Lab 1

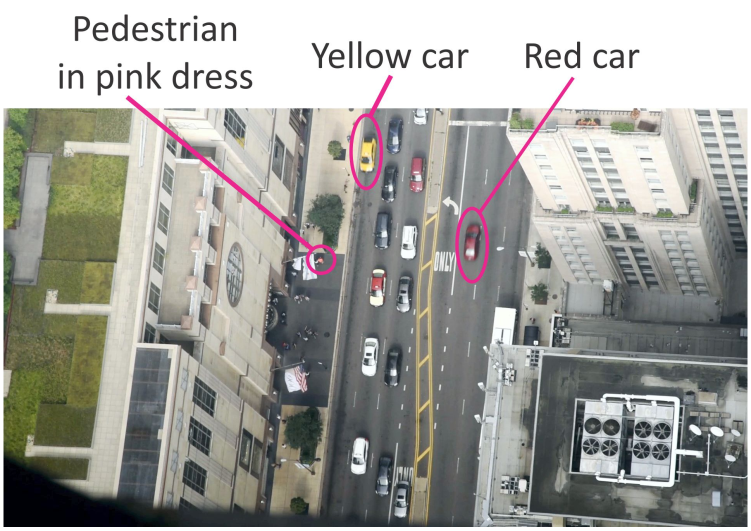
Kinematics: Motion in One Dimension

2.1 What is motion?

OALG 2.1.1 Describe

Watch the video of cars moving on a street [https://youtu.be/Hut8HINHWZ8]

Use the comma and period keys on your keyboard to play the video frame by frame. Notice the yellow and red cars and a pedestrian in the pink dress on the street (see photo below).



a. Describe how a passenger in the yellow car sees the motion of the driver of the yellow car, the driver of the red car, the pedestrian on the sidewalk.

b. How does the pedestrian describe the motion of the driver of the yellow car?

c. Why would the passenger in the yellow car and the pedestrian disagree about the motion of the driver of the yellow car?

d. Based on your answers in parts a. through c., explain what it means when someone says an object is “moving” and what it means when we say “motion is relative”.

2.2 A conceptual description of motion

OALG 2.2.1 Observe

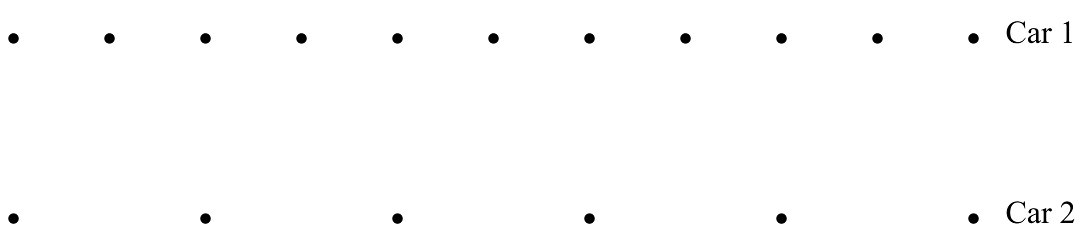
Watch the four experiments in video OET 2.1 [https://mediaplayer.pearsoncmg.com/assets/_frames.true/secs-experiment-video-1]. Use the data from the video to sketch the position of the bean bags by representing them as dots.

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?

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?

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?

