Note Booklet #2:

Kinematics

Scalars and Vectors

A vector is a measurement with both _____ and _____

A scalar does not have _____

Displacement and Distance

Displacement is _____ in _____ from some _____.

Distance is how far an _____ has _____.

Displacement is a _____ and distance is a _____.

Example: Someone walks 25 m North, and then walks 15 m South. What distance did they travel? What is their displacement?

Example: A ball rolls 15 cm, hits a wall and comes back to where it started. What distance did it travel? What is the displacement of the ball?

Speed and Velocity

Speed is the rate at which _____ changes over time. It is a _____

Speed =

Velocity is the rate at which _____ changes over time. It is a _____

Velocity =

Example: Someone walks 26 m North, and then 42 m South in a total time of 15 seconds. What is the distance they travelled? What is their displacement? What is their average speed? What is their average velocity?

Example: A person runs with velocity of 6.3 m/s East for 27.5 seconds. They then stop and rest for 3.0 seconds, turn around walk West at 2.9 m/s for 15 seconds. What is their total distance? What is their total displacement? What is their average speed? What is their average velocity?

Practice

1. Consider the diagram to the right:

   a. What is the distance between car A and car B?

   b. What is the distance between car B and car A?

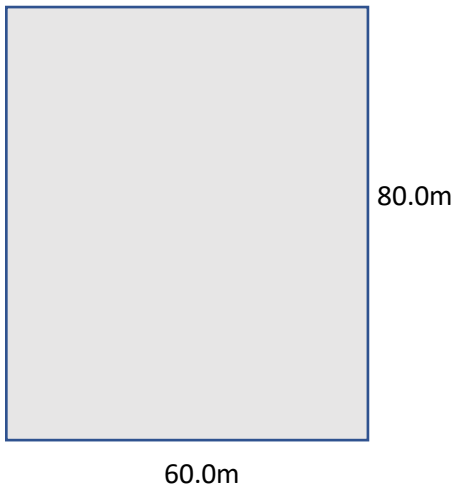
   c. What is the displacement from car A to car B?

   d. What is the displacement from car B to car A?

2. A shopping cart moves from a point 3.0 m West of a flagpole to a point 18m East of a flagpole in 2.5 seconds. Find its average velocity.

3. If someone runs with average speed of 10.2 km/hr, how long will it take them to run 42 km?

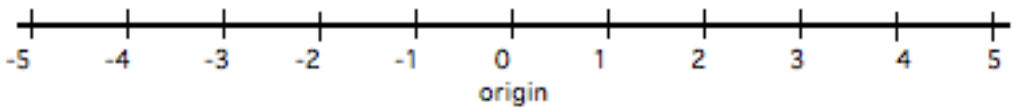
4. Sally takes her dog for a walk around the block shown.
   a. What distance did she travel?



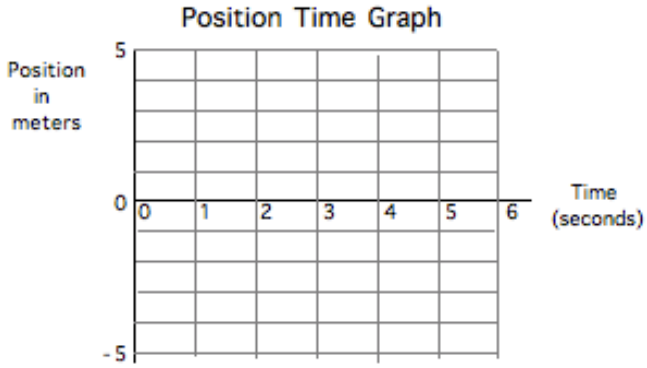
   b. What is her displacement?

Position-Time Graphs

Consider the motion of an object moving back and forth along a straight line.



Time (s)	0	1	2	3	4	5	6
Position (m)							



What is the position of the object at 5.5 seconds?

What is the displacement of the object between:

0 and 3 seconds?	3 and 6 seconds?	0 and 6 seconds?

What is the distance travelled of the object between:

0 and 3 seconds?	3 and 6 seconds?	0 and 6 seconds?

