Teaching kinematics through the ISLE approach

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Please rename yourself

First name

Country

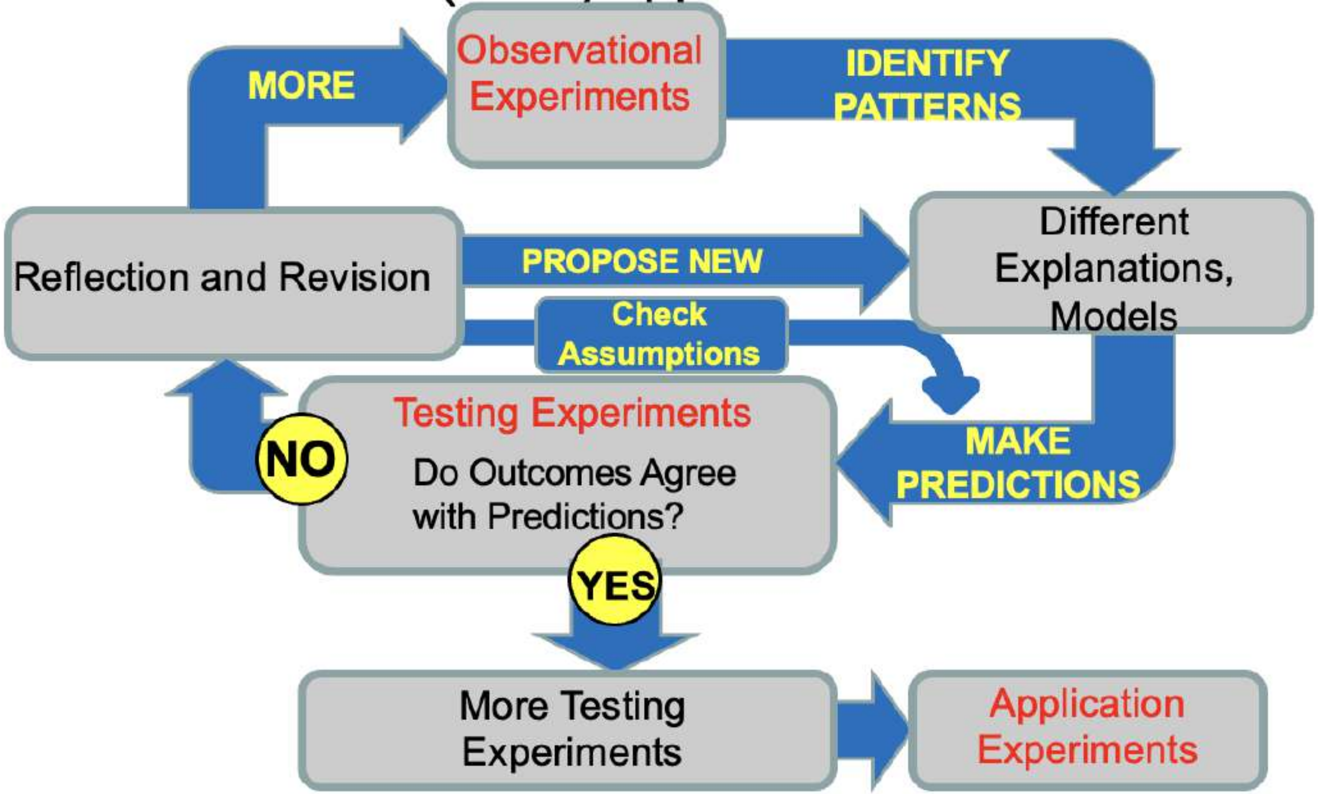
High school or college/university

Today’s meeting materials

Materials for this meeting are in the folder

https://drive.google.com/drive/folders/1rA2B68WaDKR-FQu9YFyNXygZoTp_IFzK?usp=sharing

The Investigative Science Learning Environment (ISLE) approach



Overview important activities in Chapter 1

https://docs.google.com/document/d/1ljPreYBTrZ7A05YCvEsL7XJ2bwqCGv9O/edit

Kinematics

Students should be able to:

1. "Read and write" with motion diagrams (students can interpret a given diagram and draw a diagram for a given scenario).
2. "Read and write" with motion graphs; reading in this context means being able to interpret a graph, to write a mathematical function for the motion on the graph, to find the slope of the graph and the area between the graph and the time axis; writing in this context means being given a function for any kinematics quantity and using it to draw all three graphs (position-vs-time, velocity –vs-time, and acceleration-vs-time).
3. "Read and write" with vectors.
4. Find consistency or inconsistency between different representations of motion.
5. Operate with average quantities and differentiate between the quantity and its change (and for example).
6. Compare and contrast displacement, velocity, and acceleration, and solve problems involving these quantities.
7. Compare and contrast position, displacement, distance, and path length, and solve problems involving these quantities.
8. Explain where the equations for position as a function of time for motion at constant velocity and at constant acceleration come from.
9. Explain the meaning of the term "reference frame" and analyze the same motion using different reference frames.

Brief summary of student difficulties with kinematics

Students have difficulties differentiating between velocity and acceleration, between velocity and displacement, and between position and displacement, understanding the difference between a physical quantity and the change in that quantity, interpreting graphs (including what quantity is represented on the graph, slopes and areas), interpreting signs of physical quantities (thinking that negative acceleration means slowing down), thinking that when velocity is zero acceleration must be zero.