OALG 2.2.4 Explain

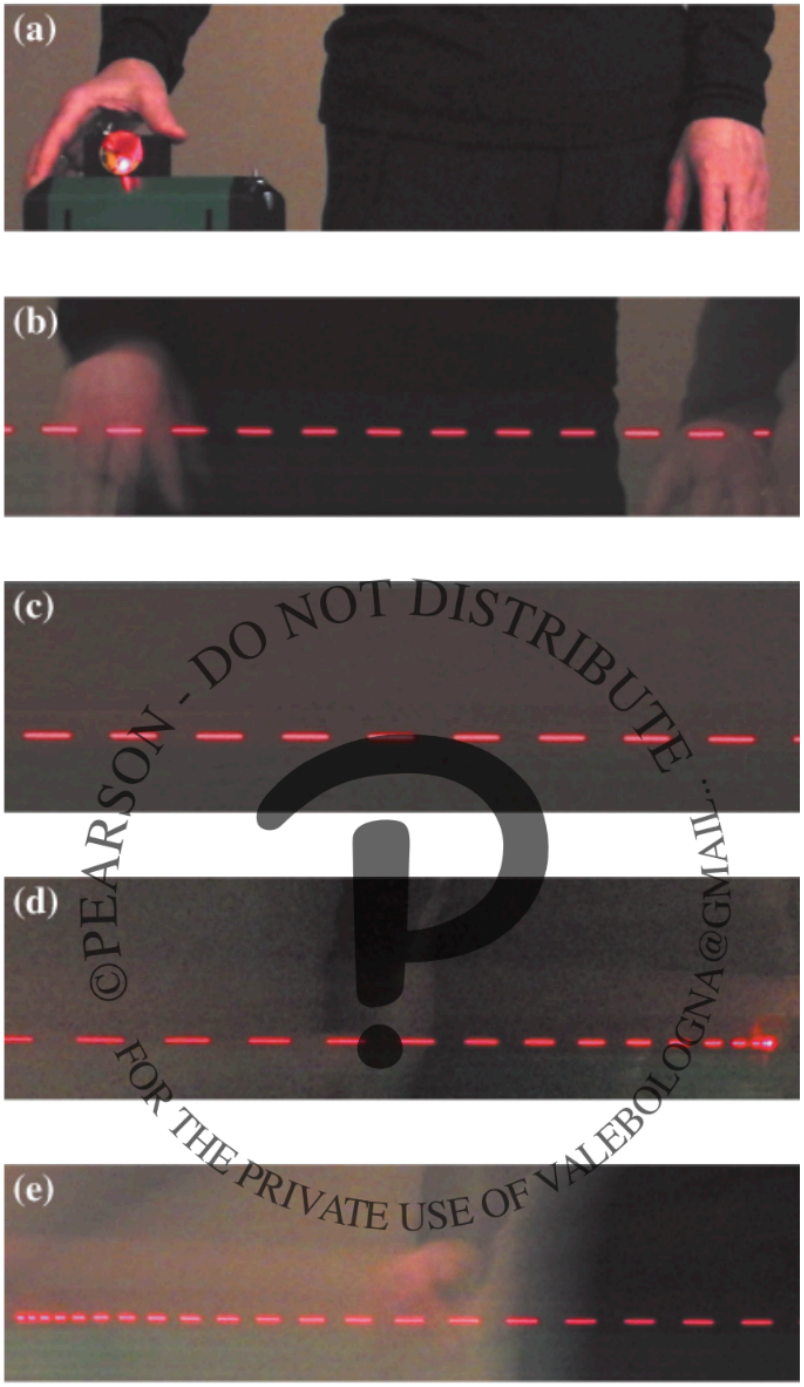
Examine Figure 2.2. Explain the changes in the light traces of the LED in each experiment (do not forget to state your assumption about the direction of motion). In particular:

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?

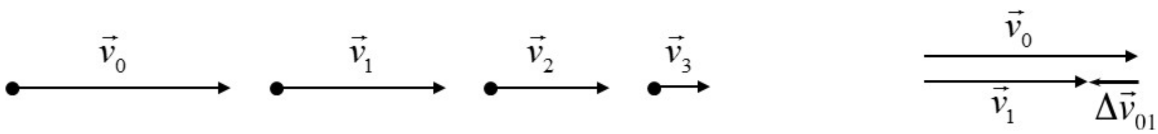
c. If each subsequent light trace gets longer, what does that tell you about the motion of the cart?

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



OALG 2.2.5 Represent and reason

The illustration below relates to the experiment you performed with the ball in Activity 2.2.3. 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 $\Delta\vec{v}_{01}$ 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.*



Use the Physics Tool Box 2.1 to learn how to represent motion using qualitative motion diagrams.

