ConcepTest 3.1
You drive at 30 mi/hr for one hour and then at 50 mi/hr for another hour. What is your average speed for the whole 2 hour trip?

Cruising along
1) more than 40 mi/hr
2) equal to 40 mi/hr
3) less than 40 mi/hr
**ConcepTest 3.1**

You drive at 30 mi/hr for one hour and then at 50 mi/hr for another hour. What is your average speed for the whole 2 hour trip?

**Cruising along**

1) more than 40 mi/hr
2) equal to 40 mi/hr
3) less than 40 mi/hr

Remember that the average speed is distance/time. You travel 30 + 50 miles = 80 miles in two hours. Therefore, your average speed is 40 mi/hr.

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**Displacement and velocity**
To determine your **position**, you need a **coordinate system**

Distance = total length of travel

Displacement = change in position
= final position – initial position

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**Speed and Velocity**

Speed and velocity measure how position **changes** with time.

**Average speed**

\[ \text{average speed} = \frac{\text{total distance traveled}}{\text{total time}} \]

**Average velocity**

\[ \text{average velocity} = \frac{\text{displacement}}{\text{total time}} = \frac{x_2 - x_1}{t_2 - t_1} = \frac{\Delta x}{\Delta t} \]

**Question:** Does the speedometer in a car measure speed or velocity?
### ConceptTest 3.2

<table>
<thead>
<tr>
<th><strong>You drive 4 miles at 30 mi/hr and then another 4 miles at 50 mi/hr.</strong> What is your average speed for the whole 8 mile trip?</th>
<th><strong>Cruising along</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. more than 40 mi/hr</td>
<td>1) more than 40 mi/hr</td>
</tr>
<tr>
<td>2. equal to 40 mi/hr</td>
<td>2) equal to 40 mi/hr</td>
</tr>
<tr>
<td>3. less than 40 mi/hr</td>
<td>3) less than 40 mi/hr</td>
</tr>
</tbody>
</table>

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It is not 40 mi/hr! Remember that the **average speed is distance/time**. Since it **takes longer to cover 4 miles at the slower speed**, you are actually **moving at 30 mi/hr for a longer period of time**! Therefore, your average speed is closer to 30 mi/hr than it is to 50 mi/hr.
Instantaneous Velocity

The velocity at a specific instant of time

Review:
Average velocity between \( x_1 \) and \( x_2 \)

\[ v_{av} = \frac{\Delta x}{\Delta t} \]

What is the velocity right at point \( x_2 \) at the instant the time is \( t_2 \)?

Take two times very close to each other so \( \Delta t \) is very small

\[ v = \lim_{{\Delta t \to 0}} \frac{\Delta x}{\Delta t} = \frac{dx}{dt} \]

\[ v(t_2) = \text{slope of line tangent to path at } t_2 \]

Acceleration
Acceleration measures change in velocity!

Note that acceleration $a$ does **not** have to be in the same direction as velocity $v$!

**Acceleration**

Acceleration measures how the velocity changes with time.

The formula for average acceleration is:

$$\text{average acceleration} = \frac{\text{change in velocity}}{\text{total time}} = \frac{v_2 - v_1}{t_2 - t_1} = \frac{\Delta v}{\Delta t}$$

For instantaneous acceleration, the acceleration at a specific instant of time again let $\Delta t \to 0$.

$$a = \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t} = \frac{dv}{dt}$$
You drop a rubber ball. Right after it leaves your hand and before it hits the floor, which of the above plots represents the $v$ vs. $t$ graph for this motion? (Assume your y-axis is pointing up).

The ball is dropped from rest, so its initial velocity is zero. Since the y-axis is pointing upwards and the ball is falling downwards, its velocity is negative and becomes more and more negative as it accelerates downward.
You toss a ball straight up in the air and catch it again. Right after it leaves your hand and before you catch it, which of the above plots represents the $v$ vs. $t$ graph for this motion? (Assume your $y$-axis is pointing up).

The ball has an initial velocity that is positive but diminishing as it slows. It stops at the top ($v = 0$), and then its velocity becomes negative and becomes more and more negative as it accelerates downward.
You drop a very bouncy rubber ball. It falls, and then it hits the floor and bounces right back up to you. Which of the following represents the $v$ vs. $t$ graph for this motion?

Initially, the ball is falling down, so its velocity must be negative (if UP is positive). Its velocity is also increasing in magnitude as it falls. Once it bounces, it changes direction and then has a positive velocity, which is also decreasing as the ball moves upward.