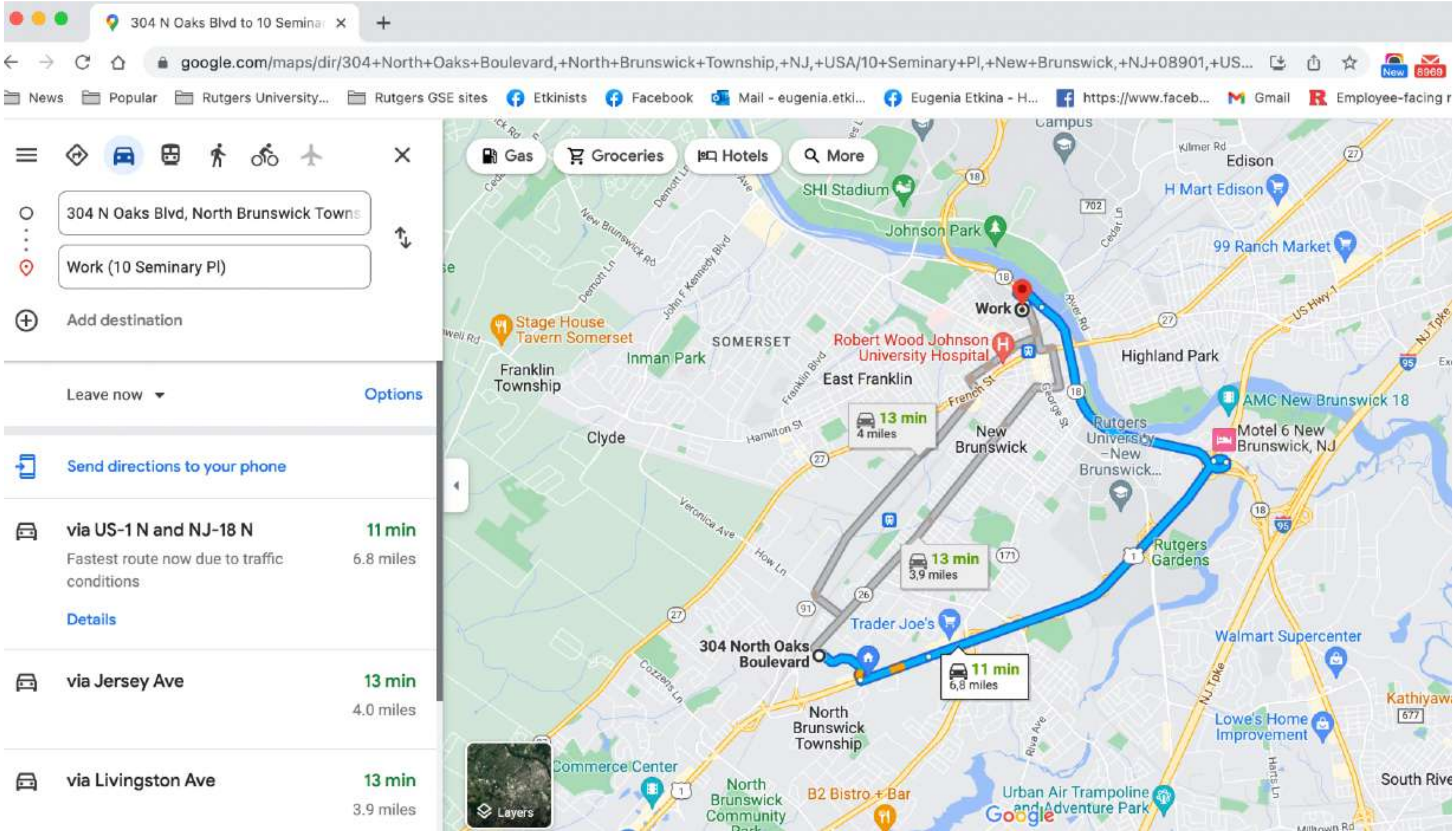
Need to know

Kinematics: Motion in One Dimension

When you drive, you are supposed to follow the three-second tailgating rule. When the car in front of you passes a sign at the side of the road, your car should be far enough behind it that it takes you 3 s to reach the same sign. In this chapter, we will learn the physics behind the three-second rule.

- What is a safe following distance between your car and the car in front of you?
- Can you be moving and not moving at the same time?
- Why do physicists say that an object thrown upward is falling?

Need to know



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Rutgers GSE sites
Etkinists
Facebook
Mail - eugenia.etki...
Eugenia Etkina - H...
https://www.faceb...
Gmail
Employee-facing r
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Work (10 Seminary Pl)
Add destination
Leave now
Options
Send directions to your phone
via US-1 N and NJ-18 N
11 min
Fastest route now due to traffic conditions
6.8 miles
Details
via Jersey Ave
13 min
4.0 miles
via Livingston Ave
13 min
3.9 miles
Gas
Groceries
Hotels
More
SHI Stadium
Johnson Park
Edison
H Mart Edison
99 Ranch Market
Work
Stage House Tavern Somerset
SOMERSET
Robert Wood Johnson University Hospital
Inman Park
Franklin Township
East Franklin
Highland Park
AMC New Brunswick 18
13 min
4 miles
New Brunswick
Rutgers University –New Brunswick...
Motel 6 New Brunswick, NJ
Clyde
13 min
3.9 miles
Rutgers Gardens
Trader Joe's
304 North Oaks Boulevard
11 min
6.8 miles
Walmart Supercenter
North Brunswick Township
Lowe's Home Improvement
Commerce Center
North Brunswick Community Park
B2 Bistro + Bar
Urban Air Trampoline and Adventure Park
South Rive
Layers
Google

Need to know - multiple steps, watch the whole video before

https://www.youtube.com/watch?v=vvbN-cWe0A0

What is the purpose of this first activity?

ALG 2.1.1 Describe

Class: *Equipment per group:* none.

Each member of your group plays a role in the story described below. Assign roles and discuss the answers to the questions. Then get up and enact the story for the rest of the class.

Story: A person sits in the passenger seat of a car that is traveling along a street. Describe the person’s motion as seen by each of the following observers:

a. another person sitting in the backseat of the car;

b. a pedestrian standing on the sidewalk as the car passes; and

c. the driver of a second car moving in the same direction and passing the first car.

Concrete representations of motion

ALG 2.2.1 Observe

***PIVOTAL* Lab or class:** *Equipment per group:* metronome (download a metronome app.) or any device to keep track of time in seconds, low-speed battery-operated car, sugar packets (or any other marking device), meter stick (or any other length-measuring device), whiteboard and markers.

This activity requires collaboration and coordination of all group members. Set a metronome to about one beat per second. Person 1 turns on a battery-operated toy car and releases it to roll across the floor. Person 2 places sugar packets on the floor at the points where the car is located at every blip of the metronome (instead of sugar packets you can use anything else that will allow you to mark the floor where the car was every second, be creative!). Do not try to put the sugar packets where the car was just released. After about 5 to 7 blips, stop the car and draw a sketch showing the locations of the sugar packets as dots. Discuss with the group members how you can use the dots to describe the motion of the car. After you come to a consensus, draw your representations on the board and share it with the class. [If you do not have a toy car, you can use a hard ball such as a billiard ball or bowling ball that you roll on a smooth floor.]

Variation for on-line learning

OALG 2.2.1 Observe

Watch the four experiments in video OET 2.1 on page 15 in the textbook [https://mediaplayer.pearsoncmg.com/assets/_frames.true/secs-experiment-video-1]. Use the data from the video to sketch the position of the bean bags by representing them as dots.

a. What patterns did you notice in the placement of the dots?

b. How can you use the distances between the dots to describe the motion of the bowling ball?

Team 1 OALG 2.2.1

a. What patterns did you notice in the placement of the dots?

1st one: bean bags equal distance from each other

2nd: equal distance but further apart

3rd: beans bags got closer and closer together

4th: getting further and further apart

b. How can you use the distances between the dots to describe the motion of the bowling ball?

If they are equal distance they are moving at a constant speed - traveled the same distance in the same time

If distance is smaller it is moving slower. If the distance is larger, it is moving faster.

Team 2 OALG 2.2.1

a. What patterns did you notice in the placement of the dots?

When the ball was moving slow and at a constant speed, the distance between the bean bags was smaller and fairly consistent. When the ball was moving faster and at a constant speed, the distance between the bean bags was larger and fairly consistent. When the ball was slowing down, the distance between the bean bags started larger and got smaller. When the ball was speeding up, the distance between the bean bags started smaller and got larger.

In the first two videos, the dots are equally spaced apart, the last one the bags are getting closer.

b. How can you use the distances between the dots to describe the motion of the bowling ball?

Greater distance between the dots when the ball is moving faster, and shorter distance between the dots when the ball is moving slower

The distance is related to the speed of the ball

Team 3 OALG 2.2.1

a. What patterns did you notice in the placement of the dots?depends on motion. Dots evenly spaced in fast and slow examples. Same change in time between each dot.

b. How can you use the distances between the dots to describe the motion of the bowling ball?

Closer together the dots are placed together the slower the ball is moving. Closer dots means slowing down. Farther dots means speeding up.

Team 4 OALG 2.2.1

a. What patterns did you notice in the placement of the dots?

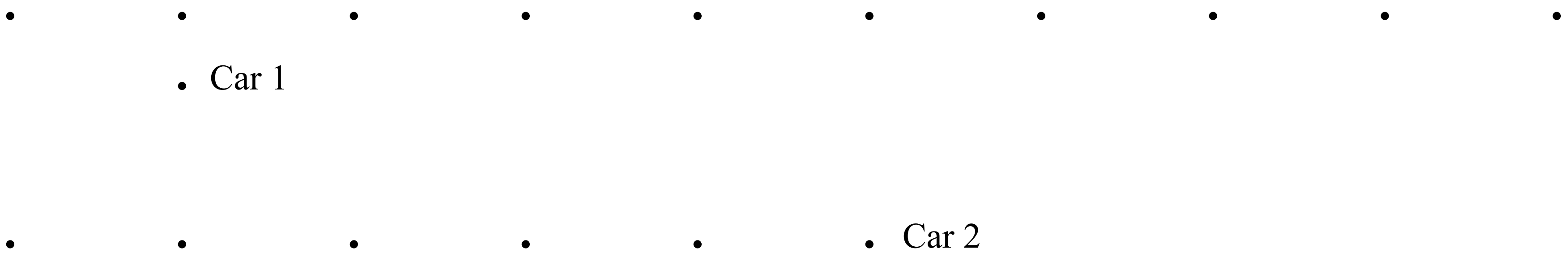
The dots stayed the same distance apart until the carpet, where they were closer together with time

b. How can you use the distances between the dots to describe the motion of the bowling ball?

