Physics 201 - Lecture 9

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

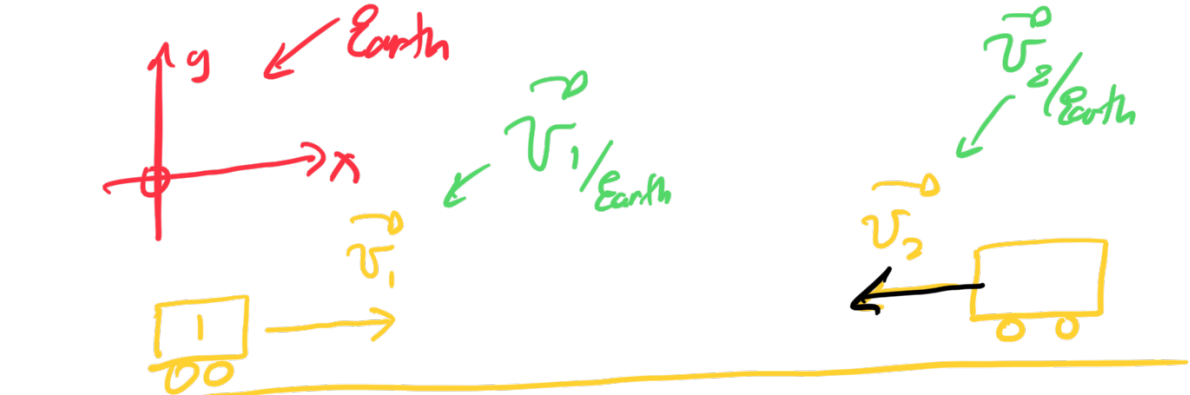
$\vec{v}$, $\vec{x}$, $\vec{a}$ are vectors.

Relativity ⇒ Einstein

↓

Galileo

Relative Motion of Multiple Objects.



