Chapter Four: Motion

- 4.1 Speed and Velocity
- 4.2 Graphs of Motion
- 4.3 Acceleration

Section 4.1 Learning Goals

- Distinguish between average speed and instantaneous speed.
- Use the speed formula.
- Distinguish between speed and velocity.

4.1 Position, Speed and Velocity

- The term speed describes how quickly something moves.
- To calculate the speed of a moving object divide the distance it moves by the time it takes to move.

SPEED

Speed (cm/s) $v = \frac{d}{t}$ ***Distance*** (cm)

Time (s)

4.1 Position, Speed and Velocity

- The units for speed are distance units over time units.
- This table shows different units commonly used for speed.

Distance	Time	Speed	Abbreviation
meters	seconds	meters per second	m/s
kilometers	hours	kilometers per hour	km/h
centimeters	seconds	centimeters per second	cm/s
miles	hours	miles per hour	mph

4.1 Average speed

- When you divide the total distance of a trip by the time taken you get the average speed.
- On this driving trip around Chicago, the car traveled and average of 100 km/h.

$$\frac{\text{150 kilometers}}{\text{1.5 hours}} = \text{100 kilometers (km/h)}$$

4.1 Instantaneous speed

- A speedometer shows a car's instantaneous speed.
- The instantaneous speed is the actual speed an object has at any moment.

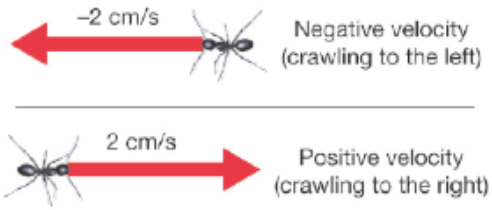
Solving Problems

How far do you go if you drive for two hours at a speed of 100 km/h?

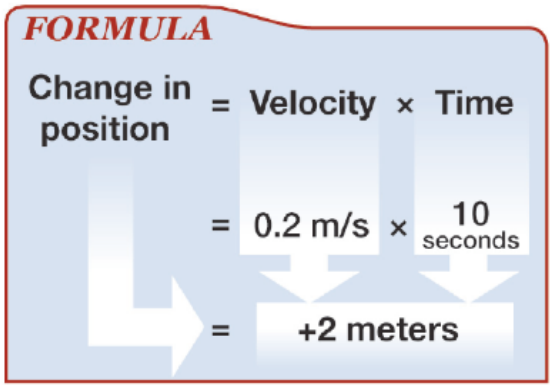
1. **Looking for:**
   - ...distance
2. **Given:**
   - ...speed = 100 km/h time = 2 h
3. **Relationships:**
   - $d = v \times t$
4. **Solution:**
   - $d = 100 \text{ km/h} \times 2 \text{ h} = 200 \text{ km}$ **= 200 km**

4.1 Velocity

- We use the term velocity to mean speed with direction.
- Velocity is usually defined as positive when moving forward (to the right from an outside observer), and negative when moving backward (to the left to an outside observer



4.1 Change in Position



- Using the formula with velocity gives you a change of position instead of distance.

Distance, Time, and Speed (Velocity)

Word Formulas		Equation
speed = distance ÷ time	velocity = distance ÷ time	$v = \frac{d}{t}$
distance = speed × time	distance = velocity × time	$d = vt$
time = distance ÷ speed	time = distance ÷ velocity	$t = \frac{d}{v}$

Solving Problems

A train travels at 100 km/h heading east to reach a town in 4 hours. The train then reverses and heads west at 50 km/h for 4 hours. What is the train's position now?

1. **Looking for:**
   - …train's new position
2. **Given:**
   - …velocity = +100 km/h, east ; time = 4 h
   - …velocity = −50 km/h, west ; time = 4 h
3. **Relationships:**
   - change in position = velocity × time

Solving Problems

4. Solution:

- **1st change in position:**
  (+100 km/h) × (4 h) = +400 km, east
- **2nd change in position**:
  (−50 km/h) × (4 h) = −200 km, west
- **Final position:**
  (+400 km) + (−200 km) = +200 km
  The train is 200 km east of where it started.