Velocity is constant with same distance; velocity is decreasing with decreased distance

OALG 2.2.2 Represent and reason

You have two battery-operated toy cars that you can release simultaneously on a smooth floor and a metronome set to 1-second intervals. You and a friend each walk next to one of the cars, and at every "blip" of the metronome, you place a sugar packet at your car's location. The dots in the figure below represent the locations of the sugar packets for the two cars. The cars start simultaneously at the dot on the left and move to the right.



a. Were the cars ever next to each other? If so, where?

b. If there were a passenger in car 1, how would the passenger describe the motion of car 2?

c. If there were a passenger in car 2, how would the passenger describe the motion of car 1?

Team 1

a. Were the cars ever next to each other? **If so, where?** At the beginning

b. If there were a passenger in car 1, how would the passenger describe the motion of car 2? Car two is moving faster and moving away from me THEY ARE BOTH MOVING AWAY FROM EACH OTHER

c. If there were a passenger in car 2, how would the passenger describe the motion of car 1? Car one is slower. It is moving less distance.

Team 2

a. Were the cars ever next to each other? If so, where?

Yes, the two cars were next to each other at the very start, but never again.

b. If there were a passenger in car 1, how would the passenger describe the motion of car 2?

EE: What will you see? Car 1 will see car 2 move farther and farther in front of car 1 (more distance will separate car 1 and car 2 with time).

c. If there were a passenger in car 2, how would the passenger describe the motion of car 1?

They would describe the motion of car 1 as slow(er). Car 2 will see car 1 move farther and farther BEHIND car 2 (in the rear view mirror).

Team 3

a. Were the cars ever next to each other? If so, where? 2 sec , 4 sec, 6 sec, 8 sec, 10 sec

b. If there were a passenger in car 1, how would the passenger describe the motion of car 2? faster

c. If there were a passenger in car 2, how would the passenger describe the motion of car 1? slower

Team 4

a. Were the cars ever next to each other? If so, where?

Only at the beginning, no other time

b. If there were a passenger in car 1, how would the passenger describe the motion of car 2?

Car 2 is moving faster ahead

c. If there were a passenger in car 2, how would the passenger describe the motion of car 1?

It is moving backwards

OALG 2.2.3 Observe

Equipment: a ball, sugar packets, a distance measuring device.

For this activity you will need any ball that you can find in the house. A basketball, a tennis ball – any rolling object (even a mechanical toy car will work). Using your computer or your phone, find a metronome that beeps every second. You will also need sugar packets or any objects that you can place on the floor to mark the position of the ball. Place the ball (or a toy car) at rest on the floor. Push the ball abruptly and, as it rolls, place the sugar packets to mark its location every second. Make sure that the ball rolls in a straight line. Take a picture of the sugar packets and paste it into the document you are working on. Use it to draw a corresponding dot diagram representing the packets. Describe the relative distances between the packets. How does the distance between the packets correspond to the observed motion of the ball?

Screenshot of the answers to OALG 2.2.3

OALG 2.2.4 Explain Please do not type on this slide

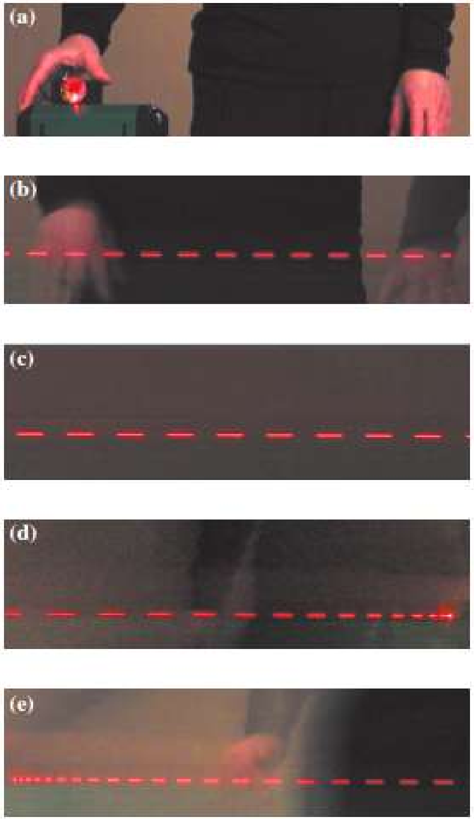
Examine Figure below. Explain the changes in the light traces of the LED in each experiment (do not forget to state your assumption about the direction of motion). In particular:

a. What can the length of the light trace tell you about the motion of the cart?

b. If each subsequent light trace gets shorter, what does that tell you about the motion of the cart?

c. If each subsequent light trace gets longer, what does that tell you about the motion of the cart?

FIGURE 2.2 Long-exposure photographs of a moving cart with a blinking LED.



Team 1 OALG 2.2.4

a. What can the length of the light trace tell you about the motion of the cart? If it’s longer, it has moved a further distance during the time frame and is moving faster.

b. If each subsequent light trace gets shorter, what does that tell you about the motion of the cart? It is traveling less distance in the same amount of time.

c. If each subsequent light trace gets longer, what does that tell you about the motion of the cart? It is traveling more distance in the same amount of time.

Team 2 OALG 2.2.4

a. What can the length of the light trace tell you about the motion of the cart?

Assumptions: Light blinks for the same amount of time for each blink. And the cart is moving from left to right.

> The length of the light trace helps us to know how far the cart travelled in a constant amount of time. i.e. it shows the distance the car traveled during the time that the light was on. This also helps us to know how fast the cart was moving (longer = faster).

b. If each subsequent light trace gets shorter, what does that tell you about the motion of the cart?

It tells you that the car is slowing down

c. If each subsequent light trace gets longer, what does that tell you about the motion of the cart?

It tells you that the car is speeding up

Team 3 OALG 2.2.4

a. What can the length of the light trace tell you about the motion of the cart?length of the tra ce which changes. Time between each trace in each diagram. Length each travels is different/ EE: What does it tell you about the motion? Travels farther whenlight trace is longer

b. If each subsequent light trace gets shorter, what does that tell you about the motion of the cart? Distance traveled gets shorter in each time interval.

c. If each subsequent light trace gets longer, what does that tell you about the motion of the cart?

Team 4 OALG 2.2.4

a. What can the length of the light trace tell you about the motion of the cart?

The longer the red line the faster it's moving moving faster EE: Agree!

b. If each subsequent light trace gets shorter, what does that tell you about the motion of the cart?

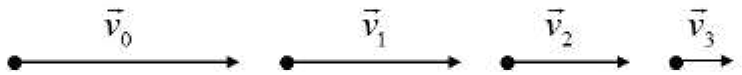
It's slowing down object is slowing down

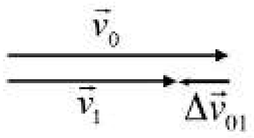
c. If each subsequent light trace gets longer, what does that tell you about the motion of the cart?

