COLLEGE PHYSICS

Chapter 2 INTRODUCTION: Kinematics in One Dimension

Lesson 3

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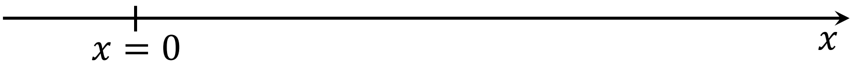
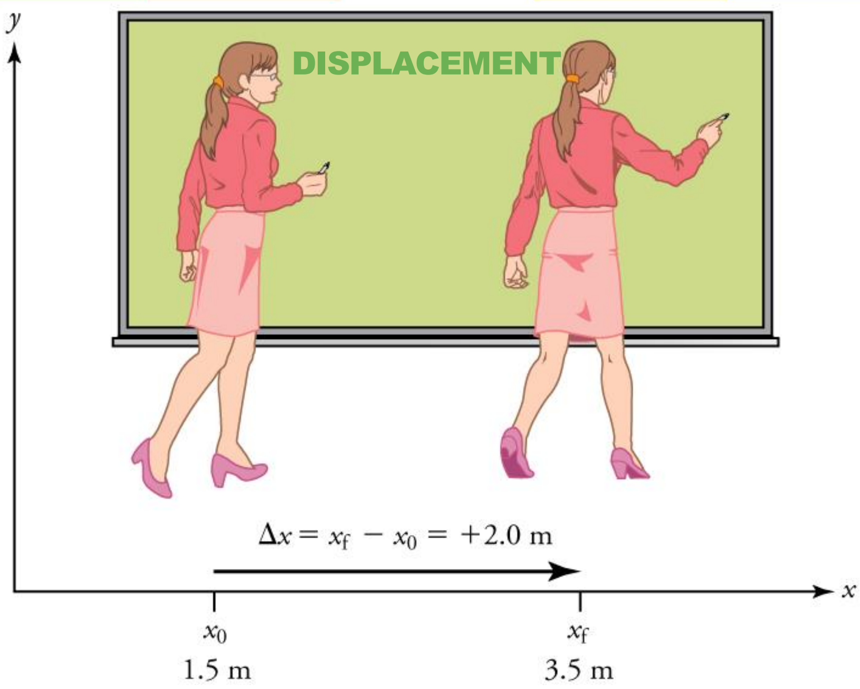
KINEMATICS

- **Kinematics** is the study of motion without considering its causes.
- **Dynamics** is the study of motion considering causes, such as force and energy.
- In this chapter, we examine the simplest type of kinematics: motion along a *straight line*, or **one-dimensional kinematics**.
- In the next chapter, **two-dimensional kinematics**, we apply the concepts developed here to study motion along *curved* paths.

POSITION

- These cyclists in Vietnam can be described by their **position** relative to buildings and a canal.
- Position is often described numerically by the distance from a certain point: the origin.
- The origin and the x-axis define a **reference frame**





DISTANCE VS. DISPLACEMENT

- Displacement is simply the final position minus the initial position: $\Delta x = x_f - x_0$
- For example, if $x_0 = 0$ and $x_f = 3$ m, then $\Delta x = +3$ m.

- If the object started at $x_0 = 0$, traveled all the way to $x = 4$ m, then, returned to $x_f = 3$ m, then the distance traveled was $d = 4 + 1 = 5$ m.
- Displacement can be positive or negative; distance is always positive.

GIVE IT A TRY!

You walk from 3 km to the grocery store and then back home. What is your distance traveled, d, and displacement, Δx?

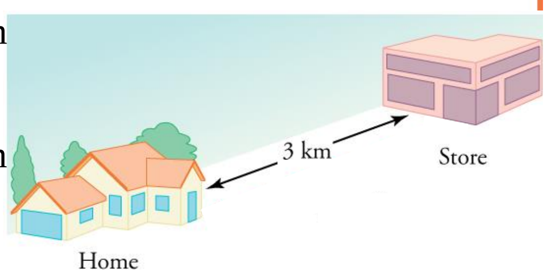
A. $d = 0$ km, $\Delta x = 6$ km

B. $d = 3$ km, $\Delta x = 0$ m

C. $d = 6$ km, $\Delta x = 6$ km

D. $d = 6$ km, $\Delta x = 0$ m

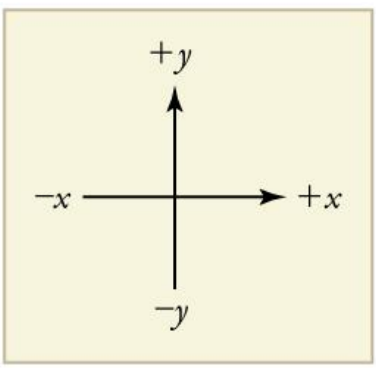
E. $d = 6$ km, $\Delta x = 3$ km



VECTORS VS. SCALARS

- A **vector** is any quantity with both magnitude and direction.
- Examples of vectors include displacement, velocity, acceleration and force.
- The direction of a vector in one-dimensional motion is given simply by a plus (+) or minus (−) sign.
- A **scalar** is a quantity that has magnitude, but no direction.
- Examples of scalars include distance, speed, temperature and mass.

