Physics – Lecture 2

Dundas Valley Highschool Co-Op

Physics

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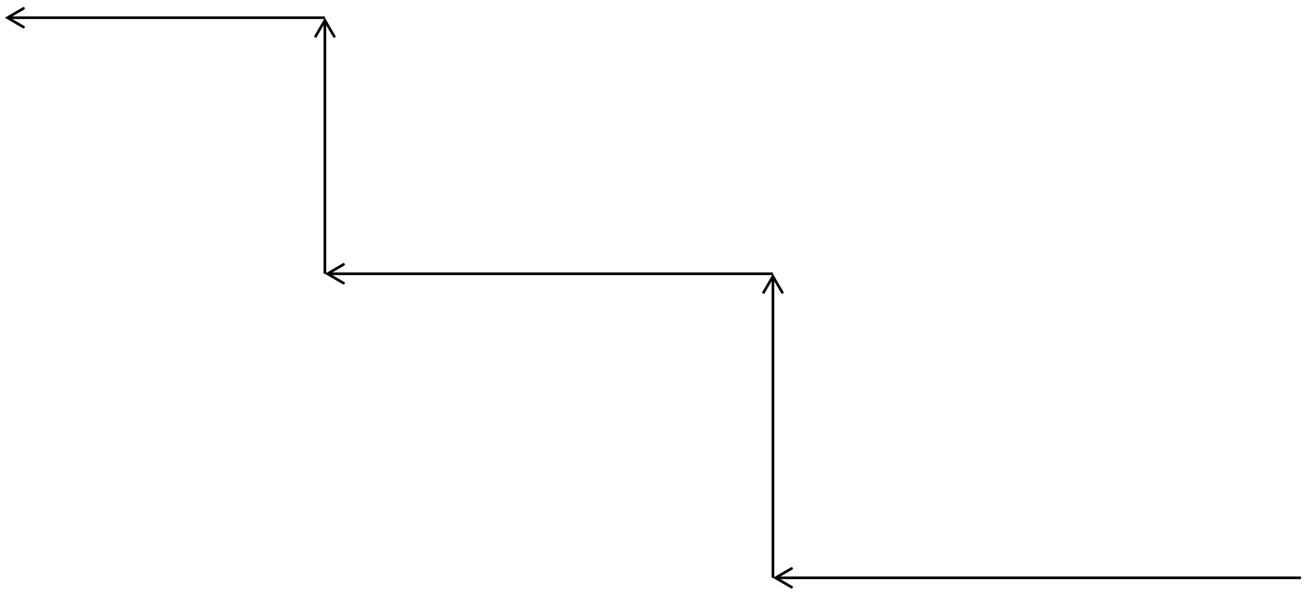
1. Displacement Review

- You (a physics student) are kidnapped by political-science majors (who are upset because you told them political science is not a real science). Although blindfolded, you can tell the speed of their car (by the whine of the engine), the time of travel (by mentally counting off the seconds), and the direction of travel (by turns along the rectangular street system). From these clues you know that you are taken along the following course:
  - 50 km/h for 2.0 min East turn 90 degrees to the right.
  - 20 km/h for 60.0s turn 90 degrees to the left.
  - 50 km/h for 60.0s turn 90 degrees to the right.
  - 20.0km/h for 2.0 min turn 90 degrees to the left.
  - 50 km/h for 30.0s.
- At that point, what is your displacement?

