

Space Relations - Part 1

PHYSICS 203, PROFS. MARTENS YAVERBAUM & BEAN
JOHN JAY COLLEGE OF CRIMINAL JUSTICE, THE CUNY

I. RELATIVE POSITION VECTORS

A. Relative Positions in 1-D

1. A Pontiac and a Toyota are **both** parked **exactly** 60 miles **due** north of a certain gas station. How far is the Pontiac from the Toyota? (Draw a picture, please.)
2. A Pontiac is parked 60 miles due north of a gas station. A Toyota is parked 30 miles due south of the same gas station. How far and in what direction is the Pontiac from the Toyota? (Draw a picture, please.)
3. At some moment in time, an Pontiac is located exactly 30 miles due north of a Toyota. At this same moment, the Toyota is located exactly 60 miles due south of a gas station.
 - a. If the Pontiac is north of the Toyota, which way is the Toyota from the Pontiac?
 - b. How far and in what direction is the gas station from the Toyota?
 - c. Create a bird's-eye-view diagram of the situation. Use a dot to represent each object. (**Bird's-eye-view** means looking **down** from **directly above**.) Make sure your diagram matches the given data & is drawn approximately to scale.
 - d. How far and in what direction is the Pontiac from the gas station? (I.e., if you walked **from** the gas station **to** the Pontiac, how far would you walk & what direction?)

B. Relative Positions in 2-D

A Pontiac is parked 30 miles, in the direction 30 degrees North-East, from a Toyota. The Toyota is parked 60 miles, in the direction 20 degrees South-East, from a certain gas station.

1. Use the following steps to create a bird's-eye-view diagram of this situation:
 - a. Draw a dot for the gas station. Label it with a G.
 - b. Draw a very light (pencil) east-west line running through the gas station.
 - c. Draw a dot for the Toyota and draw an arrow from the gas station to the Toyota. Do your best to estimate a 20° angle south-east from the gas station.
 - d. Draw a dot for the Pontiac and draw an arrow from the Toyota to the Pontiac. Do your best to estimate a 30° angle north-east from the Toyota.
2. How far and in what direction is the **Toyota** from the **Pontiac**?
3. How far and in what direction is the **gas station** from the **Toyota**?
4. Draw an arrow from the gas station to the Pontiac.
5. Use everything you know about vectors, components, and trigonometry to find the exact distance, direction, and angle from the gas station to the Pontiac.

II. RELATIVE VELOCITY VECTORS - An Introduction

You are in a *rowboat* on a choppy ocean. There is no land in sight. You have no radio, radar, GPS, etc. You have a ship's compass that tells you which way is north, but it does *not* tell which way you are actually moving, if at all.

A. Is there any way to tell which way you are going and how fast? Why/how?

A *speedboat* appears on the eastern horizon. You see it coming towards you at a speed of 40 mph relative to you. It passes you and continues on towards the western horizon.

B. Relative to you, how fast and in what direction does the speedboat seem to be moving?

In other words, what is the velocity of the speedboat relative to the rowboat?

(Not a trick question, total giveaway.)

C. Now imagine *you are a person in that speedboat*. (You also have a compass but no way to find out your velocity relative to the earth.)

Relative to you, how fast and in what direction would the rowboat seem to be moving?

In other words what is the velocity of the rowboat relative to the speedboat?

D. Now imagine this: as the speedboat passes the rowboat, it shoots a torpedo due north.

The torpedo continues to travel due north relative to the speedboat. In other words, if you're in the speedboat, you see the torpedo always staying due-north of you, traveling due north.

But what if you're in the rowboat: which *direction* would a person in the rowboat see the torpedo moving?

(No need to provide an angle or a speed, all we want are compass points)

E. **EXTRA CREDIT:** same scenario as part D. Now find the exact angle & direction of the torpedo, from your perspective in the rowboat.