DIRECTION SIGN CONVENTION



It is usually convenient to consider motion *upward* or *to the right* as positive (+) and motion *downward* or *to the left* as negative (−) .

TIME

- **Time** is *change*, or the interval over which change occurs.
- Any measurement of time, t, is calibrated by comparison with a standard.
- **Elapsed time** Δt is the difference between the ending and beginning time:

$$\Delta t = t_{\mathrm{f}} - t_0$$

- For example, if the lecture starts at 11:10 AM and ends at 12:00 noon, the elapsed time of the lecture is 50 minutes.

VELOCITY

- **Average velocity** is the displacement divided by the elapsed time:

$$\bar{v} = \frac{\Delta x}{\Delta t}$$

- Notice that velocity is a vector because displacement is a vector.
- The average velocity is in the same direction as the displacement.
- The **instantaneous velocity** v (a.k.a. "**velocity**") is your velocity at a specific instant in time.
- v can be found by taking the limit of $\bar{v}$ as $\Delta t \to 0$.

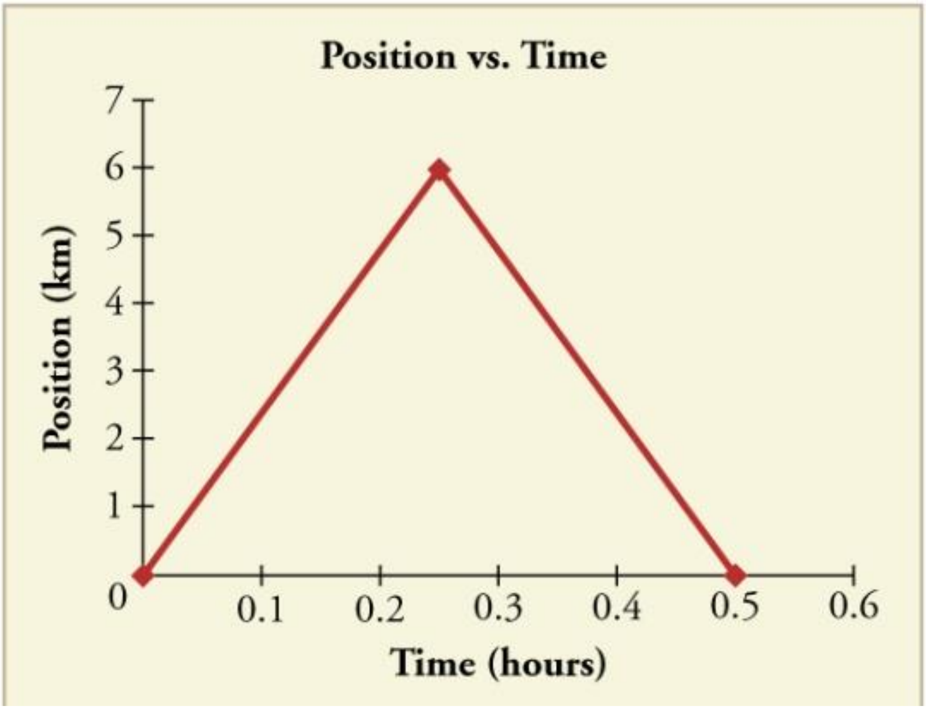
SPEED

- Average speed is the distance traveled divided by the elapsed time
- Average speed doesn't take into acount various instantaneous speeds along the way.
- For example, if you drove a distance of 200 km, and it took you a total of 2 hours, your average speed was 100 km/hr.
- Instantaneous speed (a.k.a. "speed") is your speed at any instant.
- Your instantaneous speed is given by your speedometer.

