Chapter 02: Motion

Physical Science, Tillery, 13th ed.

Lab 03: One-Dimensional Motion

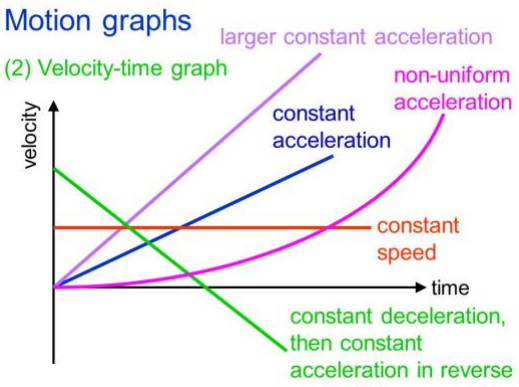
DUE: 11 June 2024

Introduction

Do you know what you are looking at there on the right? Can you look at, say, the green line and visualize what's actually happening? When you see that green line, does it look to you like a car slowing down, stopping for the briefest instant, then speeding up in reverse?

That green line also describes exactly what happens when you take a tennis ball (go get one, I'll wait), toss it straight up in the air, and let it come back down again.

If that seems like a mystery to you, don't worry. We're going to practice a few skills that will help us visualize and analyze the quantities of motion (displacement, velocity, and acceleration) that we understand intuitively—but probably not quite completely.

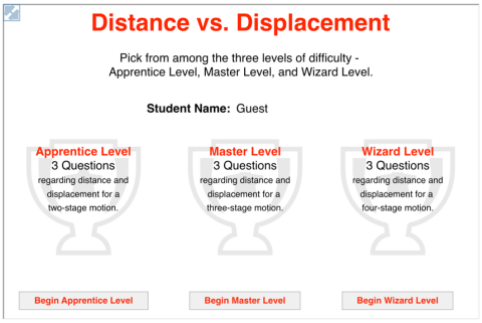


Objectives

- Become familiar with vector concepts of magnitude and direction
- Understand the difference between scalar and vector motion descriptors
- Examine the relationships between displacement, velocity, and acceleration
- Analyze one-dimensional motion of an accelerating object

Equipment

- Internet-connected device capable of running a browser
- Paper and pen or pencil (you're always going to need these)
- Scientific Calculator



Procedure

1. Read this handout completely before you try to dive in. It will save you time and frustration later. If you are able to print it, you will not have to tab between windows—you can look at this and the simulation at the same time.
2. Do you have paper and pencil handy? Don't forget your calculator.
3. In a browser window, navigate to the Distance vs Displacement Concept Builder. Don't try to start doing the lab yet! Just verify that when you click LAUNCH the interactive opens properly.

Distance and Displacement

You should proceed with the Distance and Displacement exercise as GUEST. No need to log in. There are three separate exercises, each with a few situations to resolve. You should begin at APPRENTICE LEVEL and work your way through WIZARD LEVEL. Once you have, you should be able to answer the questions below easily. (Hint: Clicking the HELP ME! button is really useful.)

1. What's the difference between distance and displacement?
   A) No difference. It's like when an English person calls an elevator a 'lift,' or a truck a 'lorry.'
   B) Distance is a vector: You must use a magnitude (or size) and direction to completely express the quantity. Displacement is a scalar, which means that the magnitude (size) is relevant, but the direction is not.
   C) Displacement is a vector: You must use a magnitude (or size) and direction to completely express the quantity. Distance is a scalar, which means that the magnitude (size) is relevant, but the direction is not.
2. Can the distance an object travels and its displacement be different?
   A) Yes. For example, if you run a lap on the track, you have traveled a distance of a quarter mile, but when you end up back where you started, your displacement will be zero.
   B) Yes, but if you run that lap on the track, your distance will be equal to zero and your displacement will be a quarter mile!
   C) No. If you run a lap on the track and finish where you started, both your distance and your displacement are both exactly the same: zero.
   D) No. If you run a lap on the track and finish where you started, both your distance and your displacement are both exactly the same: a quarter mile.

   A tennis player shuffles 3.3 meters to the east, and then runs 5.7 meters to the west.
3. For this motion, what is the distance d she traveled?
   A) $d = 2.4\text{m}$ B) $d = 3.3\text{m}$ C) $d = 5.7\text{m}$ D) $d = 9.0\text{m}$

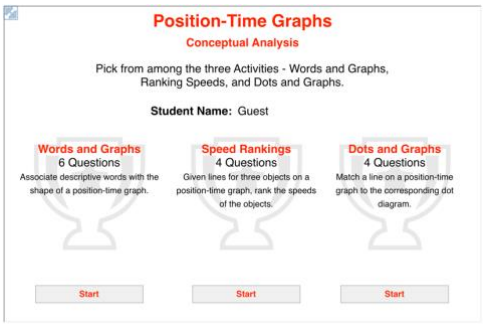
4. What is the magnitude of her **displacement** Δx?
   A) $\Delta x = 2.4\text{m}$ B) $\Delta x = 3.3\text{m}$ C) $\Delta x = 5.7\text{m}$ D) $\Delta x = 9.0\text{m}$
5. What is the **direction** of her displacement?
   A) North. B) South. C) East. D) West.

