Using Graphs of Position vs. Time

Purpose and Expected Outcome

Having analyzed the position of objects in one, two, and three dimensions, we would now like to represent the motion of objects. To do this, we consider objects moving in a straight line and plot the (one-dimensional) position versus time. After doing this activity, you will know how to interpret position vs. time graphs.

Prior Experience / Knowledge Needed

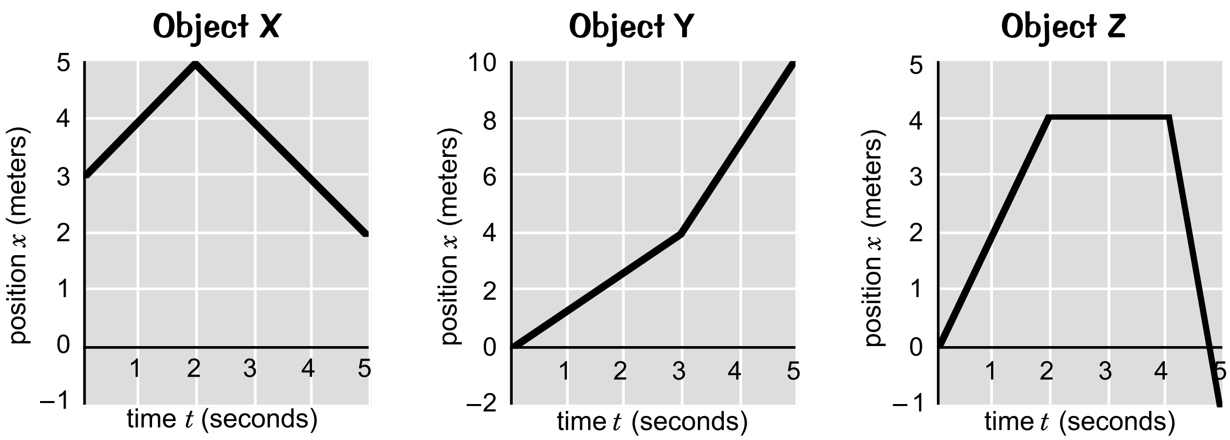
You should be familiar with the coordinate (component) representation of position in one dimension.

Explanation of Activity and Examples

There are two parts in this activity.

PART A: Reading and Interpreting Graphs of Position

Below are shown the position versus time graphs for three different objects. Assume that all three objects begin their motion at $t = 0$ seconds. Answer the following questions about the motion of the objects. In some cases, you will be asked to explain your answers.



E1. When is Object Y six meters away from the origin?

Answer: *Object Y is 6 meters from the origin at about $t = 3^1/_2$ seconds.*

E2. Which object is at $x = 2$ meters first?

Answer: *Object Z is 2 meters from the origin first, arriving at about $t = 1s$.*

A1. How far is Object Z from the origin at $t = 3$ seconds?

A2. Which object takes the least time to reach a position 4 meters from the origin?

A3. Which object is farthest from the origin at $t = 2$ seconds?

A4. Is there an object that eventually returns to the origin and, if so, which one does this and when does this occur?

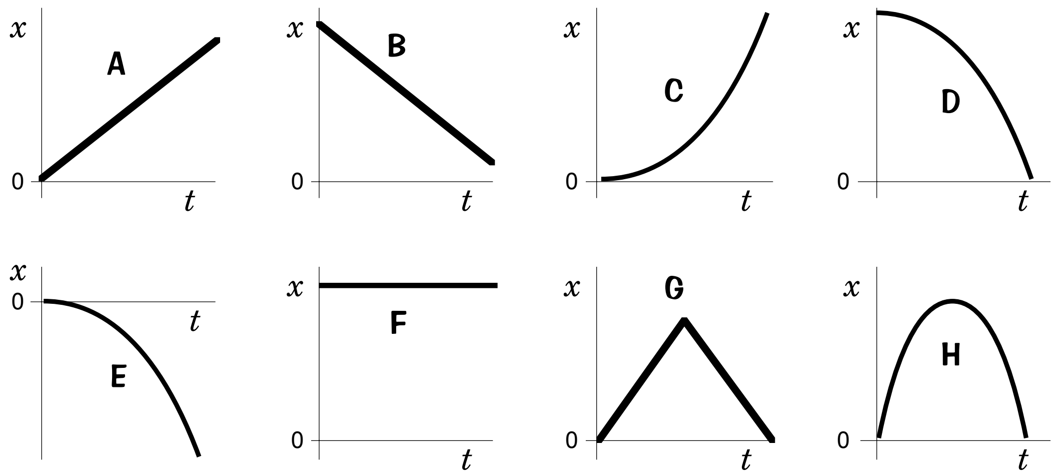
A5. What is the total <u>distance</u> traveled by each of the 3 objects during the full 5-second time interval? Explain.

A6. Which object has the largest <u>displacement</u> (change in position) between $t = 1$ second and $t = 3$ seconds? Explain.

A7. Which object has the largest displacement during the full 5 seconds? Explain.

PART B: Associating Motion with Graphs of Position vs. Time

For each description of a physical situation, (a) identify which of the graphs below could represent the motion of the object; and (b) indicate how the variable x relates to the physical situation. In some cases, you should specify which direction is positive before choosing a graph. (**Note**: For some situations, more than one graph is acceptable.)



> **E3.** A ball is dropped from a height of 1 meter above the floor. Take the origin to be at the level of the floor.
>
> ***Answer:*** *For "up" chosen to be the positive direction, graph D would represent the motion of the ball.*
>
> ***Explanation:*** *The variable x represents the height of the ball above the floor. This height starts at 1 meter at t = 0s and diminishes to zero at a later time. Graph E is incorrect because the graph does not start at x = 1m. Graph B qualitatively describes the motion since the graph starts at positive x and diminishes.*

B1. A marble is rolled at constant speed along a horizontal surface toward the origin. The marble is released at a distance of 1 meter away from the origin.

B2. A block sits at rest on a table 1 meter above the floor. Take the origin to be the level of the floor.

B3. A ball is dropped from a height of 2 meters above the floor. Take the origin to be the point from which the ball is released.

B4. A ball is rolled along a horizontal surface. The ball strikes a wall and rebounds toward the origin.

B5. A car is parked on a steep hill.

Reflection

R1. Define what is meant by the expressions "origin of a coordinate system", "origin of a graph", and "original position of an object". How are they similar? How are they different? Which objects (in parts A and B) have the origin as its original position?

R2. Can the "distance traveled" by an object ever be zero? How? Is there any time interval (in part A) for which any of the objects traveled zero distance? Which object, and what interval?

R3. Can the "displacement" of an object ever be zero? How? For a particular time interval beginning at t = 0s, Object A (in Part A) has zero displacement. What is the ending time of this interval?

R4. Which graph (in part B) represents a stationary object? Explain how you know the object is stationary.