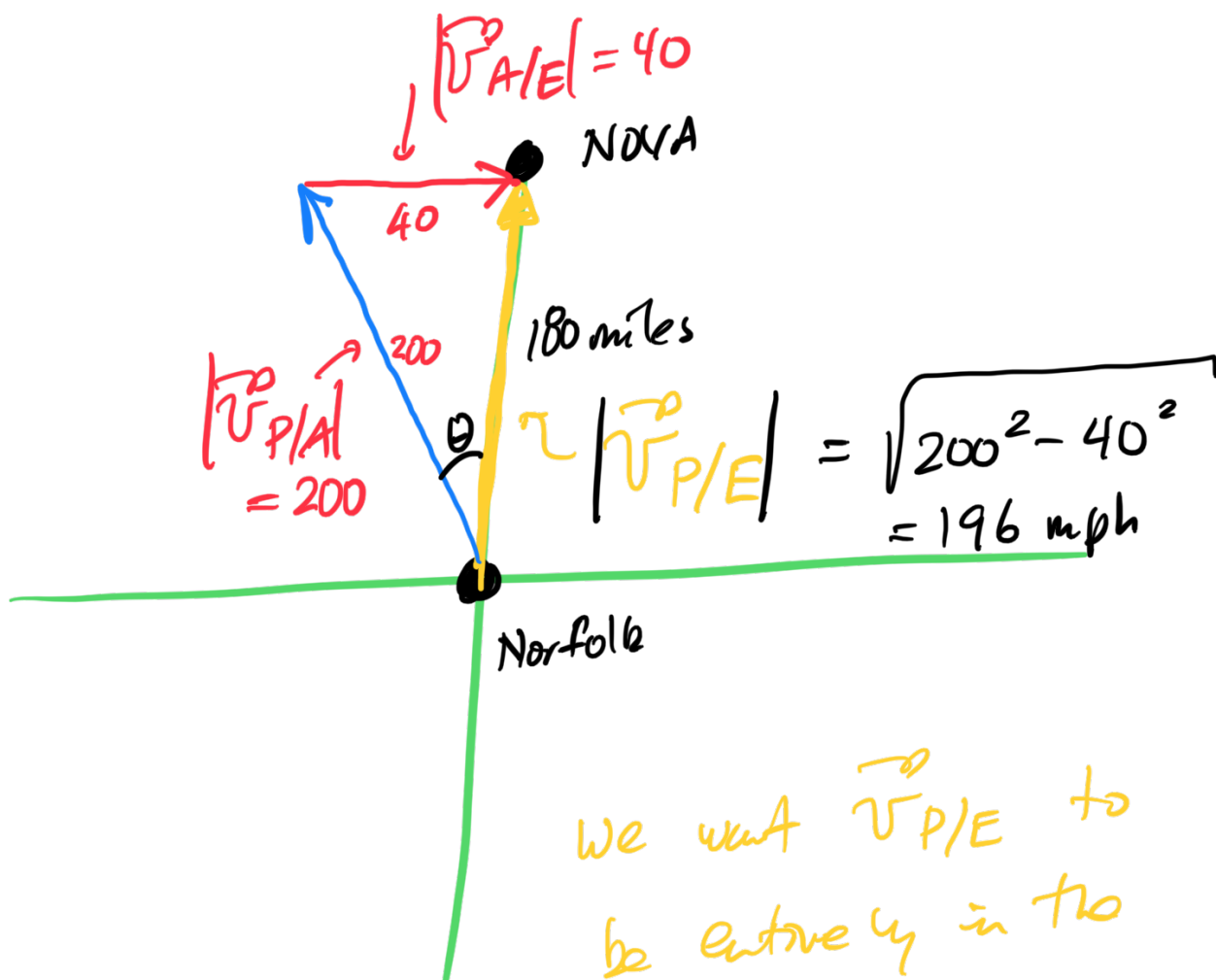
$$\vec{v}_{P/A} = 200\hat{j}$$

What is the velocity of the plane relative to the earth?

$$\vec{v}_{P/E} = \vec{v}_{P/A} + \vec{v}_{A/E}$$

Diagram illustrating the vector addition of the plane's velocity relative to the air ($\vec{v}_{P/A}$) and the air's velocity relative to the earth ($\vec{v}_{A/E}$) to find the plane's velocity relative to the earth ($\vec{v}_{P/E}$). Green arrows and checkmarks indicate the vectors and the resulting equation.

$$\vec{v}_{P/E} = 200 \hat{j} + 40 \hat{i}$$



y-direction.

