Calculating Acceleration

Practice:

For the following problems, state whether the acceleration is positive, negative or zero and state whether the change in velocity is positive, negative or zero.

1. A car speeding up in the forward direction
   Forward direction is positive, change in velocity is positive, acceleration is positive

2. A car is slowing down in the forward direction

   Forward direction is positive, the change in velocity is negative, and acceleration is negative

3. A car is speeding up in the backward direction
   Backward direction is negative, change in velocity is negative, acceleration is negative (but speeding up)

4. A car slowing down in the backward direction
   Backward direction is negative, change in velocity is positive, acceleration is negative (slowing down)

Acceleration is a rate of change – the change in velocity over a time interval.

How do we calculate this?

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

Example: A pool ball travelling at 2.5 m/s towards the cushion bounces off at 1.5 m/s. If this movement took 0.20 s, what is the ball's acceleration?

$$a = \frac{(1.5\, m/s - 2.5 m/s)}{0.20 s} = -5\frac{m}{s^2}$$

Rearrange the above equation to solve for change in velocity and change in time.

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

Practice:

1. A car accelerates from rest at 3.0 m/s^2 forward for 5.0 s. What is the velocity of the car at the end of 5.0 s?

$$v = 3.0 \ \times 5.0\ s = 15\ m/s$$

2. A train is travelling east at 14 m/s. How long would it take to increase its velocity to 22 m/s east, if it accelerated at 0.50 m/s^2 east?

$$\Delta t\ = \frac{(22 - 14)}{0.5} = 16\ s$$

3. A car travelling forward at 25.0 m/s stops and backs up at 4.0 m/s.

a) What is the car's change in velocity?

- 29 m/s

b) What is the direction of the car's acceleration?
negative

c) If the car time it took for the change in velocity was 20 s, what was the acceleration of the car?

-29 m/s / 20 s = 1.45 m/s^2

4. A car starting from rest accelerates uniformly to 15 m/s [E] in 5.0 s. What is the car's acceleration?

$a = \frac{(15m/s)}{5s} = 3\ m/s^2$

5. A motorcycle is travelling north at 11 m/s. How much time would it take for the motorcycle to increase its velocity to 26 m/s [N] if it accelerated at 3.0 m/s^2?

$$\Delta t\ = \frac{(26 - 11\ m/s)}{3.0\ m/s^2} = 5\ s$$

Velocity-Time Graphs

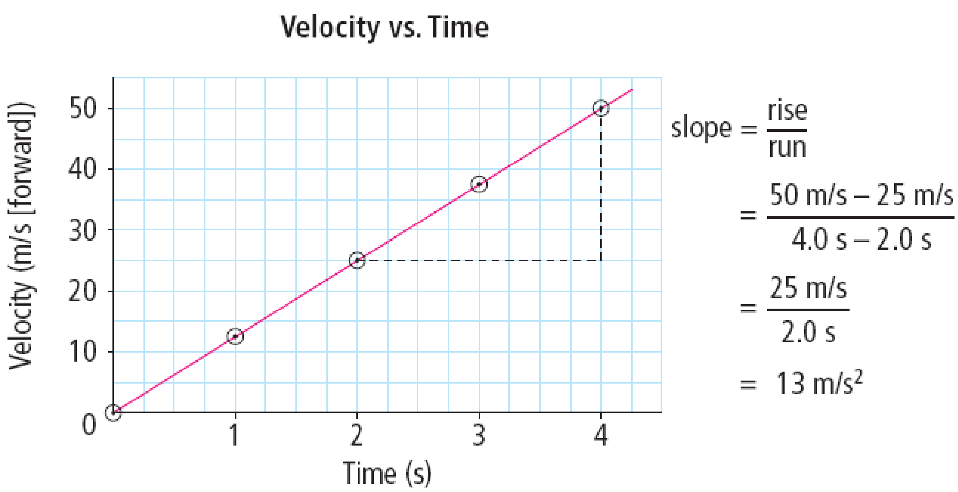
The motion of an object with a changing **velocity** can be represented by a velocity-time graph.

The slope of a velocity-time graph is **average** acceleration (in m/s^2).

Recall: In position-time graphs, the slope represented average velocity.

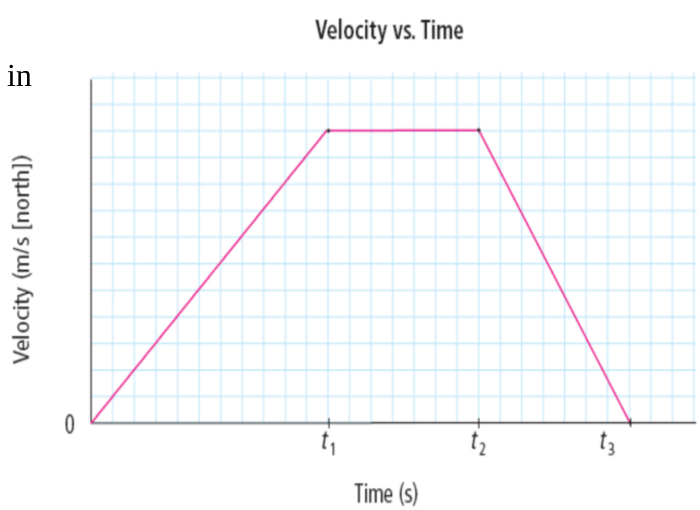
Thinking question: How can you calculate the average acceleration using a velocity-time graph?

The slope of a velocity-time graph is the average acceleration of the object.



Just like a position-time graph, a velocity-time graph can be used to describe the **motion** of an object.

- Positive slope – velocity is increasing in the **positive** direction = positive acceleration
- Zero slope – velocity is constant = **zero** acceleration
- Negative slope – velocity is **decreasing** in the positive direction OR velocity is increasing in the negative direction = **negative** acceleration



Thinking question: if there is a horizontal line on a velocity-time graph (0 m/s^2 acceleration), is the object still moving? Explain.

The object is moving – it just has constant velocity (it is not accelerating or decelerating)

Use the velocity-time graph below to state during which time interval the following motions occurred:

a) The acceleration was zero $t_1 - t_2$

b) The acceleration was negative $t_2 - t_3$

c) The acceleration was positive $t_0 - t_1$

d) The object was increasing its velocity north $t_0 - t_1$

e) The object was decreasing its velocity north $t_2 - t_3$

f) The object was moving at a constant velocity north $t_1 - t_2$