Work, Force, and Motion

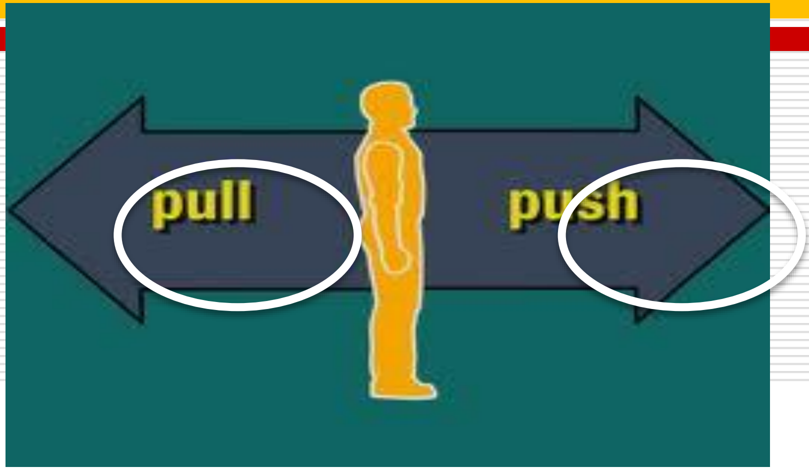
SOL Standard

- PS.10 The student will investigate and understand the scientific principles of work, force and motion. Key concepts include
  - Speed, velocity and acceleration
  - Newton’s laws of motion
  - Work, force

Guiding Questions

- What is the difference between work, force and motion?
- How is the speed, velocity, and acceleration of an object measured and calculated?
- How does speed, velocity, and acceleration describe motion?
- What is the difference between mass and weight?
- What is an example of each of Newton's three Laws of Motion?
- What is the relationship between force, mass and acceleration?

What is a force?



A force is a push or a pull on matter

Motion

- a change in position, or location of a place or object, over a certain amount of time
- relies on a frame of reference or something assumed to be stationary
- Frame of reference is a stationary location or object to which you compare other locations or objects

How does Frame of Reference relate to motion?

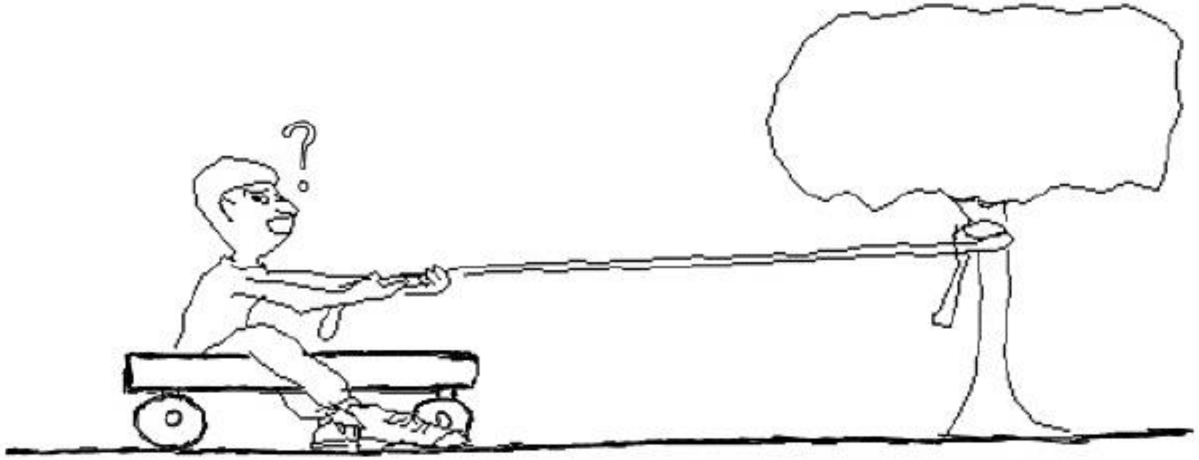
- Motion is relative to a frame of reference
- Something that is not moving in one point of reference can be moving in a different point of reference

Understanding frame of reference

- Nothing is truly stationary when relative to all other objects
- If you sit perfectly still, are you moving?

What Is Work?

- Work is a transfer of energy
- In science, work is done when a force causes an object to move in the direction of the force.
- If there is no movement in the direction of the force. no work is done



How to Calculate Work

We use the equation W = F x D "Work equals Force times Distance"

$W = 80\ \text{N} \times 1\ \text{m} = 80\ \text{J}$

The force needed to lift an object is equal to the gravitational force on the object—in other words, the object's weight.