An athlete runs 224 meters westward, then 156 meters eastward, then 84 meters westward, and finally 248 meters eastward.

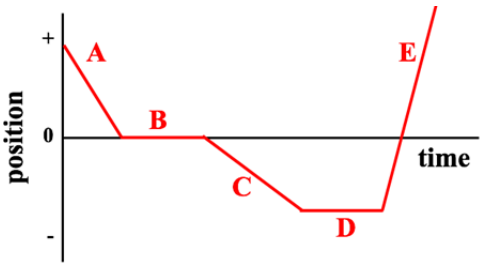
6. For this motion, what is the **distance** d they traveled?
   A) $d = 84\text{m}$ C) $d = 156\text{m}$ E) $d = 248\text{m}$
   B) $d = 96\text{m}$ D) $d = 224\text{m}$ F) $d = 712\text{m}$
7. What is the magnitude of their **displacement** Δx?
   A) $\Delta x = 84\text{m}$ C) $\Delta x = 156\text{m}$ E) $\Delta x = 248\text{m}$
   B) $\Delta x = 96\text{m}$ D) $\Delta x = 224\text{m}$ F) $\Delta x = 712\text{m}$
8. What is the **direction** of their displacement?
   A) North. B) South. C) East. D) West.
9. **True or false:** The distance an object travels might be larger than its displacement, but the displacement cannot be larger than the distance traveled.

Position vs Time Graphs

Return to your browser window and launch the Position-Time Graphs Concept Builder. Like last time, continue as a GUEST. Also like the previous simulation, there are three sets of exercises to complete. Each one practices a different skill, so don't skip any! Once you have worked through all three, you should be able to answer the following questions easily. (Hint: Clicking the HELP ME! button is always really useful.)

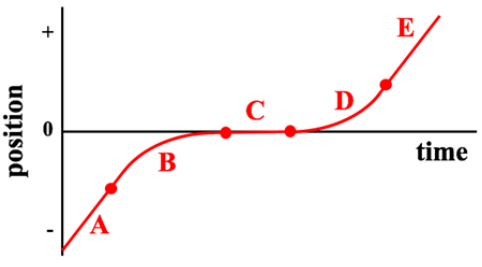


Examine the position graph for an object in motion on the right. Use this figure to answer Questions 10–12.



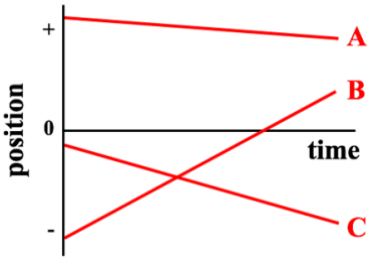
10. During which interval(s) is the object **at rest**?
    A) A only. D) D only. G) B and D.
    B) B only. E) E only. H) A, C, and E.
    C) C only. F) A and C.
11. During which interval(s) does the object have a **constant velocity**?
    A) A only. D) D only. G) B and D.
    B) B only. E) E only. H) A, C, and E.
    C) C only. F) A and C.
12. Over which interval(s) does the object have a **positive velocity**?
    A) A only. D) D only. G) B and D.
    B) B only. E) E only. H) A, C, and E.
    C) C only. F) A and C.

Now examine the middle position vs time graph for an object in motion. Use the figure below to answer Questions 13–14.



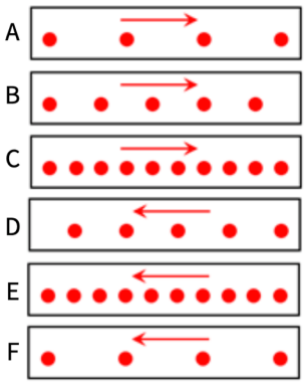
13. Over which interval(s) is the object's speed **changing**?
    A) A only. D) D only. G) B and D.
    B) B only. E) E only. H) A, C, and E.
    C) C only. F) A and C.
14. Over which interval(s) is the object's speed **increasing**?
    A) A only. D) D only. G) B and D.
    B) B only. E) E only. H) A, C, and E.
    C) C only. F) A and C.

Here's one last position vs time graph for three different objects in motion. Use this figure on the right to answer Questions 15–16.