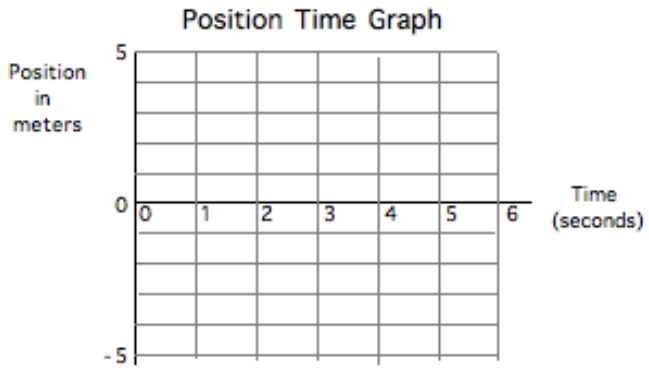
What is the average velocity and speed of the object between:

0 and 3 seconds?	3 and 6 seconds?	0 and 6 seconds?

Practice

1. Sketch a position time graph based on the data in the following chart

Time (s)	0	1	2	3	4	5	6
Position (m)	-1	1	3	3	3	-4	-1



2. Determine the distance travelled between time 0 and time 6

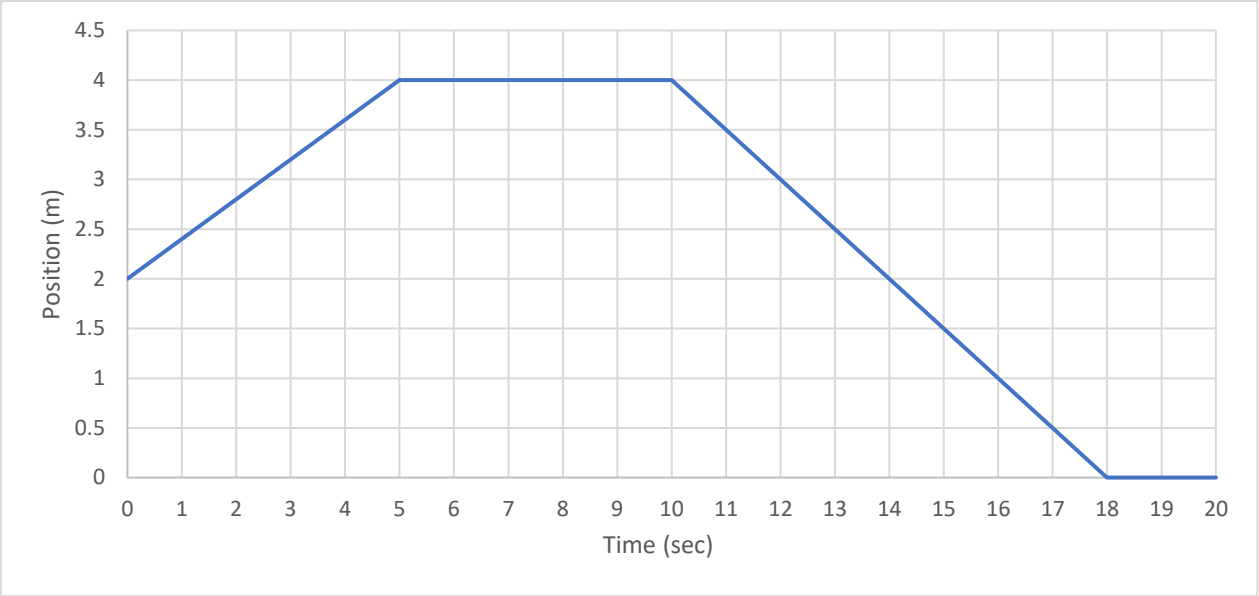
3. Determine the average speed between time 0 and time 6

4. Determine the displacement between time 0 and time 6

5. Determine the average velocity between time 0 and time 6

6. In what interval of time is the velocity negative?

Slope in a position time graph



Determine the slope of the position time graph shown with units, rounded to 2 sig figs

Between t=0 to t=5

Between t=5 to t=10

Between t=10 to t=18

Between t=18 to t=20

The slope of a position time graph is the _____ of the object.