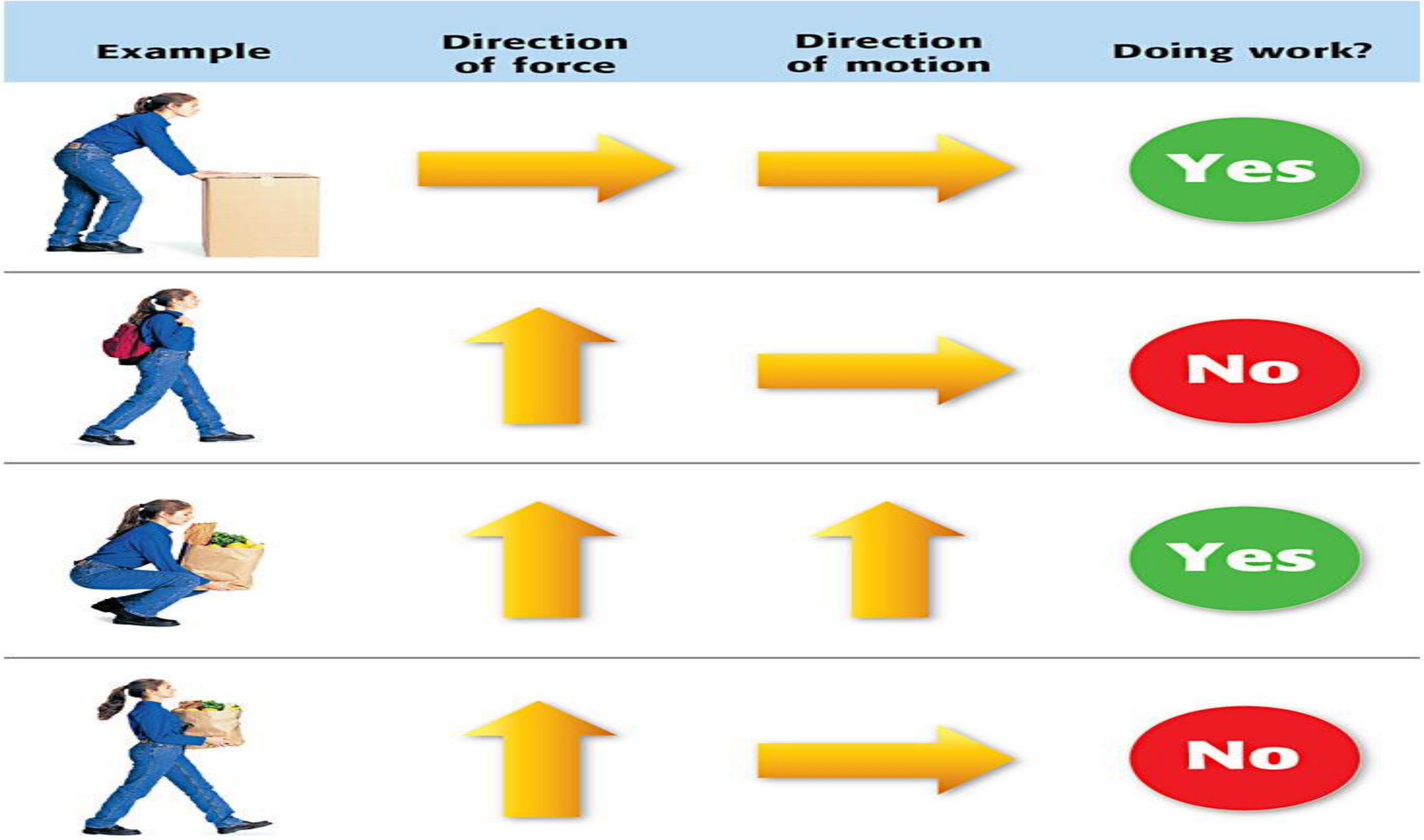
$W = 160\ \text{N} \times 1\ \text{m} = 160\ \text{J}$

If you increase the weight, an increased force is needed to lift the object. This increases the amount of work done.

$W = 80\ \text{N} \times 2\ \text{m} = 160\ \text{J}$

Increasing the distance also increases the amount of work done.

Do forces always cause work?



Speed

- the <u>rate</u> at which an object moves
- a measure of how <u>fast</u> something moves, or the <u>distance</u> it moves, in a given amount of <u>time</u>
  - **Formula: $S = \frac{d}{t}$**
- typically expressed in units of <u>m/s</u>
- is considered <u>***average***</u> when taking into account the total distance covered and the total time of travel
- is considered <u>***constant***</u> when it does not change
- is considered ***instantaneous*** when it represents a specific <u>instant</u> in time

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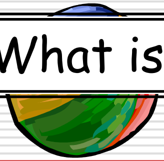


What is the ball's speed?