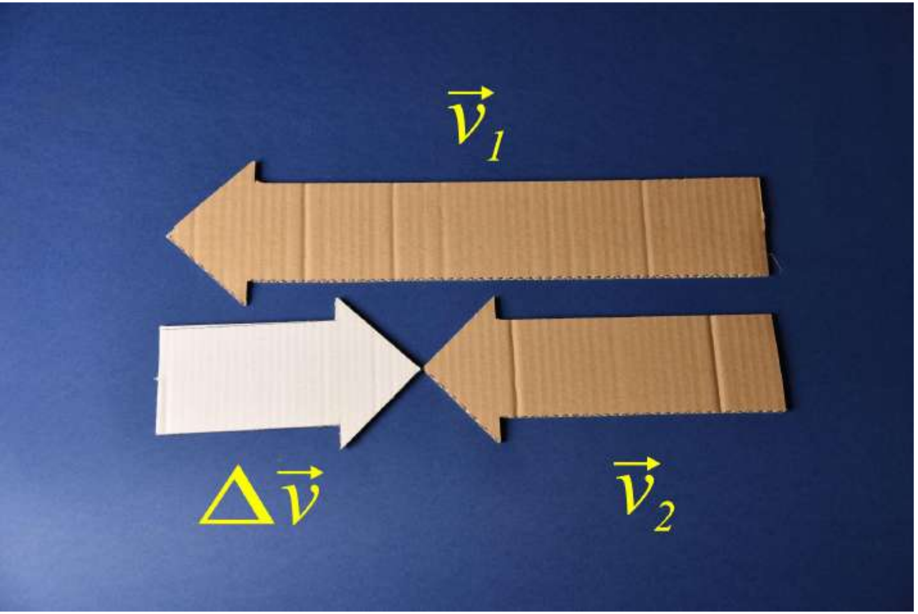
It's speeding up. Object is speeding up

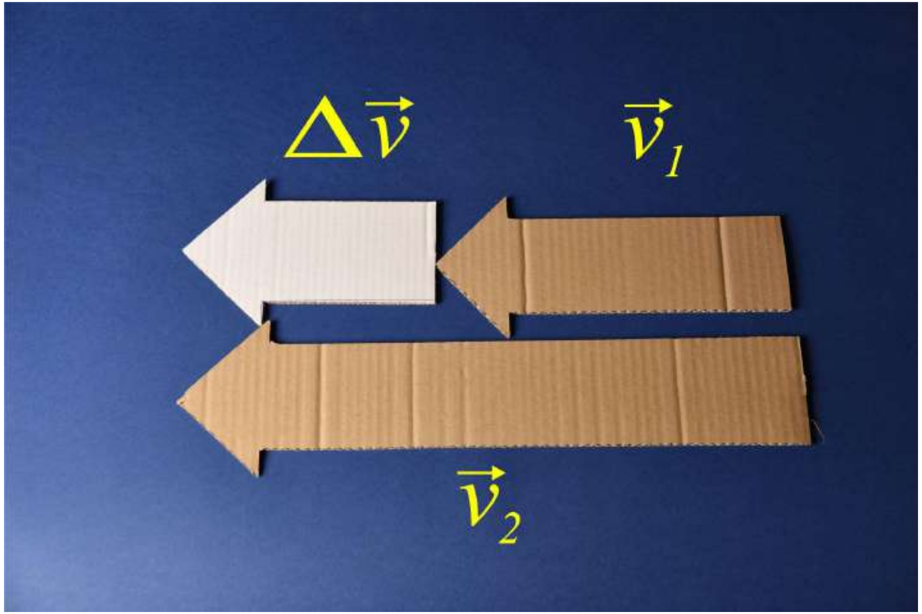
OALG 2.2.5 Represent and reason

The illustration below relates to the experiment you performed with the ball on the carpet.. The dots represent the locations of the ball measured each second. The arrows represent the direction of motion and how fast the ball was moving (we call them *velocity arrows*). Consider velocity arrows 0 and 1. Move them side by side with their tails at the same horizontal position. Decide what change arrow you would have to add to arrow 0 to make it the same length as arrow 1. Repeat for arrow 1—what change arrow is needed to change it into arrow 2, and what change arrow is needed to change arrow 2 into arrow 3? We call these *velocity change arrows.*






$\vec{v}_1$
$\Delta\vec{v}$
$\vec{v}_2$


$\Delta\vec{v}$
$\vec{v}_1$
$\vec{v}_2$

Physical quantities describing motion

ALG 2.4.1 Explain

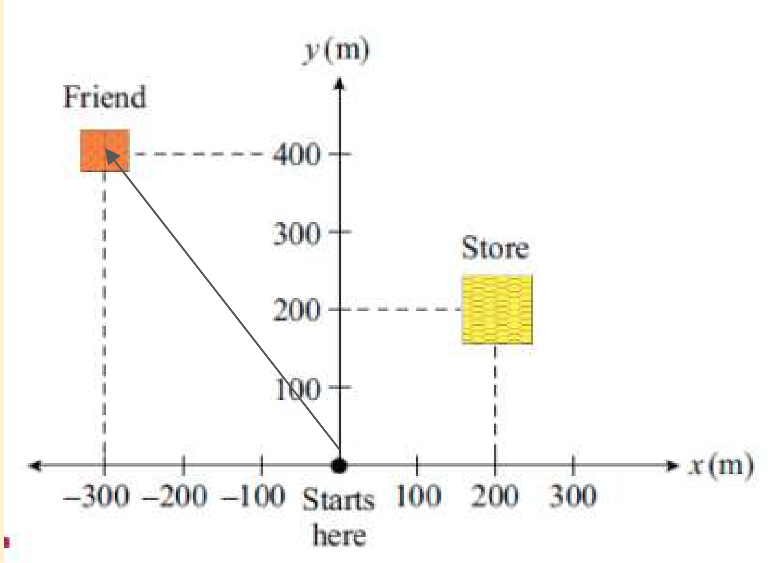
Class: *Equipment per group:* none.

Work with Chapter 1 in the textbook to learn what a physical quantity is. Discuss with your group: What is the difference between a physical quantity and unit? Give examples of physical quantities that have different units in the SI system and the British system. What are the quantities that have the same units in both systems?

Team 1 OALG 2.4.2a and b

https://docs.google.com/document/d/1vdHREK0kJBwGAn7dHCc5KOAD7N36hFbo/edit

a. (0,0), (-300, 400) (200,200)
b. 300 m,



Team 2 OALG 2.4.2a and b

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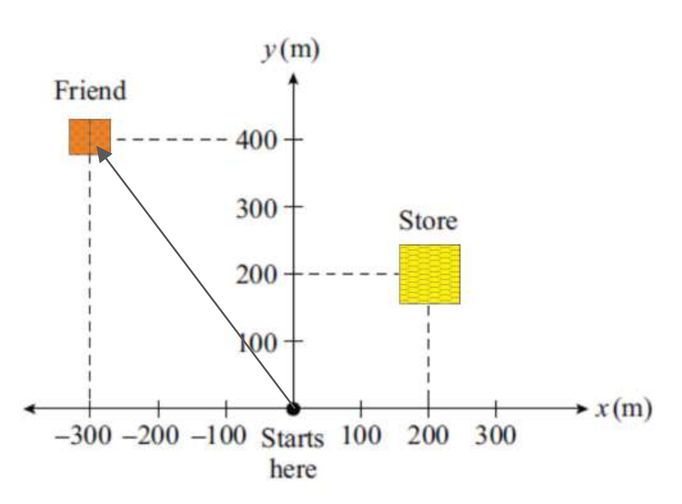
(a) Initial: (0 m, 0 m), Final: (-300 m, 400 m), Store: (200 m, 200 m)

(b) X component is 300 m???, total distance (magnitude of displacement?) is 500m, and the path length is unknown (we don't know what path the person traveled to get to one location to the next).



