



Introduction to Mechanics

Relative Motion

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Last time

- introduction to motion in 2 dimensions
- reference frames
- relative motion

Overview

- lots of relative motion examples

Relative Motion

Observers A and B have different descriptions of the motion of particle P . We can relate these descriptions using vector addition.

$$\vec{v}_{PA} = \vec{v}_{PB} + \vec{v}_{BA}$$

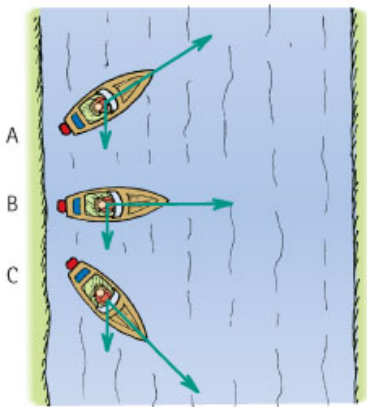
\vec{v}_{BA} is the velocity of observer B 's frame *relative to* frame A .

If we want to think of how A moves relative to B , then we need to swap the subscripts. Swapping the subscripts flips the sign.

$$\vec{v}_{AB} = -\vec{v}_{BA}$$

Relative Motion Practice: Concepts

Three motorboats are crossing a river. All have the same speed relative to the water.



(a) Sketch resultant vectors for each boat showing the speed and direction of the boats.

Rank them from most to least for

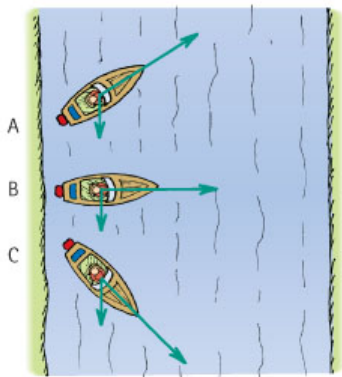
(b) the fastest ride.

(c) the time to reach the opposite shore.

¹Figure and question from Hewitt, "Conceptual Physics".

Relative Motion Practice

Suppose the river is 50 m wide, the motorboats move at 5 m/s relative to the water, the river has a current of 1 m/s, and that boat A makes an angle of 30° to the horizontal and boat C makes an angle of 60° to the horizontal as shown in the picture.



- How long does it take each boat to cross?
- How far downstream is boat B when it reaches the opposite shore?

Summary

- relative motion

Homework

- relative motion question on next slide (don't hand in)
- relative motion worksheet (answer on scantron and hand in, due Thurs, Feb 13)

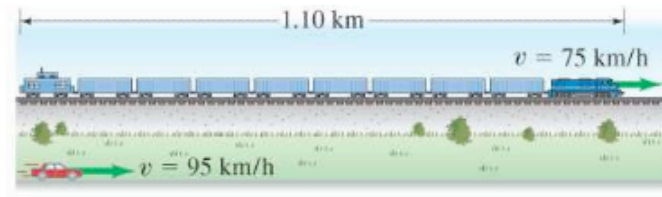
Walker Physics:

- **Ch 3**, onward from page 76. Problems: 49, 51, 53*, 57

*There is a mistake in the vector diagram answer in the back of the book. It looks like $v_{pg} = 340$ km/h, but as it says in the question, the airspeed $v_{pa} = 340$ km/h, so $v_{pg} \neq 340$ km/h.

Extra Homework Question

An automobile traveling 95 km/h overtakes a 1.10-km-long train traveling in the same direction on a track parallel to the road. If the train's speed is 75 km/h, how long does it take the car to pass it, and how far will the car have traveled in this time? What are the results if the car and train are traveling in opposite directions?



¹Giancoli, "Physics: Principles with Applications", 6th ed, page 43.

Ans: 3.3 min, 5.2 km; 23 s, 0.61 km