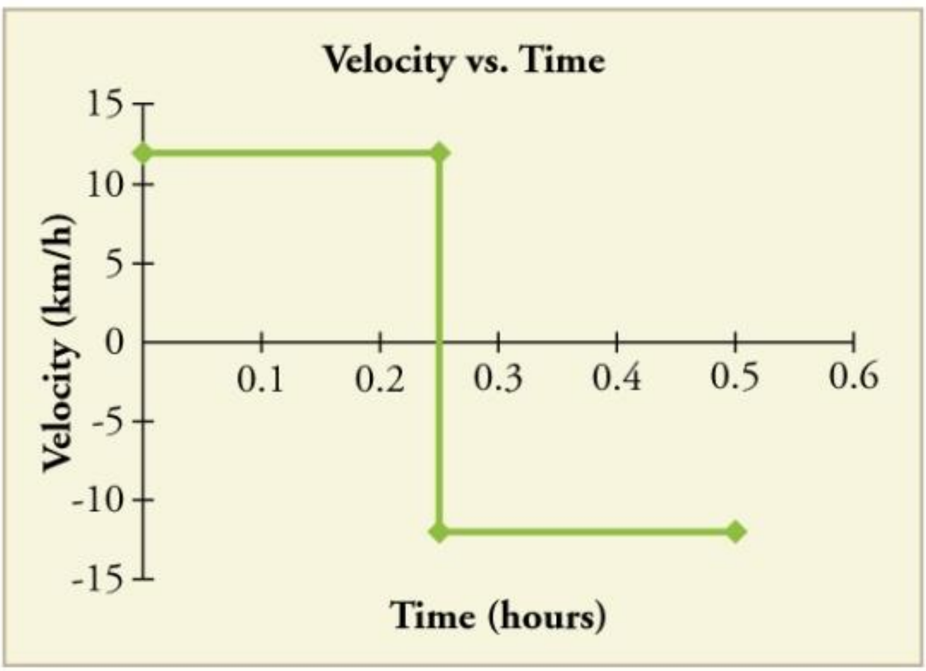
GIVE IT A TRY!

You drive from 3 km to the grocery store and then back home in half an hour. What was your average speed and average velocity?

A. speed = 0 km/hr, velocity = 12 km/hr
B. speed = 6 km/hr, velocity = 0 km/hr
C. speed = 12 km/hr, velocity = 12 km/hr
D. speed = 12 km/hr, velocity = 0 km/hr
E. speed = 12 km/hr, velocity = 6 km/hr



Position vs. Time
Position (km)
7
6
5
4
3
2
1
0
0.1
0.2
0.3
0.4
0.5
0.6
Time (hours)



Velocity vs. Time
Velocity (km/h)
15
10
5
0
-5
-10
-15
0.1
0.2
0.3
0.4
0.5
0.6
Time (hours)

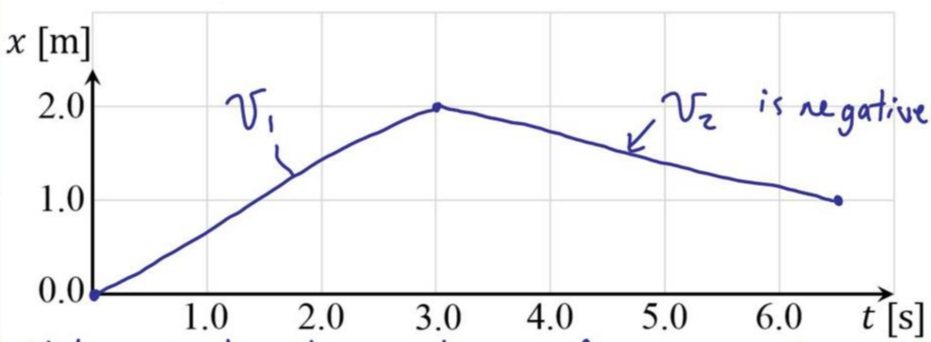
Example: Graphs of Hockey Puck Motion

Given video data of the motion, make plots of position vs. time and velocity vs. time.

First, let's make a table of the important data from the video.

x	t
0.0 m	0.0 s
2.0 m	2.99 s
1.0 m	6.60 s

Assume puck moves smoothly between these 3 moments



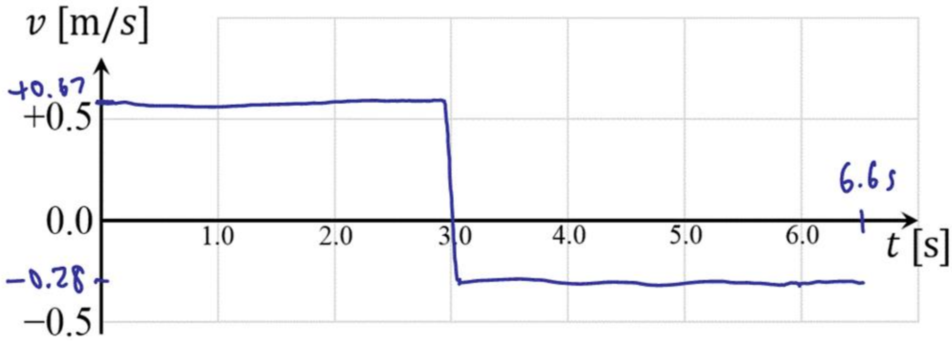
Note: velocity = slope of pos. vs. t graph

$$= \frac{\text{rise}}{\text{run.}}$$

$$v_1 = \frac{+2.0\,m}{2.99\,s} = \boxed{+0.67\,m/s}$$

$$v_2 = \frac{-1.0\,m}{(6.6-2.99\,s)}$$

$$\boxed{v_2 = -0.28\ m/s}$$


v [m/s]
+0.67
+0.5
0.0
−0.28
−0.5
1.0
2.0
3.0
4.0
5.0
6.0
6.6 s
t [s]