6 meters

Interesting Speeds

	meters/second	miles/hour
Cockroach	1.25	2.8
Kangaroo	15	34
Cheetah	27	60
Sound *(in 20^{0}C air)*	343	767
Space Shuttle *(getting into orbit)*	7,823	17,500
Light	300,000,000	671,080,888

Practice Problems - Speed

1. If you walk for 1.5 hours and travel 7.5 km, what is your average speed?

$$S = \frac{d}{t}$$

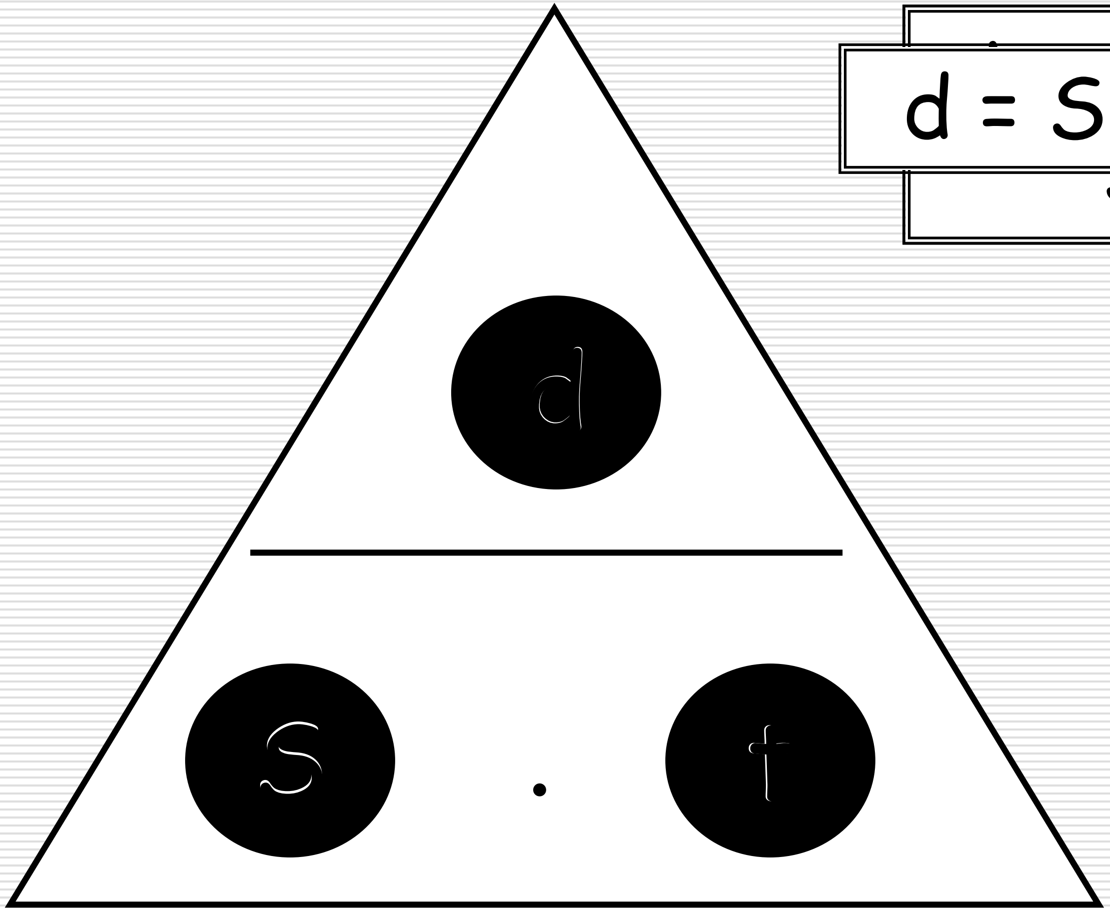
$$S = \frac{7.5\ km}{1.5\ hr} = \frac{5\ km}{hr}$$