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

$\vec{v}_{2/1}$

$\vec{v}_{A/B}$

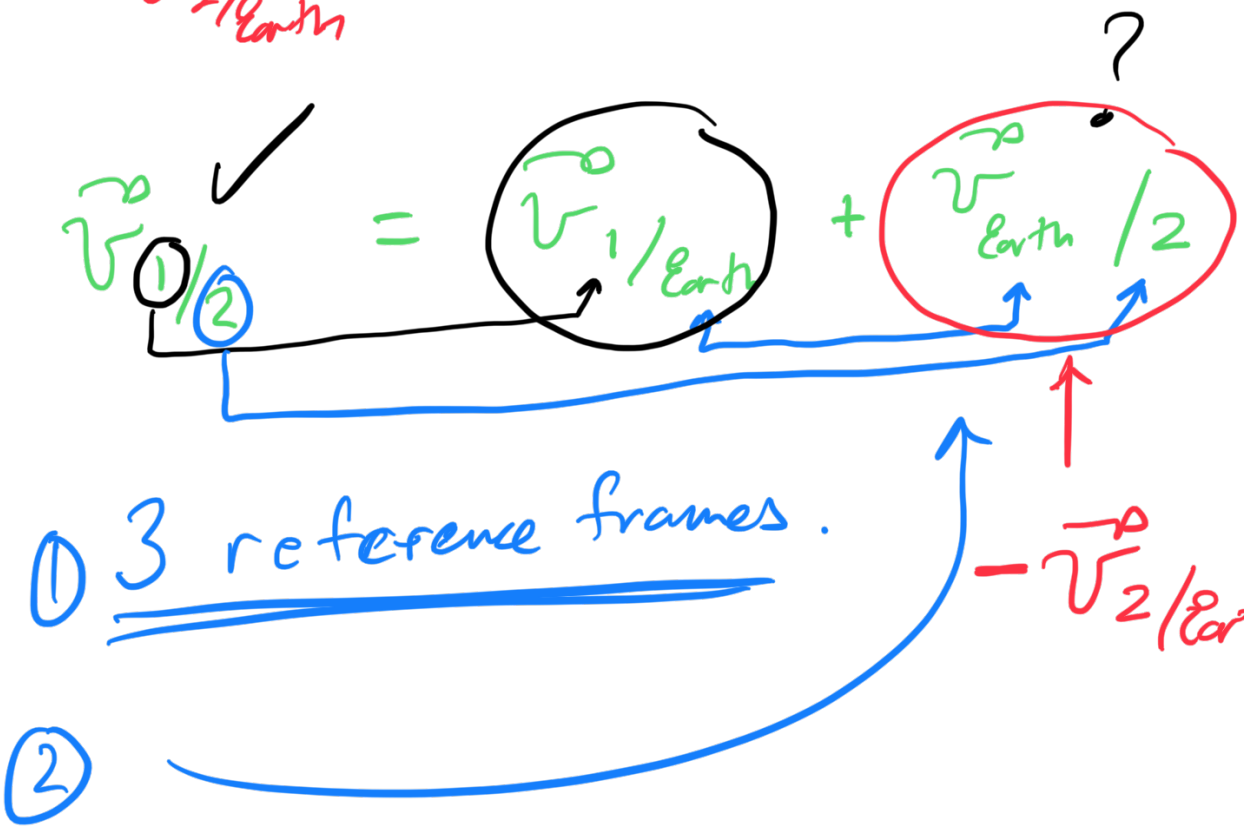
A: object

B: reference frame

Time

$\vec{v}_{1/Earth} = v_1 \hat{i}$ ✓

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



① 3 reference frames.

② $-\vec{v}_{2/Earth}$

A, B, C

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

③ $\vec{v}_{A/B} = -\vec{v}_{B/A}$

$\vec{v}_{1/2} = \vec{v}_{1/Earth} - \vec{v}_{2/Earth}$

$= v_1 \hat{i} - (-v_2 \hat{i})$

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

120 mph

$v_1 = 60 \text{ mph}$

$v_2 = 60 \text{ mph}$

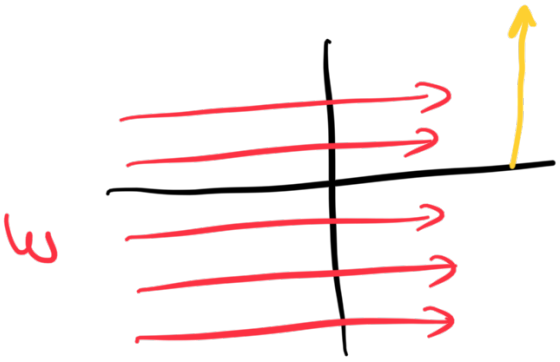
Airplane.

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

1 ⟶ 1 200 mph

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

Wind blowing from the West at 40mph.



$\vec{v}_{A/Earth} = 40\hat{i}$

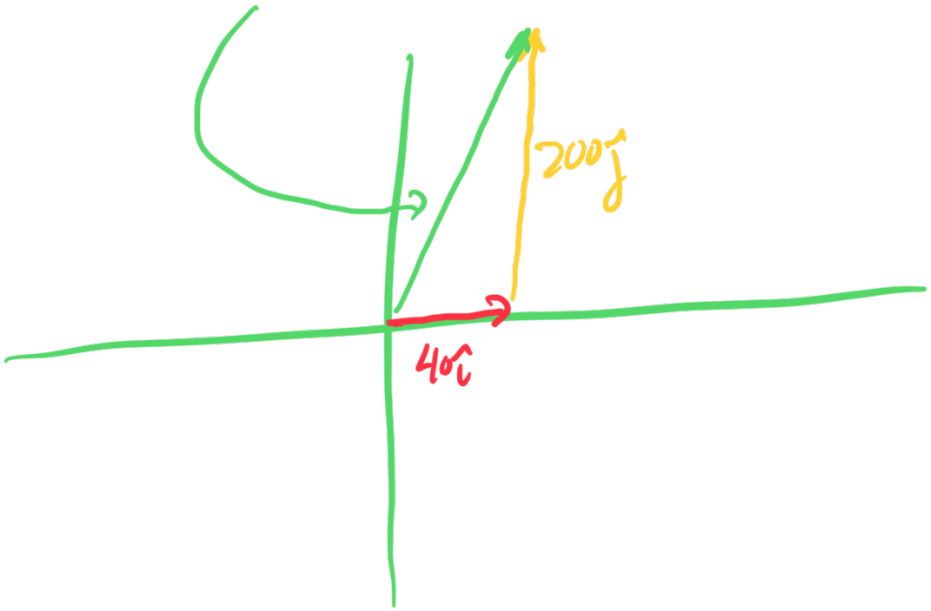
Plane sets its heading at North.