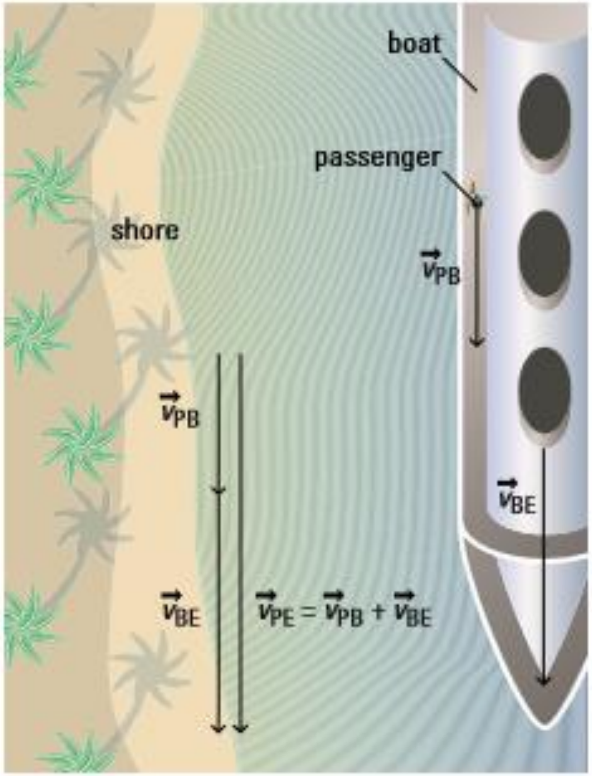
1. Displacement Review - Answer



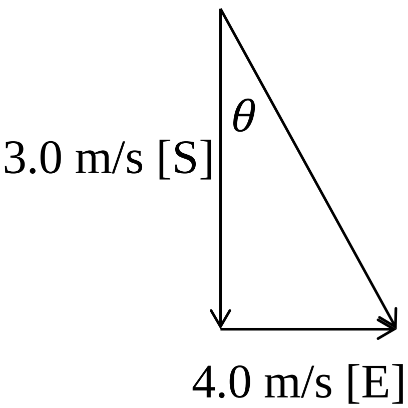
- 3.08 km East 18.9 degrees North

2. Relative Motion

- Suppose a large cruise boat is moving at a velocity of 9.0 m/s [S] relative to the shore and a passenger is jogging at a velocity of 4.0 m/s [S] relative to the boat. Relative to the shore, the passenger's velocity is the addition of the two velocities, 9.0 m/s [S] and 4.0 m/s [S], or 13.0 m/s [S]. The shore is one frame of reference, and the boat is another.



- Suppose while that cruise ship was moving 3.0 m/s [S] relative to the shore the jogger went 4.0 m/s [E] relative to the ship. What is the joggers velocity (relative to the shore)?



$$\vec{v}_{B,S} = 3.0\,\frac{\mathrm{m}}{\mathrm{s}}\,[\mathrm{S}]$$
$$\vec{v}_{J,B} = 4.0\,\frac{\mathrm{m}}{\mathrm{s}}\,[\mathrm{S}]$$
$$\vec{v}_{J,S} = ?\,\frac{\mathrm{m}}{\mathrm{s}}$$

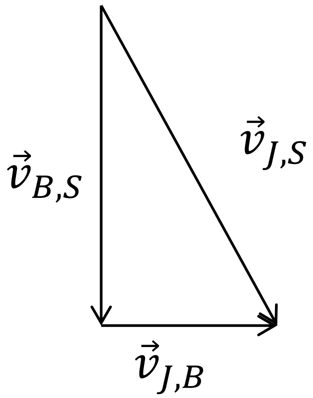
$$v_{J,S}^2 = v_{B,S}^2 + v_{J,B}^2$$
$$v_{J,S} = \sqrt{v_{B,S}^2 + v_{J,B}^2}$$

$$v_{J,S} = \sqrt{\left(3.0\,\frac{m}{s}\right)^2 + \left(4.0\,\frac{m}{s}\right)^2} = \sqrt{25.0\,\frac{m^2}{s^2}} = 5.0\,\frac{m}{s}$$

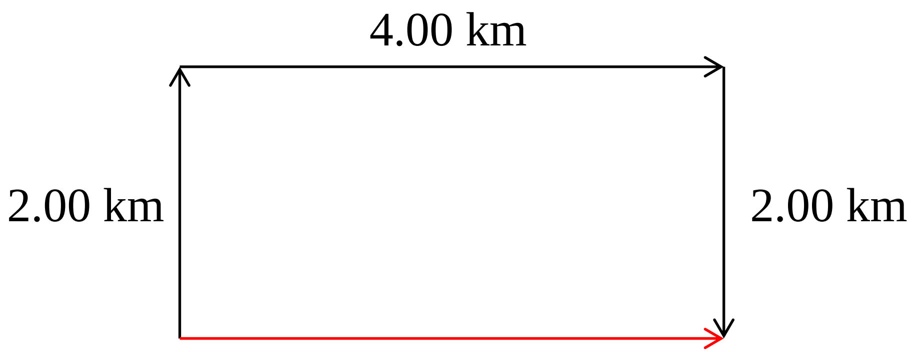
$$\tan(\theta) = \frac{v_{J,B}}{v_{B,S}} \qquad \theta = \tan^{-1}\left(\frac{v_{J,B}}{v_{B,S}}\right) = \tan^{-1}\left(\frac{4.0\,\frac{m}{s}}{9.0\,\frac{m}{s}}\right) = 24°$$

