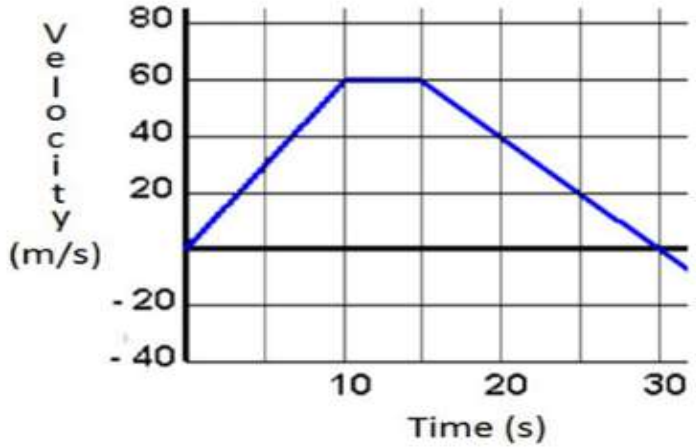
Physics Honors
Acceleration and Kinematics

Velocity Graphs and Acceleration

Look at the velocity graph to the right.

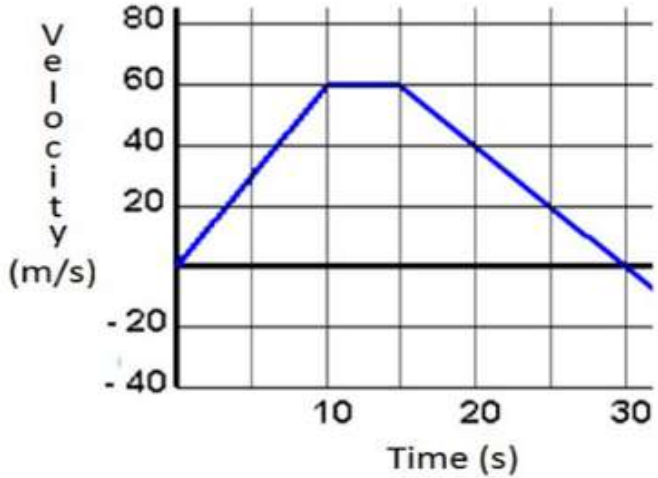
How would you define acceleration? (2 ways!)

Based on your definition, where on this graph is the object accelerating?



Acceleration is defined as the rate of change of velocity.

That means that it is the slope of a velocity vs time graph



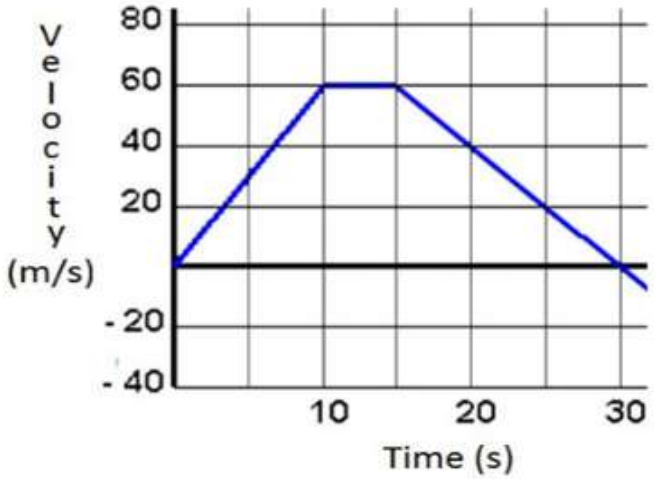
In everyday language, we only use “acceleration” for when things are speeding up.

However, in physics, acceleration is ANY change in velocity.

So from 0 - 10 seconds, this graph has a positive (+) acceleration.

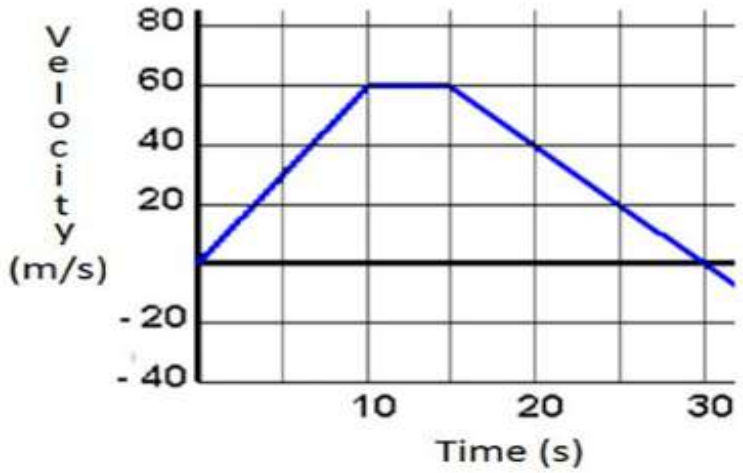
From 15 - 30 seconds, this graph has a negative (-) acceleration

What about from 10-15 seconds?



We know that the slope of the velocity vs time graph is the acceleration.