Team 3 OALG 2.4.2a and b

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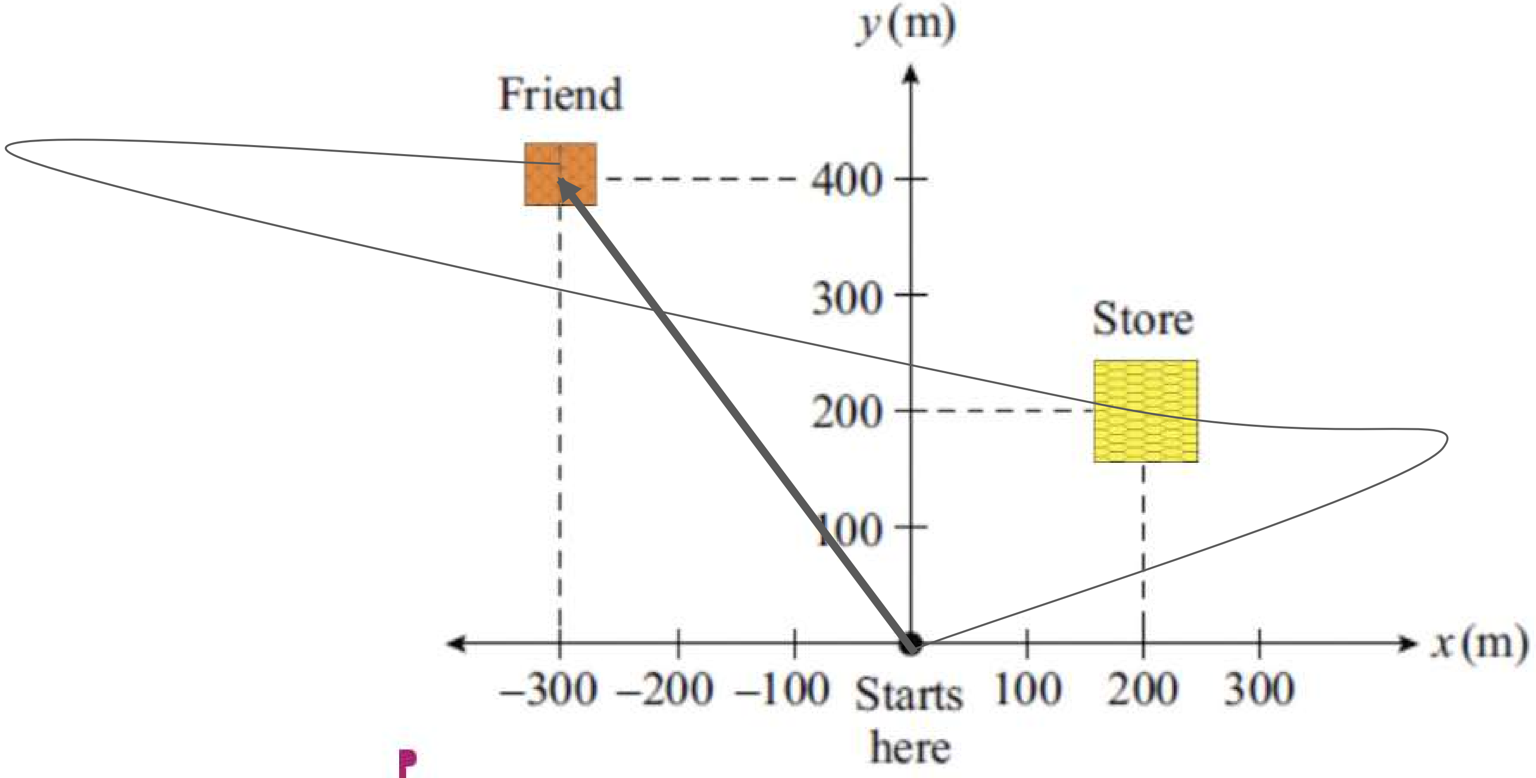
Team 4 OALG 2.4.2a and b

https://docs.google.com/document/d/1vdHREK0kJBwGAn7dHCc5KOAD7N36hFbo/edit


y (m)
Friend
400
300
Store
200
100
x (m)
−300
−200
−100
Starts here
100
200
300

How do we connect conceptual understanding to mathematics?

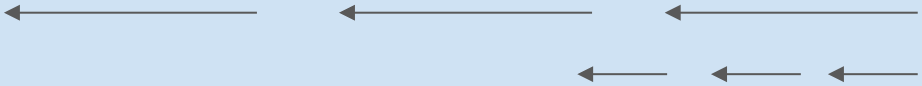
We will start with Activities **2.5.1 and 2.6.1.** They have a lot of steps, so if you need additional slides, just add a new slide after your team's slide. It is important that you see the connection between these two activities. When you get to part C in 2.5.1 do not make graphs (I know you can make them) to save time, I put the graph for each team AFTER the slide for the activity.

Team 1 OALG 2.5.1 and 2.6.1

https://docs.google.com/document/d/1vddHCc5KOAD7N36hFbo/edit

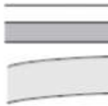
a. Write everything you can about the bike rides and indicate any pattern in the data. What was happening at the clock reading of zero? *They start at the same position the positive direction until after 80 s then their position is in negative quadrant. Until 120 s they still moved in the negative direction. The friend is moving more distance in the same amount of time. They are traveling at constant speed. (Assuming they were already moving at 0 sec)*

b. Draw motion diagrams for both bikes.



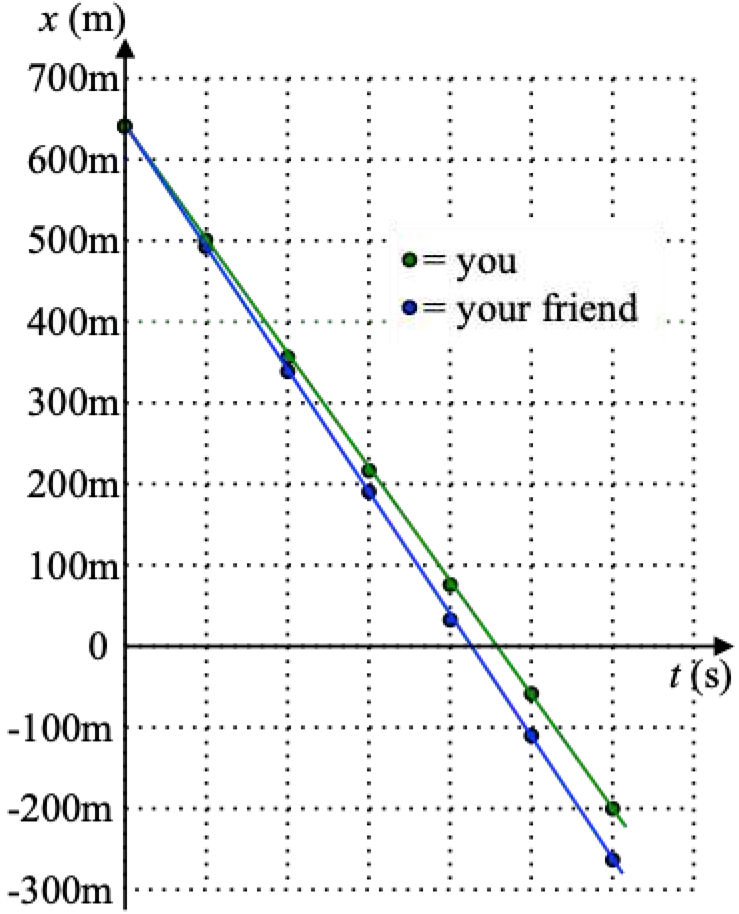
c. Construct position-versus-clock-reading graphs for both bike trips using the same coordinate axes in which *x* is a dependent variable and *t* is an independent variable. Compare and contrast the graphs – how do the graph lines represent the differences in the bikes' motions? If you are having trouble, read and interrogate section 2.5 in the textbook. *The slope is greater for the friend then for you. Or the line is steeper. The more distance moved in the same amount of time means the slope is greater or steeper.*

d. How do the motion diagrams in part b. correspond to the graphs in part c? How do you need to position the motion diagrams with respect to the graph axes so that it helps you visualize the motions? *he slope is greater for the friend then for you. Or the line is steeper. The more distance moved in the same amount of time means the slope is greater or steeper.*



Clock reading *t* (s)	**Your position *x* (m)**	**Your friend's position**
$t_0 = 0$	$x_0 = 640$	$x_0 = 640$
$t_1 = 20$	$x_1 = 500$	$x_1 = 490.$
$t_2 = 40$	$x_2 = 360$	$x_2 = 340$
$t_3 = 60$	$x_3 = 220$	$x_3 = 190$
$t_4 = 80$	$x_4 = 80$	$x_4 = 40$
$t_5 = 100$	$x_5 = -60$	$x_5 = -110$
$t_6 = 120$	$x_6 = -200$	$x_6 = -260$

Imagine that you and your friend ride bicycles along a strai
axis is shown alongside the path.


x (m)
700m
600m
500m
400m
300m
200m
100m
0
-100m
-200m
-300m
t (s)
= you
= your friend

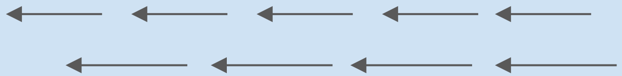
Team 2 OALG 2.5.1 and 2.6.1 https://docs.google.com/document/d/1vdHREK0kJBwGAn7dHCc5KOAD7N36hFbo/edit

a. Write everything you can about the bike rides and indicate any pattern in the data. What was happening at the clock reading of zero?