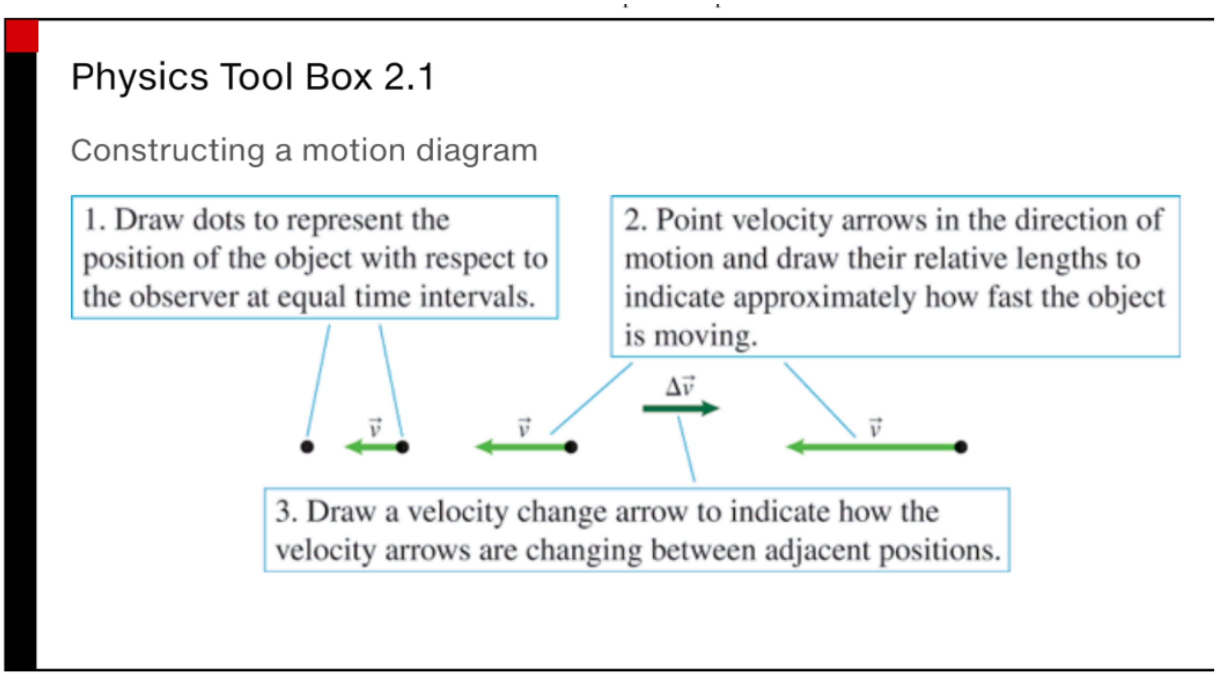
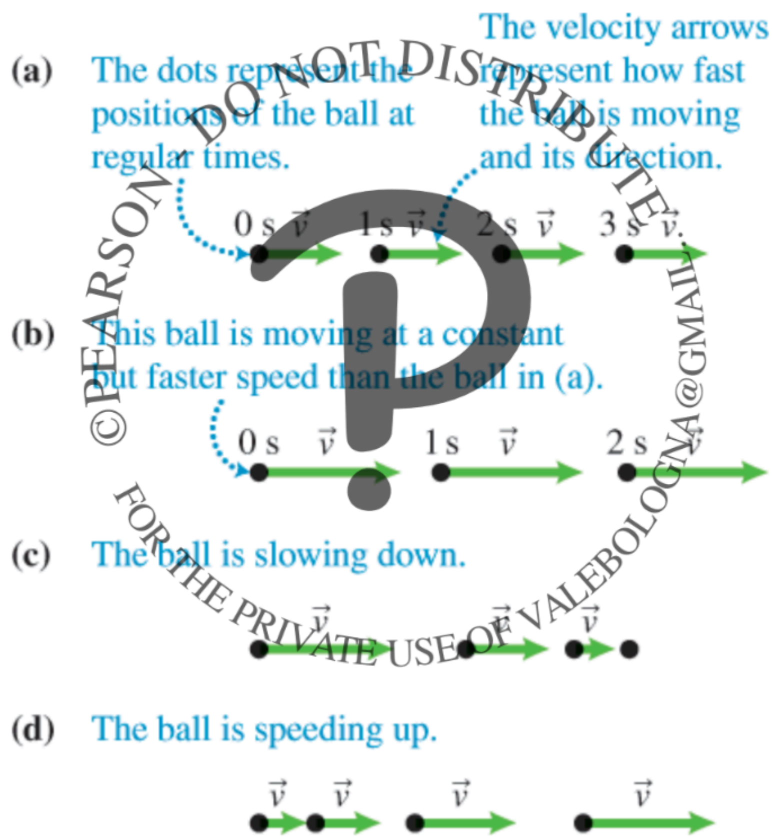
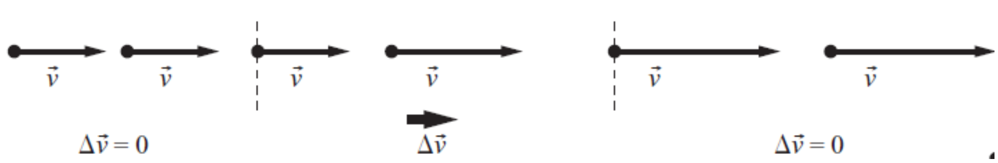