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

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

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

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



$|\vec{v}_{A/E}| = 40$

NOVA

40

200

180 miles

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

θ

$|\vec{v}_{P/E}| = \sqrt{200^2 - 40^2}$

$= 196$ mph

Norfolk

We want $\vec{v}_{P/E}$ to be entirely in the

y - direction.

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

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

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① 3 reference Ref frames. ✓

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

③ $\vec{v}_{A/B} = -\vec{v}_{B/A}$ ✓

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① Rain → R

② Earth → E

③ Car → C

✓ $\vec{v}_{R/E} = -6.5\hat{j}$

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

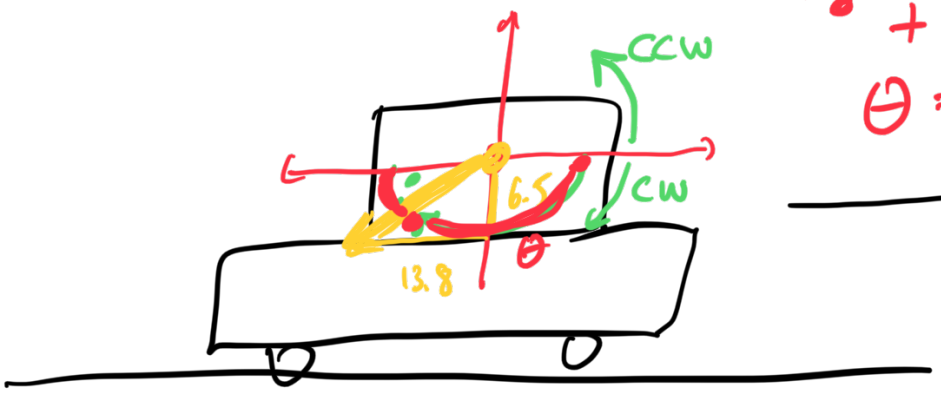
$\vec{v}_{R/C} = ?$

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

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

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

Correct



"•" + θ = 180°

θ = 180° − "•"

"magnitude" → size

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

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

$$\text{"}\cdot\text{"} = 25.2^\circ$$

$$\rightarrow \theta = 180^\circ - \text{"}\cdot\text{"} = 180 - 25.2$$

$$= 154.8^\circ$$

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

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

PAIN

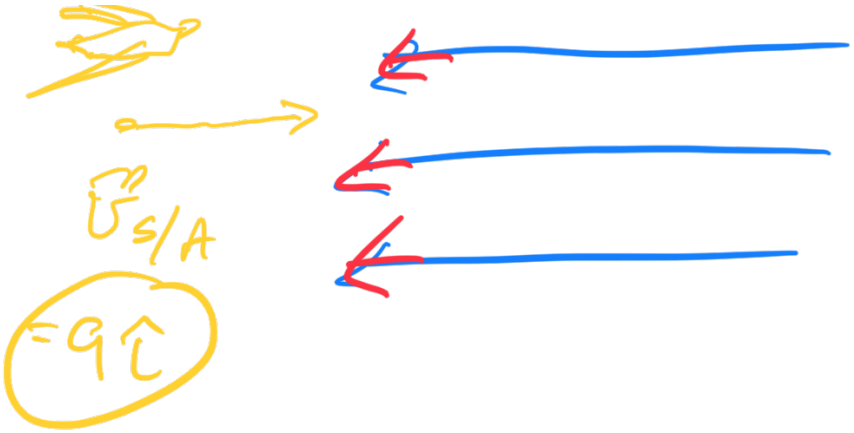
2.

Seagull S
air A
Earth R

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

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

a)



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

$$= 9\hat{i} - v\hat{i}$$

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

15 min $\rightarrow$ 4.40 Km

$$\rightarrow \frac{4400\ m}{400\ s} = 4.89\ m/s$$

$$\rightarrow |\vec{v}_{s/E}|$$

$$\rightarrow 9 - v = 4.89$$

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

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

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

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

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

$$9 + 4.11$$

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

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

$d = vt$

4400 m

$$t = \frac{4400\ \text{m}}{13.11\ \text{m/s}}$$

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