You and the friend were in the same place at the same time. They were both moving to the left (in the negative direction according to the coordinate system). Your friend is moving faster because they are covering more distance (150 m vs 140 m) during each time interval (20 s).

They both appear to have a constant velocity because the position changes by the same amount during each equal time interval

b. Draw motion diagrams for both bikes.



c. Construct position-versus-clock-reading graphs for both bike trips using the same coordinate axes in which *x* is a dependent variable and *t* is an independent variable. Compare and contrast the graphs – how do the graph lines represent the differences in the bikes' motions? If you are having trouble, read and interrogate section 2.5 in the textbook.

The graphs both have straight lines, but the slopes are different. They start at the same position but do not end at the same position

d. How do the motion diagrams in part b. correspond to the graphs in part c? How do you need to position the motion diagrams with respect to the graph axes so that it helps you visualize the motions?

The steeper slope in the graph corresponds to longer arrows in the motion diagram, both indicate faster motion.

Team 2 OALG 2.5.1 and 2.6.1 https://docs.google.com/document/d/1vdHREK0kJBwGAn7dHCc5KOAD7N36hFbo/edit

a. Examine the graphs you drew in Activity 2.5.1c. Write two functions *x* (*t*) for the graphs. Consider your labeling system: how can you distinguish the function for your bike from the function for your friend's bike?

X_{me} = (-7 (meters/second) t) + 640 meters

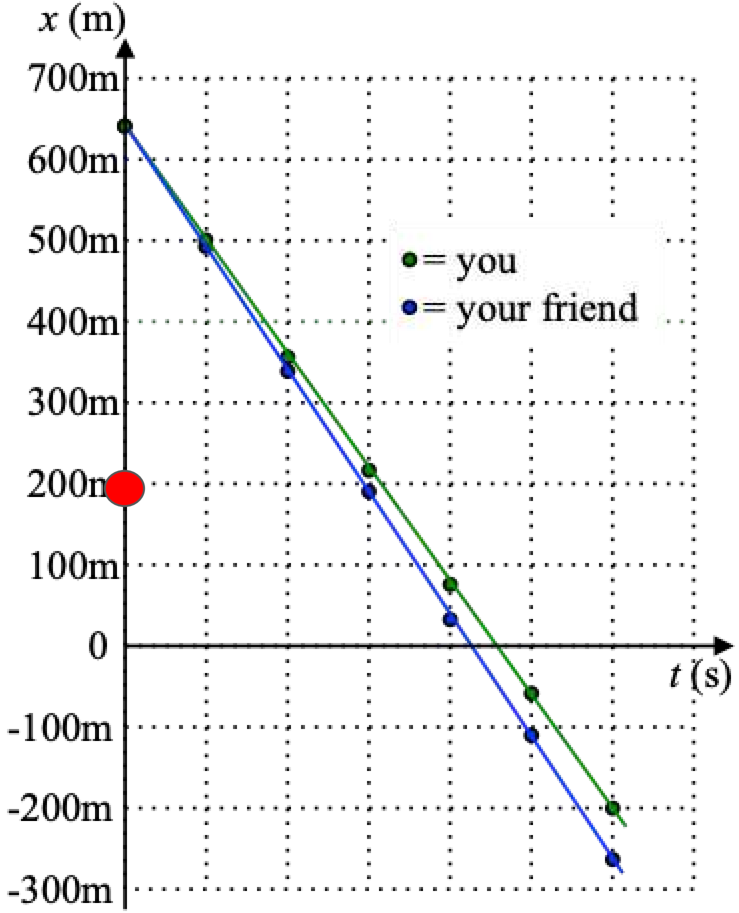
X_{friend} = -7.5 m/s t + 640 m

b. What are the physical meanings of the slope of each function and the intercepts? **What common name can you use for the slope?** Explain the meanings of positive or negative values for these physical quantities. If you are having trouble, read and interrogate Section 2.6 in the textbook. Especially pay attention to the sub-section "*Equation of motion for constant velocity linear motion.*"

The slope represents how fast or slow each person was moving (i.e. the speed). Positive or negative slope indicates the direction the person was moving

c. Compare and contrast how we write linear functions in mathematics to how you just wrote the position-versus-time functions for these motions. What is the same between them? What is different?

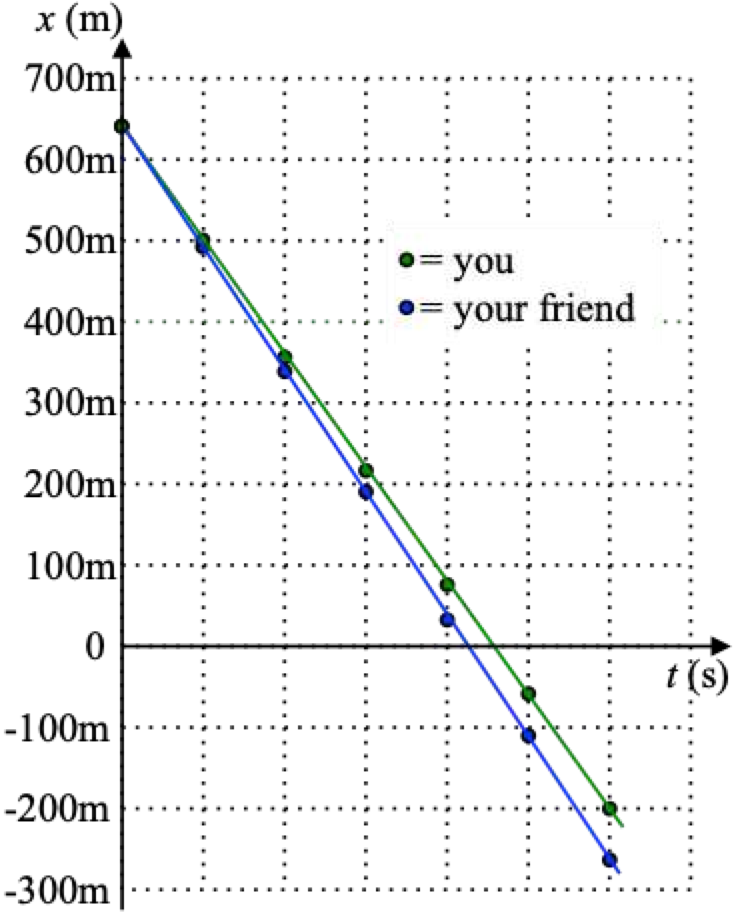
We don't use units in math class! The function could be written the same, but, in physics, each number has a specific physical meaning.



x (m)
700m
600m
500m
400m
300m
200m
100m
0
-100m
-200m
-300m
t (s)
= you
= your friend

Team 3 OALG 2.5.1 and 2.6.1 https://docs.google.com/document/d/1vdHREK0kJBwGAn7dHCc5KOAD7N36hFbo/edit

X = slope .t + 640



x (m)
700m
600m
500m
400m
300m
200m
100m
0
-100m
-200m
-300m
t (s)
= you
= your friend

Team 4 OALG 2.5.1 and 2.6.1

https://docs.google.com/document/
dHCc5KOAD7N36hFbo/edit

Clock reading t (s)	Your position x (m)	Your friend's position
$t_0 = 0$	$x_0 = 640$	$x_0 = 640$
$t_1 = 20$	$x_1 = 500$	$x_1 = 490.$
$t_2 = 40$	$x_2 = 360$	$x_2 = 340$
$t_3 = 60$	$x_3 = 220$	$x_3 = 190$
$t_4 = 80$	$x_4 = 80$	$x_4 = 40$
$t_5 = 100$	$x_5 = -60$	$x_5 = -110$
$t_6 = 120$	$x_6 = -200$	$x_6 = -260$