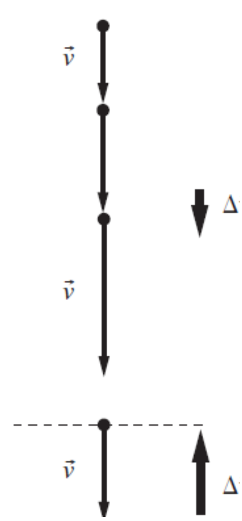
Figure 2.3 Motion diagrams represent the types of motion shown in Table 2.1.



OALG 2.2.6 Represent and reason

The illustration below is a motion diagram for an object. Remember that the dots represent the object's position after equal time intervals. Describe the object’s motion in words by devising a story that is consistent with this diagram. Note that the process has three distinct parts: vertical dashed lines separate each part.





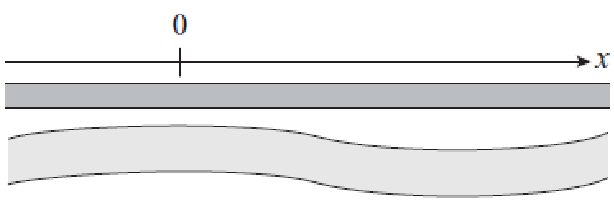
OALG 2.2.7 Represent and reason

The illustration to the right is a motion diagram for an object. Describe the object's motion in words by devising a story that is consistent with this diagram. Note that the process has two distinct parts: the horizontal dashed line separates each part.

2.5 Representing motion with data tables and graphs

OALG 2.5.1 Observe and describe

Imagine that you and your friend ride bicycles along a straight path beside a river. A coordinate axis is shown alongside the path.



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

The table indicates your position along the path at different clock readings.

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?

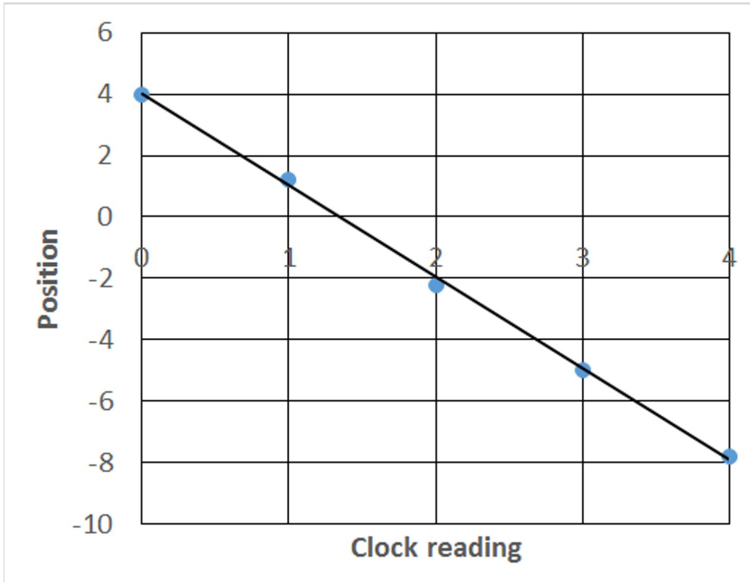
b. Draw motion diagrams for both bikes.

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?

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?

OALG 2.5.2 Represent and reason

Examine the graph below. Is the graph complete? If not, complete it and represent the same information with a table and a motion diagram.



2.6 Constant velocity linear motion

OALG 2.6.1 Represent mathematically

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?

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.*"

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?