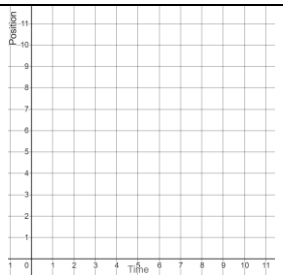
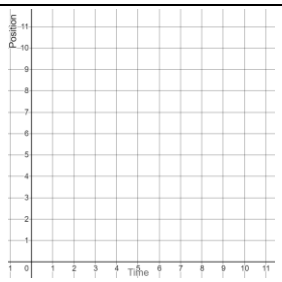
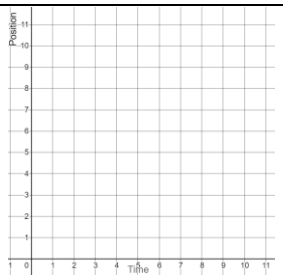
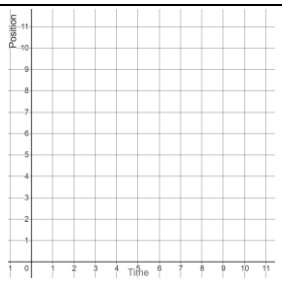
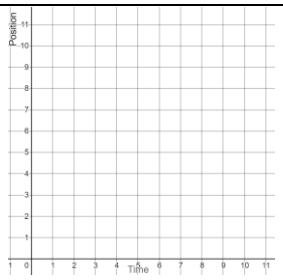
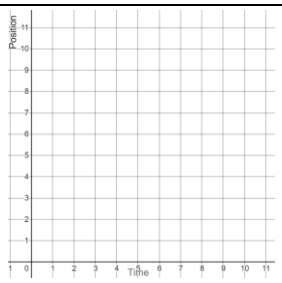
Positive slope means the object is moving in the _____ direction.

Negative slope means the object is moving in the _____ direction.

Zero slope means the object is _____.

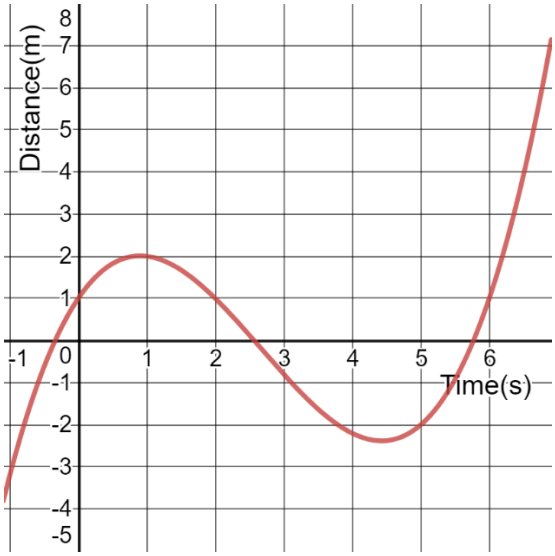
The steeper the line the _____ the object is moving.

Examples:

Draw a position time graph for an object moving quickly in the positive direction 	Draw a position time graph for an object moving slowly in the positive direction. 
Draw a position time graph for an object moving quickly in the negative direction 	Draw a position time graph for an object moving slowly in the negative direction. 
Draw a position time graph for an object which isn't moving. 	Draw a position time graph for an object the moves in the positive direction quickly, pauses, and then moves in the negative direction slowly. 

Instantaneous Velocity

Suppose it is necessary to determine the velocity of an object at one instant in time. In this case an average will not do because an average involves a time interval, Δt. In order to obtain an instantaneous velocity the concept of a _____ to a curve is required.



1. What is the average velocity between t=0 and t= 6?

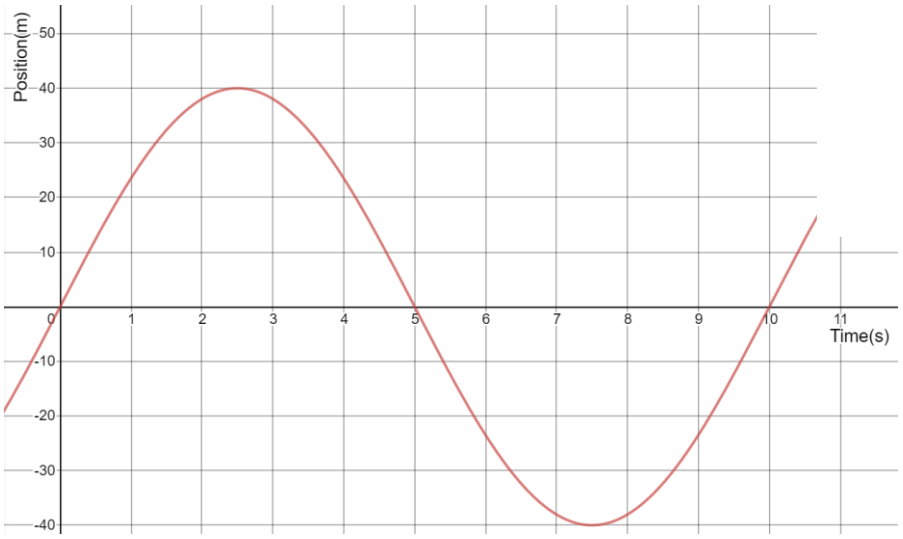
2. What is the average velocity between t=1 and t =5?