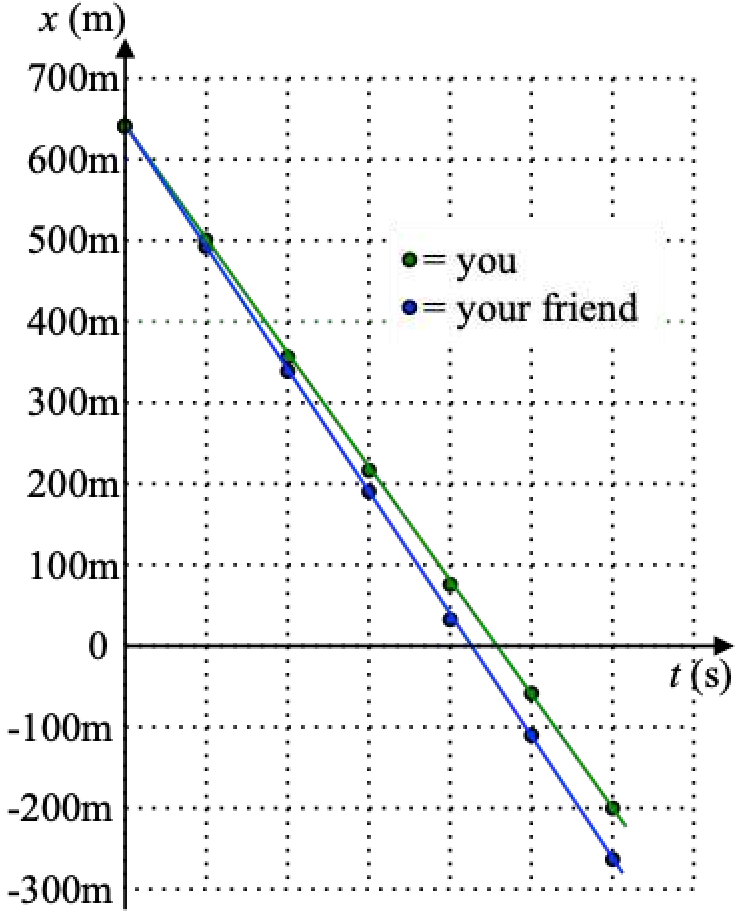
a. Write everything you can about the bike rides and indicate any pattern in the data. What was happening at the clock reading of zero?

Both people start in same position. Friend is going slower. Both at constant speeds.

b. Draw motion diagrams for both bikes.

c. Construct position-versus-clock-reading graphs for both bike trips using the same coordinate axes in which x is a dependent variable and t is an independent variable. Compare and contrast the graphs – how do the graph lines represent the differences in the bikes' motions? If you are having trouble, read and interrogate section 2.5 in the textbook.

d. How do the motion diagrams in part b. correspond to the graphs in part c? How do you need to position the motion diagrams with respect to the graph axes so that it helps you visualize the motions?



x (m)
700m
600m
500m
400m
300m
200m
100m
0
-100m
-200m
-300m
t (s)
= you
= your friend

a. Examine the graphs you drew in Activity 2.5.1c. Write two functions *x* (*t*) for the graphs. Consider your labeling system: how can you distinguish the function for your bike from the function for your friend's bike?

$x_o=640+(-140t)$

$x_f=640-150t$

b. What are the physical meanings of the slope of each function and the intercepts? **What common name can you use for the slope?**

Speed is slope, intercept is starting point.

Explain the meanings of positive or negative values for these physical quantities. If you are having trouble, read and interrogate Section 2.6 in the textbook. Especially pay attention to the sub-section "*Equation of motion for constant velocity linear motion.*"

Negative towards starting point so it's a direction.

c. Compare and contrast how we write linear functions in mathematics to how you just wrote the position-versus-time functions for these motions. What is the same between them? What is different?

Experimental testing of ideas - see ALG

2.6.2 Test your idea

***PIVOTAL* Lab:** *Equipment per group:* whiteboard and markers, metronome or any device to keep track of seconds, 2 battery-operated toy cars that move with *different* speeds, sugar packets (or any other marking device), meter stick or ideally a longer tape measure.

Work with your group members on the following assignments. Make sure that your group keeps detailed records of the experiments so that another group from your class can repeat the experiments and get the same results.

a. For car A, design an experiment to decide if the car moves with constant velocity. If it does, determine the magnitude of the velocity (the car's speed).

b. For car B, use the same equipment and method to decide if this car moves with constant velocity. If it does, determine the magnitude of the velocity (the car's speed).

c. Predict where the cars will meet if you simultaneously release them from 2.0 m apart moving straight toward each other. List all assumptions that you made about how the cars move. If the assumptions were not valid, how would your prediction change?

d. Decide how you will record the data. How will you represent the data? In your representation, mark the predicted value for the meeting location. Perform the experiment and collect data.

e. Did the outcome match your prediction? How many times do you need to conduct the experiment to be able to say for sure whether the outcome of the experiment matches the prediction or not? Write the result of the experiment (meeting location) accounting for the discrepancies in the meeting location in different repetitions of the experiment.

How should students define velocity? How did the students invent the concept of velocity? What is the connection between physics and mathematics?

Delta x/delta t= (x2-x1)/(t2-t1)

Team 1 OALG 2.6.5

https://docs.google.com/document/d/1vdHREK0kJBwGAn7dHCc5KOAD7N36hFbo/edit

Discuss what additional information students need to find on the internet and what assumptions they need to make.

Team 2 OALG 2.6.5

https://docs.google.com/document/d/1vdHREK0kJBwGAn7dHCc5KOAD7N36hFbo/edit

Discuss what additional information students need to find on the internet and what assumptions they need to make.

Team 3 OALG 2.6.5

https://docs.google.com/document/d/1vdHREK0kJBwGAn7dHCc5KOAD7N36hFbo/edit

Discuss what additional information students need to find on the internet and what assumptions they need to make.

Team 4 OALG 2.6.5

https://docs.google.com/document/d/1vdHREK0kJBwGAn7dHCc5KOAD7N36hFbo/edit

Discuss what additional information students need to find on the internet and what assumptions they need to make.

Kinesthetic activities for physical quantities, units, and relations

How long is 1 m?

How fast do you need to move to move at 1 m/s?

2 m/s?

3 m/s?

Using arrows to imagine positive and negative velocity.
Positive and negative velocity change.

Acting out mathematical representations - use ALG

2.6.3 Represent

Class: *Equipment per group:* none.

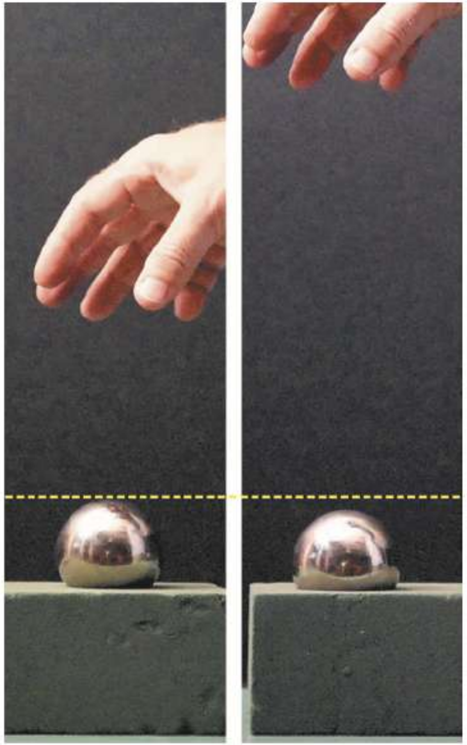
The motion of two objects is represented by the expressions below. Study the motions and act them out with your classmates. Note that it is important to focus on what was happening at . What are your assumptions about the observer?

$$x_A = (-7.5\text{ m}) + (1.7\text{ m/s})t$$

$$x_B = (5.2\text{ m}) + (-0.8\text{ m/s})t$$

How can you explain this photo?
(better do the experiment)

FIGURE 2.21 Dropping a metal ball onto a foam block from different heights.



What about velocity then?

Activity modified from the textbook

You dropped a ball and recorded its motion using video.