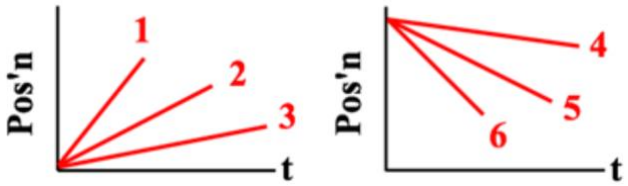
15. Which object is moving at the **slowest speed** (regardless of direction)?
    A) Object A. D) Trick question; all three objects have the same speed, they are just moving in different directions.
    B) Object B.
    C) Object C.
16. Which object is moving at the **fastest speed** (regardless of direction)?
    A) Object A. D) Trick question; all three objects have the same speed, they are just moving in different directions.
    B) Object B.
    C) Object C.

Now look at the position dot diagrams for six different objects in motion. Answer Questions 17–19 using this figure.



17. Which objects are moving at the **slowest speed** (regardless of direction)?
    A) Objects A and F.
    B) Objects B and D.
    C) Objects C and E.
    D) Objects A, B, and C.
    E) Objects D, E, and F.
    F) All objects have the same speed!

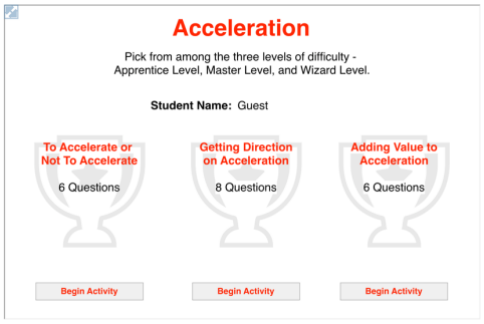
18. Which graph correctly shows the motion of **Object A**? Respond with the number of the graph below.



19. Which graph correctly represents the motion of **Object E**? Respond with the number of the graph above.

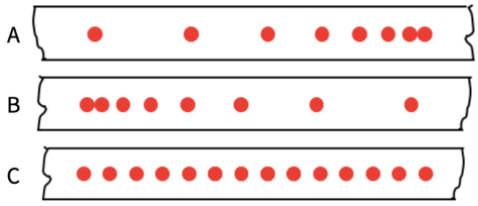
Acceleration

Return to your browser window and launch the Acceleration Concept Builder. Like last time, continue as a GUEST. Also like the previous simulation, there are three sets of exercises to complete. Each one practices a different skill, so don't skip any! Once you have worked through all three, you should be able to answer the following questions easily. (Hint: Clicking the HELP ME! button is always really useful.



Examine the dot-diagram figure below on the right and use it to answer Questions 20–21. Assume that all three objects are moving to the left.

20. **True or false**: All three dot diagrams represent an object that is accelerating.
21. Which of the three dot diagrams illustrates the motion of an object with increasing velocity? Use the choices on the figure.

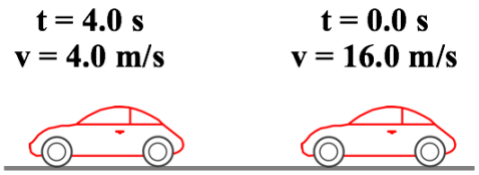


Now look at the table below, which represents the motion of a motorcycle. Use this table to answer Questions 22–24.

Time (s)	Velocity (m/s)
0.0	20.0, left
1.0	16.0, left
2.0	12.0, left
3.0	8.0, left
4.0	4.0, left

22. Which of the dot diagrams on the right can be used to illustrate this motion? Use the multiple choices on the figure above.
23. What is the direction of the acceleration of the motorcycle?
    A) To the right.
    B) To the left.
    C) Neither. The motorcycle is not accelerating.
24. Calculate the magnitude a of the motorcycle's acceleration.
    A) $a = 0\frac{m}{s^2}$ B) $a = 1\frac{m}{s^2}$ C) $a = 2\frac{m}{s^2}$ D) $a = 4\frac{m}{s^2}$ E) $a = 8\frac{m}{s^2}$ F) $a = 16\frac{m}{s^2}$

Use the figure below to answer Questions 25–26. Assume that the car is moving forward, which in this case is to the left. Let's also assume that the forward direction is the positive direction.



25. What is the acceleration a of the car?
    A) $a = -12\frac{m}{s^2}$
    B) $a = -4.0\frac{m}{s^2}$
    C) $a = -3.0\frac{m}{s^2}$
    D) $a = +3.0\frac{m}{s^2}$
    E) $a = +4.0\frac{m}{s^2}$
    F) $a = +12\frac{m}{s^2}$
    G) Trick question! This car is not accelerating!
26. At time $t = 1.0$s, what will the velocity v of the car be?
    A) $v = +16.0\frac{m}{s}$
    B) $v = +13.0\frac{m}{s}$
    C) $v = +12.0\frac{m}{s}$
    D) $v = -12.0\frac{m}{s}$
    E) $v = -13.0\frac{m}{s}$
    F) $v = -16.0\frac{m}{s}$