OALG 2.6.2 Test your idea

Observe the video of a snail [https://youtu.be/aJKRq2zjZeg]. Use the arrow keys on the keyboard to advance the video frame by frame.

a. Decide if the snail moves with constant velocity. If it does, determine the magnitude of the velocity (the snail's speed). Record the data below in a table and plot a position-vs-time graph for the snail.

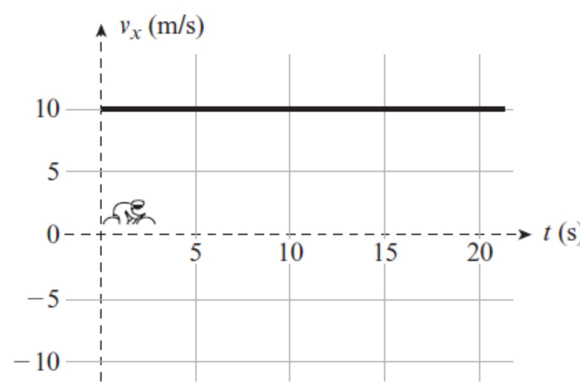
b. Predict where the snail would be in 26 minutes. What assumptions did you make?

c. Design an experiment to test whether or not you walk across a room in your house (apartment) at constant speed. Describe the experiment and the materials you will need to conduct it. If you do not have a meterstick or bean bags, use available materials to improvise. Record and analyze your data here.

d. If you determined that you walk at approximately constant speed, what is your speed? What assumption(s) did you use to make this estimate (Hint: think of what happens when you just start your motion.)

OALG 2.6.3 Analyze

The figure at the right shows a *velocity*-versus-time graph that represents the motion of a bicycle moving along a straight bike path. The positive direction of the velocity coordinate axis is toward the east.



a. Use the graph to estimate the bike's displacement during the time interval from clock reading 10 s to clock reading 15 s.

b. Use the graph to estimate its displacement during the time interval from 0 s to 20 s.

c. Formulate a general rule for using a velocity-versus-time graph to determine an object's displacement during some time interval specifically if the object is moving at constant velocity.

OALG 2.6.4 Test an idea

[https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-phys-egv2e-alg-2-6-7]

Use the video to test if the position of the object that you drop from a certain height can be described mathematically as $y = v_y t$. Consider the location from which the object is dropped to be the origin.

a. Think what it means to test an idea. In physics, experimental testing consists of the following steps:

1) you accept the idea (the hypothesis) being tested as true;

2) you design an experiment whose outcome you can predict using this idea;

3) you make the prediction of the outcome (here you also need to think of what you assume to be true in addition to the idea you are testing—these are called *assumptions*);

4) you perform the experiment and compare the outcome to the prediction, and based on the comparison, you make your judgment concerning the idea being tested.

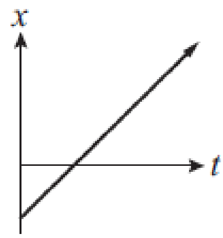
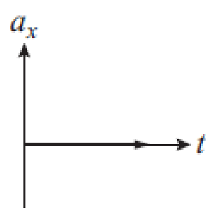
b. In this case, the experiment is performed already but you still need to make a prediction of its outcome based on the idea under test. Write your prediction down.

c. Now use the video to collect the data and compare the outcome to the prediction. Use the arrow keys on the keyboard to advance the video frame by frame. Record the data in a table. Examine the data you collected. Are they sufficient to gain confidence or reject the idea that a falling object moves at constant speed?

OALG 2.8.4 Summarize

This is a really helpful activity. Use different representations of the type of motion we have studied to fill in the empty cells in the table. Some cells are completed to give you an idea of the motions and the direction of the coordinate axis for each case. Your responses should relate to the motion already described. Completing the table will help you summarize everything you have learned about the description of motion

Motion with constant velocity
Describe the motion in words and provide an example.
Provide a motion diagram that describes this type of motion.
Provide a position-versus-time graph that describes this type of motion.


Describe the motion mathematically as $x(t)$.
Provide a velocity-versus-time graph that describes this type of motion.
Describe the motion mathematically as $v_x(t)$. $v_x = v_{x0}$
Provide an acceleration-versus-time graph that describes this type of motion. 
Describe motion mathematically as $a_x(t)$.