2. Calculate the speed of a bee that flies 22 meters in 2 seconds.

$$S = \frac{d}{t}$$

$$S = \frac{22\ m}{2\ sec} = \frac{11\ m}{sec}$$

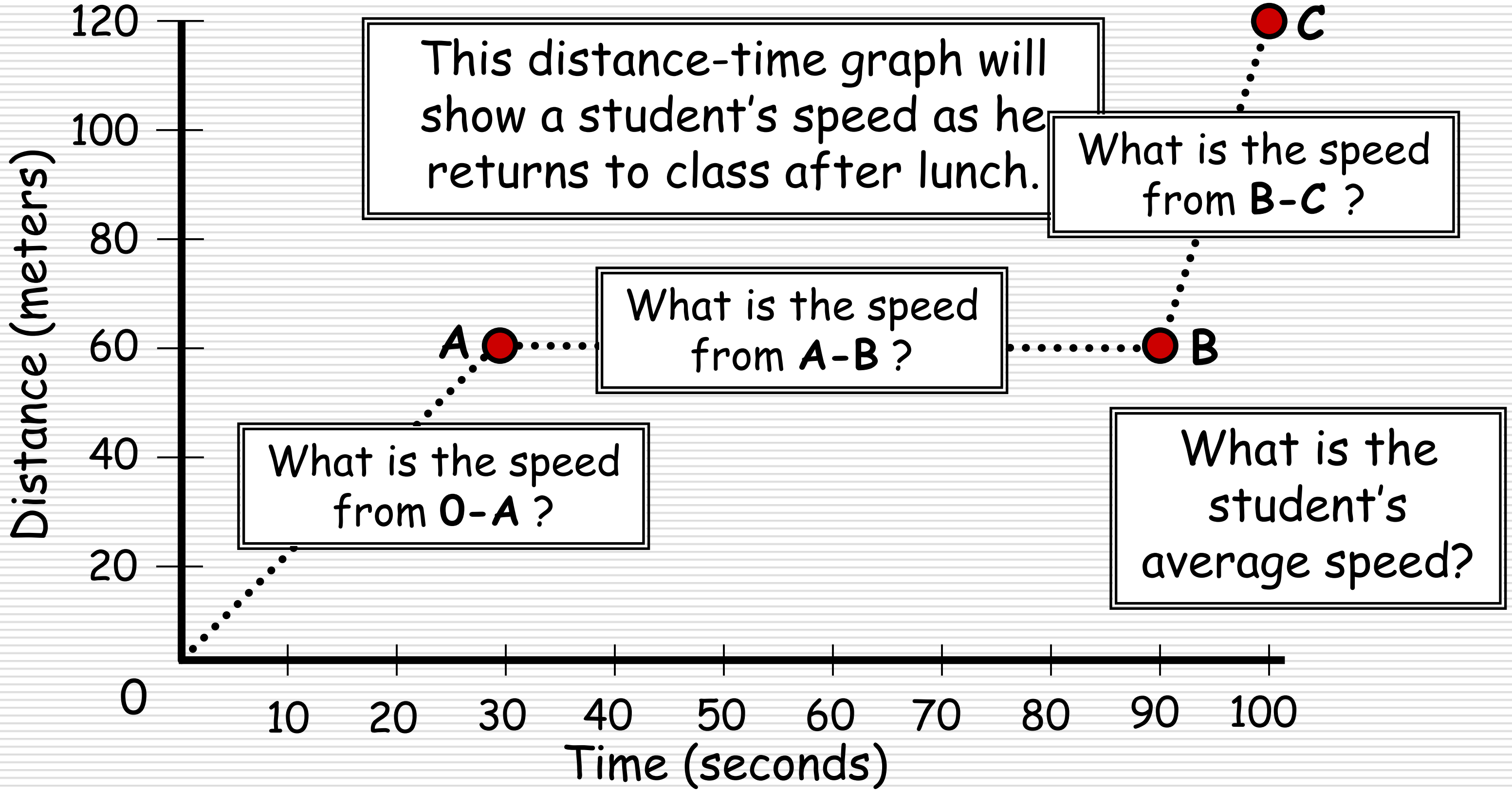
The Speed Triangle



$d = S \cdot t$

Distance-Time Graph

Shows how speed relates to distance and time

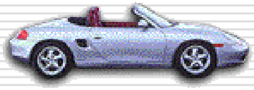


Can you figure this out?

Two birds perched directly next to each other, leave the same tree at the same time. They both fly at 10 km/h for one hour, 15 km/h for 30 minutes, and 5 km/h for one hour. Why don't they end up at the same destination?

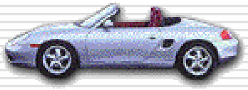
Velocity

- the rate of change of an object's position
- speed in a given direction
- is considered ***constant*** when speed and direction do not change
- changes as speed **or** direction changes
- is a vector
- can be combined (added if moving in the same direction and subtracted if moving in the opposite direction)
  - i.e. – If you are walking at a rate of 1.5 m/s up the aisle of an airplane that is traveling north at a rate of 246 m/s, your velocity would actually be 247.5 m/s



29 m/s east

25 m/s west



visuals taken from: http://www.amazing-animations.com/

What is the difference between speed and velocity

Velocity includes a direction.....Speed *does not* include a particular direction.