$$\vec{v}_{P/E} = \vec{v}_{P/A} + \vec{v}_{A/E}$$

$$\sin \theta = \frac{40}{200} \quad \theta = 11.54^\circ$$

① 3 reference Ref frames. ✓

② $\vec{v}_{A/B} = \vec{v}_{A/C} + \vec{v}_{C/B}$ ✓

③ $\vec{v}_{A/B} = -\vec{v}_{B/A}$ ✓

① Rain $\rightarrow R$

② Earth $\rightarrow E$

③ Car $\rightarrow C$

$\downarrow 6.5 \text{ m/s}$

✓ $\vec{v}_{R/E} = -6.5 \hat{j}$

$\vec{v}_{C/E} = 13.8 \hat{i}$

$\vec{v}_{R/C} = ?$

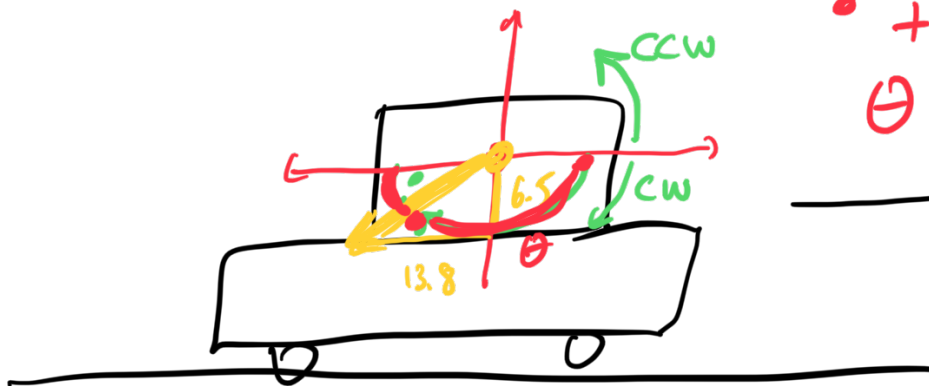


$$\vec{v}_{R/C} = \vec{v}_{R/E} + \vec{v}_{E/C}$$

$$= \vec{v}_{R/E} - \vec{v}_{C/E}$$

$$\vec{v}_{R/C} = -6.5 \hat{j} - 13.8 \hat{i}$$

Correct



$$\begin{aligned} \text{"•"} + \theta &= 180^\circ \\ \theta &= 180^\circ - \text{"•"} \end{aligned}$$

"magnitude" \rightarrow size

$$\rightarrow \sqrt{6.5^2 + 13.8^2} = 15.3 \text{ m/s}$$

$$\tan(\cdot) = \frac{6.5}{13.8}$$

$$\theta = 25.2^\circ$$

(iii)

$$\rightarrow \theta = 180^\circ - \theta = 180 - 25.2 = 154.8^\circ$$

$$= 155^\circ \text{ CW}$$

$$= -155^\circ \text{ CCW}$$

~~W~~

PAIN

2.

Seagull
air
Earth

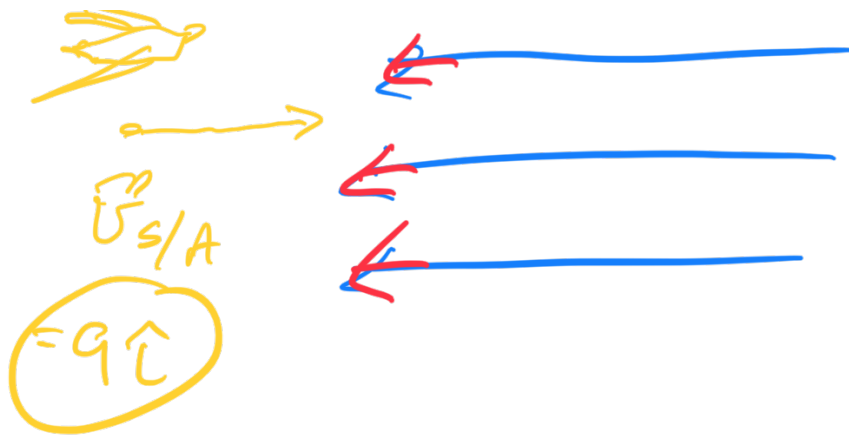
S
A
R

$$|\vec{v}_{S/A}| = 9 \text{ m/s}$$

a)

$$\vec{v}_{A/E} = -v \hat{i}$$

+ve



$$\begin{aligned}\vec{v}_{S/E} &= \vec{v}_{S/A} + \vec{v}_{A/E} \\ &= 9 \hat{i} - v \hat{i} \\ \vec{v}_{S/E} &= (9 - v) \hat{i}\end{aligned}$$

The term $(9 - v)$ is circled in red. Below it, a yellow bracket is drawn.

$$15 \text{ min} \rightarrow 4.40 \text{ km}$$

$$\begin{aligned}&\rightarrow \frac{4400 \text{ m}}{900 \text{ s}} = 4.89 \text{ m/s} \\ &\rightarrow \text{circled } 900 \text{ s} \quad \uparrow \\ &\quad \quad \quad |\vec{v}_{S/E}|\end{aligned}$$

$$\rightarrow 9 - v = 4.89$$

... 1. ✓

$$v = 4.11 \text{ m/s} \quad \checkmark$$

$$\vec{v}_{A/E} = \boxed{-4.11} \hat{i}$$

$$b) \quad \vec{v}_{S/A} = -9 \hat{i}$$

$$\vec{v}_{S/E} = (-9 - v) \hat{i}$$

$$= - \underbrace{(9 + v)} \hat{i}$$

$$9 + 4.11$$

$$\vec{v}_{S/E} = - \underline{13.11} \hat{i}$$

$$13.11 \text{ m/s} \rightarrow 4400 \text{ m}$$

$$1 \quad 4400 \text{ m}$$

$$d = vt$$

$$t = \frac{13.11 \text{ m/s}}{r}$$

$$r = 336 \text{ s}$$