You analyzed the video

and obtained the following data.

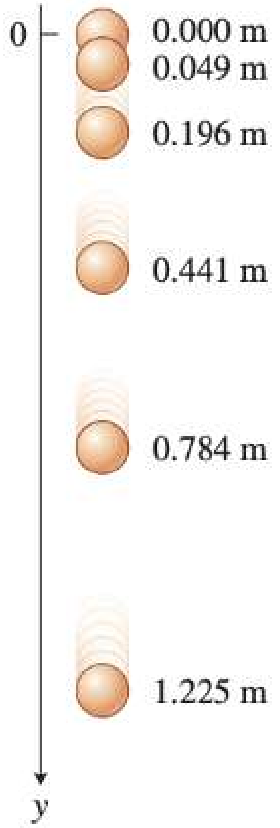
What can you say about the motion of the ball?

Spend 10 min in your teams to find everything you can.

You can draw motion diagrams, position-vs-time and

velocity -vs-time graphs.

FIGURE 2.22 The position of a fallin
every 0.100 s.



Team 1

Team 2

Team 3

Team 4

OALG activity for the invention of the concept of acceleration

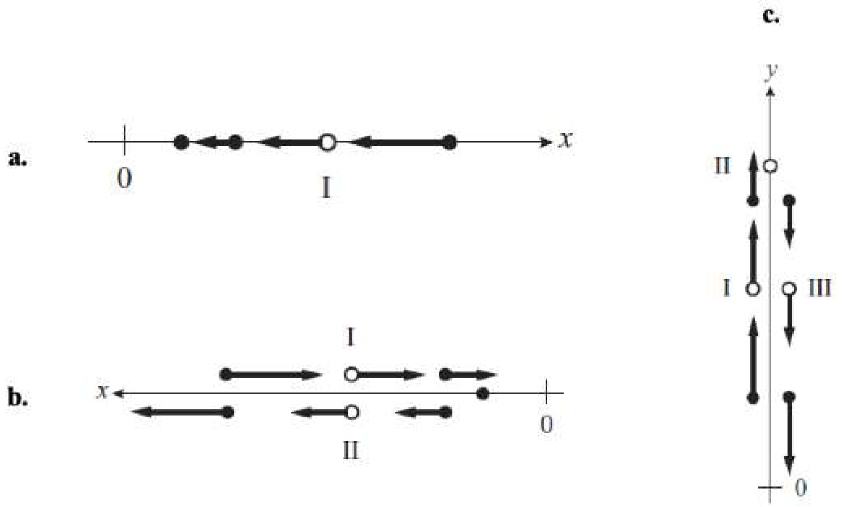
Read activity OALG 2.7.1 (do not do it). How is it similar to 2.6.1? How is it different?

https://docs.google.com/document/d/15_k0tnj8mdkse-pJsKMdlzBWexGZsJnm/edit

How do we connect the the concept of acceleration invented in 2.7.1 with the delta v arrow on the motion diagram? (use whiteboard)

OALG 2.7.2 Represent and reason

The motion diagrams in the illustrations below represent the motion of different objects. The arrows are velocity arrows.

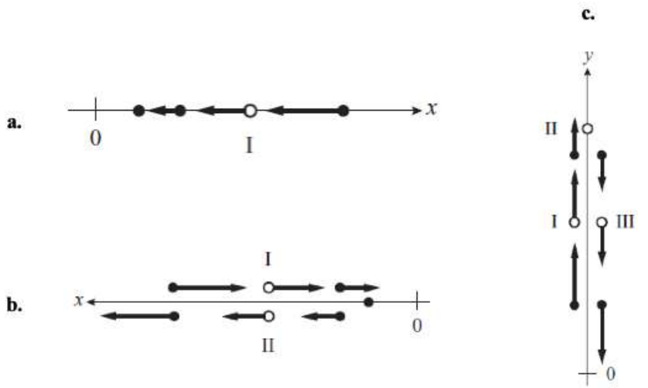


A different coordinate axis is provided for each of the three motion diagrams. An open circle indicates a location of interest (there are three locations: I, II, and III). Add a single velocity change arrow for each diagram. Then, determine the signs of the position, velocity component, velocity change component, and acceleration component at the position(s) of the open dots for each diagram. Note: what assumptions about motion do you need to make in order to use only *one* velocity change arrow for part b. and one for part c?

Team 1

OALG 2.7.2 Represent and reason

The motion diagrams in the illustrations below represent the motion of different objects. The arrows are velocity arrows.



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Team 2

OALG 2.7.2 Represent and reason

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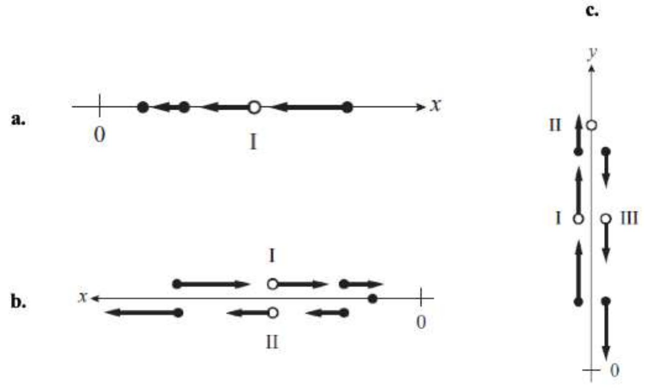

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Team 3

OALG 2.7.2 Represent and reason

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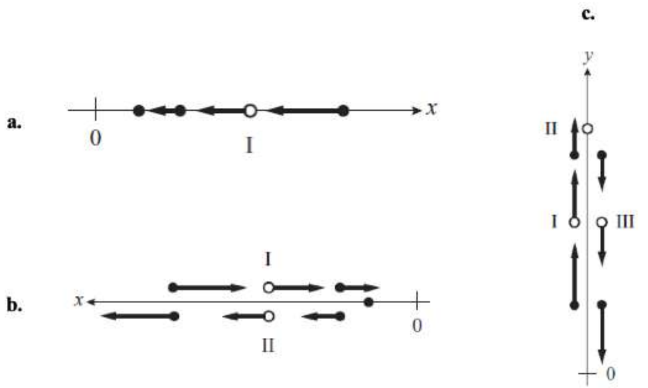

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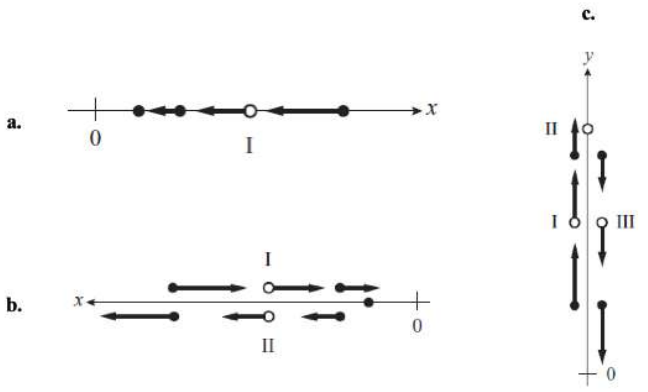
Team 4

OALG 2.7.2 Represent and reason

The motion diagrams in the illustrations below represent the motion of different objects. The arrows are velocity arrows.



A different coordinate axis is provided for each of the three motion diagrams. An open circle indicates a location of interest (there are three locations: I, II, and III). Add a single velocity change arrow for each diagram. Then, determine the signs of the position, velocity component, velocity change component, and acceleration component at the position(s) of the open dots for each diagram. Note: what assumptions about motion do you need to make in order to use only *one* velocity change arrow for part b. and one for part c?

Going back to the GPS

How does the GPS know when you will arrive to your destination?

What assumption does it make?

What did you learn today?

Liked the arrows to establish the conceptual understanding of spacing, speeding and change in velocity and the concept of direction associated with change in velocity.u

Multiple representations to build up students understanding

iI learned that we can create the need for the students to learn various concepts through activities such as a vector component.

Multiple ways to develop understanding

“Need to know” is key to student motivation