3. What is the average velocity between t=2 and t =4?

4. What is the instantaneous velocity at t=3?

5. What is the instantaneous velocity at t=1?

Practice



1. Determine the instantaneous velocity at t=3.

2. Determine the instantaneous velocity at t=3.

3. Determine the instantaneous velocity at t=2.5 and 7.5.

Acceleration

Acceleration is

Example Problems

1. A sprinter starts from rest and reaches a speed of 12m/s in 4.25 s. Find her acceleration.

2. A car starts from rest and accelerates at 15m/s^2 for 3.0 seconds. What is its top speed?

3. If a snowboarder is traveling at 8.0m/s how long will it take her to reach 36.0 m/s if she can accelerate at a rate of 3.5 m/s

All vectors include direction. Generally, up or to the right is _____ down or to the left is _____.

Where it makes sense "forward" is generally _____ and "backwards" in normally _____.

	Velocity	Acceleration
A car sitting at a stop light hits the gas		
From rest you back out of your driveway		
A car slows to a stop		
You drop a rock off a cliff		
You throw a rock straight up		

Determine the signs (positive or negative) of velocity and acceleration in each of the following

1. A stop light turns green and a car hits the gas.

2. A car backs out of a driveway.

3. A car slows to a stop.

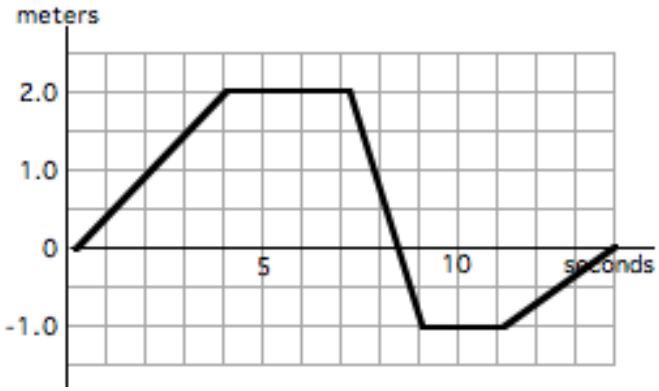
4. A rock is dropped from a cliff.

5. A rock is thrown straight up.

Velocity – Time Graphs

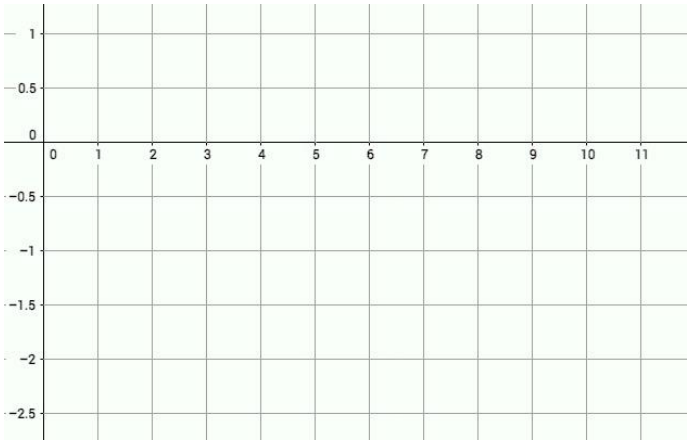
Interval	Velocity
0 – 4 s	
4 – 7 s	
7 – 9 s	
9 – 11 s	
11 – 14 s	

Position - Time Graph



Use the velocities to generate a velocity vs time graph.

Velocity-Time Graph

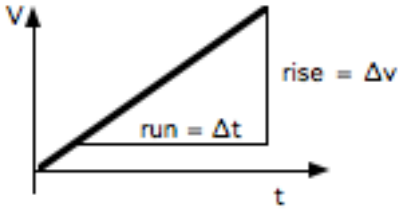


A horizontal line on a V-T graph represents a _____ velocity.