Calculate the slope for each of the three segments of this graph



Note that in the graph, you calculated acceleration as the slope, which is rise over run.

The rise is the change in velocity. The run is the time. Therefore, the acceleration can also be calculated as

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

Where v_f is final velocity, v_i is initial velocity, and a is acceleration.

The units of acceleration are m/s^2.

Try solving these problems using the equation for acceleration

A car is moving at 10 m/s initially. It speeds up to 20 m/s in 5 seconds. Calculate the acceleration of the car.

A truck is moving at 40 m/s. It slows down with an acceleration of -4 m/s^2. How fast will it be moving after 5 seconds?

An airplane is initially moving at 100 m/s. A tailwind makes it accelerate at 5 m/s^2 until it reaches a velocity of 130 m/s. How much time did this take?

Before, we saw that you could find a distance traveled with the equation x=vt.

What about if the velocity is not constant?

You have to use the average velocity. The average velocity is the average of the initial and final velocities.

$$\text{avg velocity} = \frac{v_i + v_f}{2}$$

So to find the displacement when the object is accelerating, use that instead of a constant velocity value

$$x = \left(\frac{v_i + v_f}{2}\right) t$$

Use the displacement kinematics equation to calculate displacements

A sprinter is initially at rest. When the race starts, she speeds up to 10 m/s over a time of 5 seconds. How far did she run in that time?

A baseball player is initially running at 8 m/s. He slides into bases, slowing to a stop in 0.5 seconds. How far did he slide?

A ball is dropped out a window. It it initially at rest, then it speeds up as it falls, falling a distance of 20 meters in 2 seconds. How fast is it moving at the end of that fall?

Accelerated Motion Equations

There are two other accelerated motion equations that can be derived from the first two. If you're interested in how it's derived, you take the two equations on the previous slide, solve one for a variable and substitute into the other one.

The new equations are

$$x = v_i t + \frac{1}{2} a t^2$$

and

$$v_f^2 = v_i^2 + 2ax$$

Note that each of the four equations we have seen for accelerated motion has a different combination of variables.

Accelerated Motion Equations

Problem solving steps:

1. Identify which quantities you are given in the problem. Look for keywords, such as “starts at rest” which means that $v_i=0$, or “comes to a stop” which means that $v_f=0$.

1. Identify what quantity you are trying to find.

1. Look at the four accelerated motion equations to choose one that has all the information you are given and the quantity you are solving for.

1. Substitute numbers into the equation and solve.

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

$$x = \left(\frac{v_i + v_f}{2}\right) t$$

$$x = v_i t + \frac{1}{2} a t^2$$

$$v_f^2 = v_i^2 + 2ax$$

Accelerated Motion Equations

Example problem:

A toy car is initially at rest, and then it rolls down a hill. It takes 4 seconds to roll 10 meters down the hill. Calculate the acceleration of the car.

Step 1 - what information are we given?

We know that v_i=0., we know that x=10 meters, and we know that t=4 seconds.

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

$$x = \left(\frac{v_i + v_f}{2}\right)t$$

$$x = v_i t + \frac{1}{2}at^2$$

$$v_f^2 = v_i^2 + 2ax$$

Accelerated Motion Equations

Example problem:

A toy car is initially at rest, and then it rolls down a hill. It takes 4 seconds to roll 10 meters down the hill. Calculate the acceleration of the car.

Step 2 - what are we solving for?

We are trying to find acceleration, which is the variable a.

Step 3 - which equation has v_i, x, t, and a in it?

The third one down the list!

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

$$x = \left(\frac{v_i + v_f}{2}\right)t$$

$$x = v_i t + \frac{1}{2}at^2$$

$$v_f^2 = v_i^2 + 2ax$$

Accelerated Motion Equations

Example problem:

A toy car is initially at rest, and then it rolls down a hill.
It takes 4 seconds to roll 10 meters down the hill.
Calculate the acceleration of the car.

Step 4 - substitute numbers and solve

$x=v_it + ½at^2$

$10 = 0(4)+ ½a(4)^2$

$10 = 8a$

$a = 1.25\ m/s^2$

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

$$x = \left(\frac{v_i + v_f}{2}\right)t$$

$$x = v_i t + \frac{1}{2}at^2$$

$$v_f^2 = v_i^2 + 2ax$$

Displacement Calculations in Accelerated Motion

Use the accelerated motion kinematics equation to calculate answers

1) A sprinter is initially at rest. When the race starts, she speeds up to 10 m/s over a time of 5 seconds. How far did she run in that time?
2) A baseball player is initially running at 8 m/s. He slides into bases, slowing to a stop in 0.5 seconds. How far did he slide?
3) A ball is dropped out a window. It it initially at rest, then it speeds up as it falls, falling a distance of 20 meters in 2 seconds. What is the acceleration as the ball falls?

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

$$x = \left(\frac{v_i + v_f}{2}\right) t$$

$$x = v_i t + \frac{1}{2} a t^2$$

$$v_f^2 = v_i^2 + 2ax$$