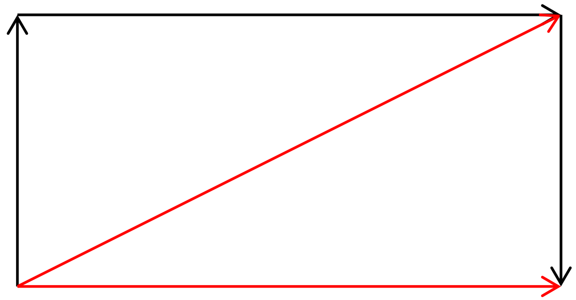
Therefore he ran 5.0 m/s South 24 degrees East

- When we're adding vectors we can draw them and connect them tail-to-tip. The sum of the vectors now forms a triangle from tail-to-tip.



- This is really what we did last week with displacement.





2. 2D Uniform Motion Wrapup

- In 2D Motion Displacement is the sum of displacement vectors
  - $\Delta\vec{d}_{\text{total}} = \Delta\overrightarrow{d_1} + \Delta\vec{d}_2$
- Average velocity is just the ratio of total displacement per total time
  - $\vec{v}_{av} = \frac{\Delta\vec{d}_{\text{total}}}{\Delta t}$
- All motion happens within some frame of reference (usually the earth)
- $\vec{v}_{AC} = \vec{v}_{AB} + \vec{v}_{BC}$

2. 2D Motion Concept Questions

1. Can the size of an objects displacement be bigger than it's total distance travelled? Why?
2. Can the total difference travelled by an object be bigger than the size of its displacement? Why?
3. How does $\vec{v}_{AB}$ compare to $\vec{v}_{BA}$?
4. A wind is blowing from the west at an airport with an east-west runway. Should airplanes be travelling east or west as they approach the runway for landing? Why?

1 Motion Review – Crashing Stuff

- A train heads south from Toronto at 5:00 pm going a constant 100.0 km/h. A train heads north from Aldershot at 5:00 pm going a constant 98.00 km/h. The distance from the Aldershot station to the Toronto station is 87.5 km. If the track switcher malfunctions so that the two trains are on the same track how long does it take for them to collide?

$$\vec{v}_{AG} = 98.00\frac{\text{km}}{\text{h}}[\text{N}]$$

$$\vec{v}_{TG} = 100.0\frac{km}{h}\ [S] = -100.0\frac{km}{h}\ [N]$$

$$\Delta\vec{d}_A = 87.5\ km\ [North] = -\Delta\vec{d}_T$$

$$\vec{v}_{AT} = \vec{v}_{AG} + \vec{v}_{GT} = \vec{v}_{AG} - \vec{v}_{TG}$$

$$\vec{v}_{AT} = 98.00\frac{km}{h}[N] - \left(-100.0\frac{km}{h}[N]\right)$$

$$\vec{v}_{AT} = 198.0\frac{km}{h}[N]$$

$$\vec{v}_{av} = \frac{\Delta\vec{d}}{\Delta t}$$

$$\vec{v}_{AC} = \vec{v}_{AB} + \vec{v}_{BC}$$

$$\vec{v}_{AT} = \frac{\Delta\vec{d}_A}{\Delta t} \rightarrow \Delta t = \frac{\Delta\vec{d}_A}{\vec{v}_{AT}} = \frac{87.5\ km\ [N]}{198.0\frac{km}{h}[N]} = 0.4419\ hr$$

$$= 26.52\ min$$

Therefore after 26.52 minutes the trains collided.