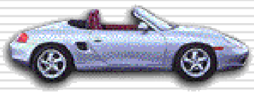
$$v = \frac{d}{t}$$

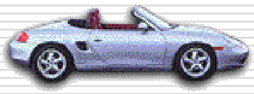
Both use the same equation:

Speed or Velocity = $\frac{\text{distance}}{\text{time}}$

Acceleration

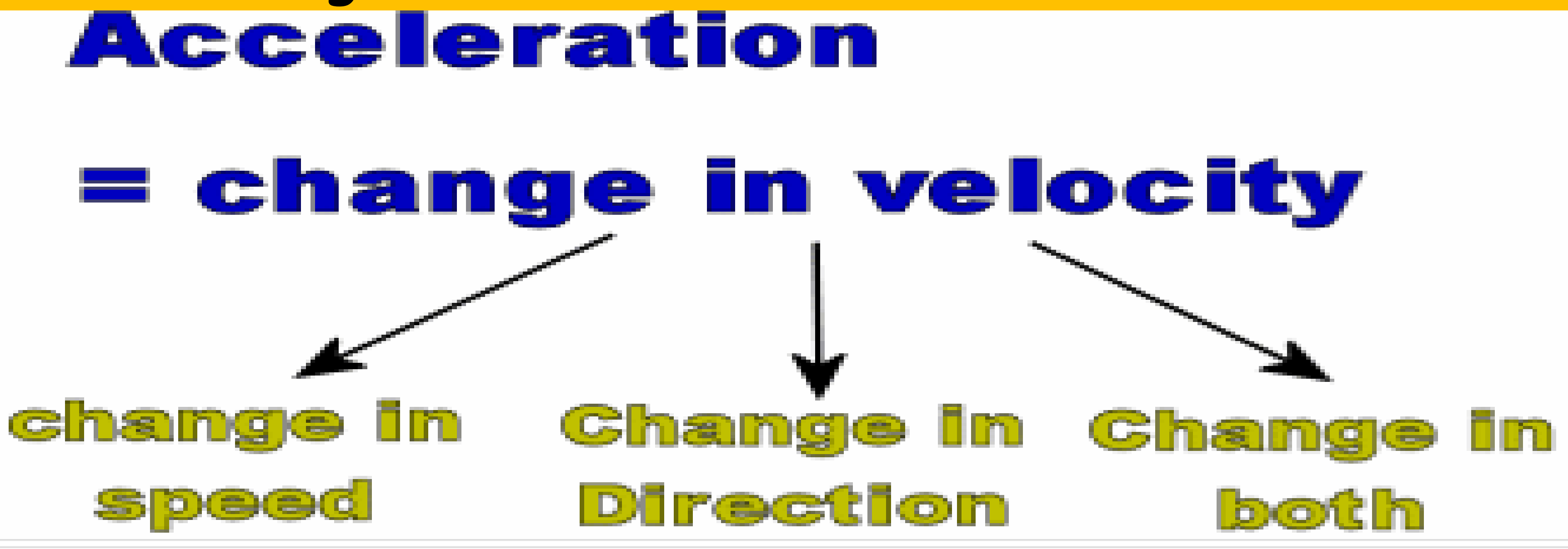
- the rate at which velocity changes
- occurs when something is speeding up (+), slowing down (-), **or** changing direction
  - **Formula:** $a = \frac{v_f - v_i}{t}$
- typically expressed in units of m/s^2
- is always changing, and considered centripetal, when traveling in a circle





Explain how both cars are accelerating.

Velocity and Acceleration



Acceleration Formula

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time}}$$

$$a = \frac{\Delta v}{t}$$

$$a = \frac{vf - vi}{t}$$

Practice Problems - Acceleration

1. Tina starts riding her bike down a hill with a velocity of 2 m/s. After six seconds, her velocity is 14 m/s. What is Tina's acceleration?

$$a = \frac{v_f - v_i}{t}$$

$$a = \frac{14\ m/s - 2 m/s}{6\ s} = 2\ \frac{m}{s^2}$$

2. A motorcyclist goes from 35 m/s to 20 m/s in five seconds. What was his acceleration?

$$a = \frac{v_f - v_i}{t}$$

$$a = \frac{20\ m/s - 35\ m/s}{5\ s} = -3\ \frac{m}{s^2}$$