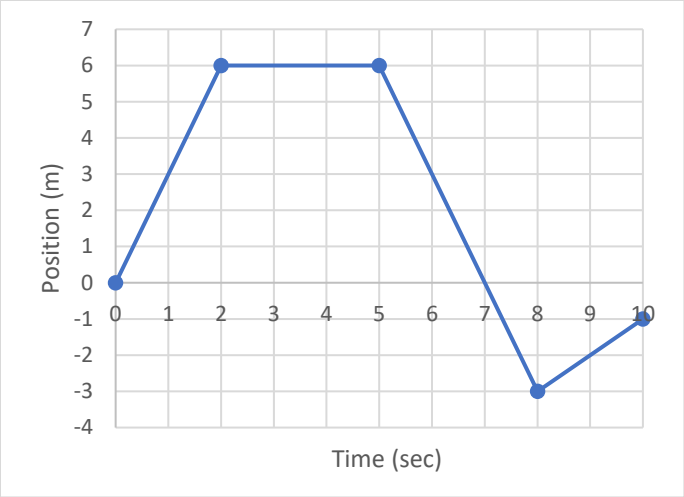
Anything above the time axis means motion in the _____ direction, below the time axis means motion in the _____ direction, and on the time axis means _____.

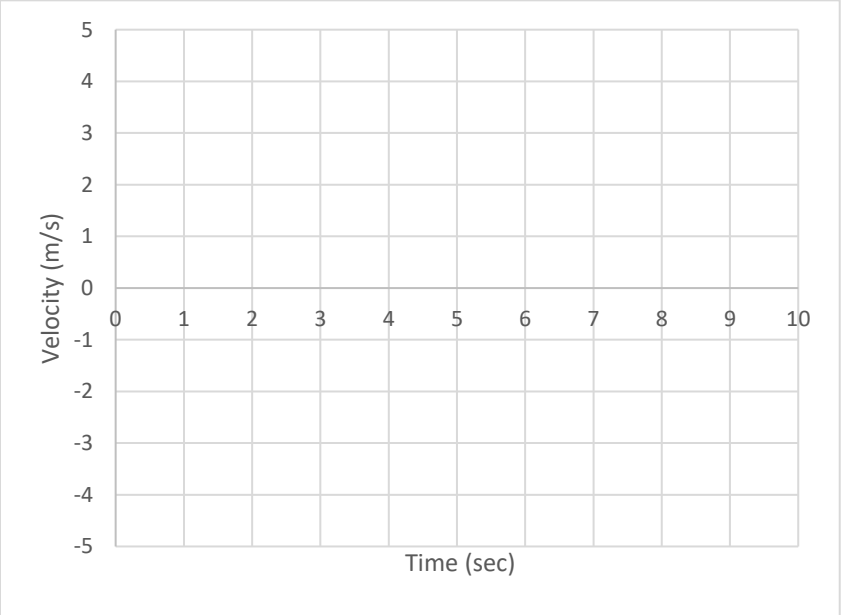
A vertical line represents an _____ change in velocity

Acceleration =

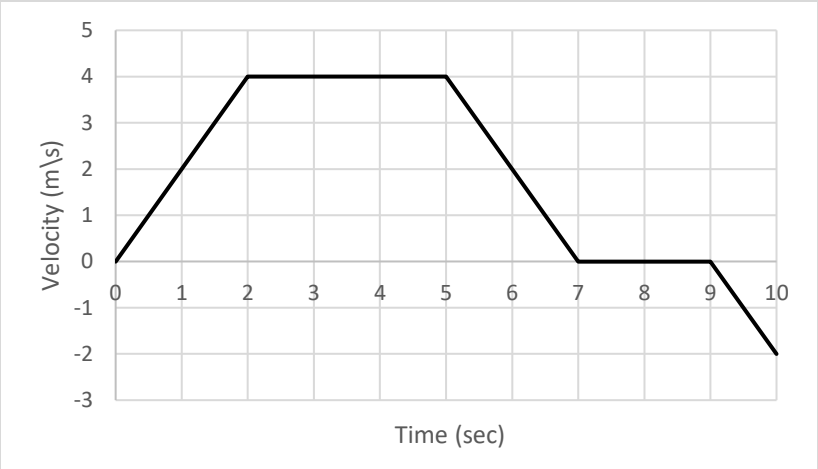


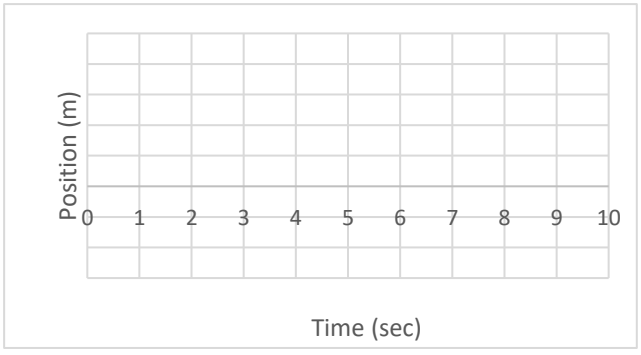
Example: Convert the following position time graph into a velocity time graph.





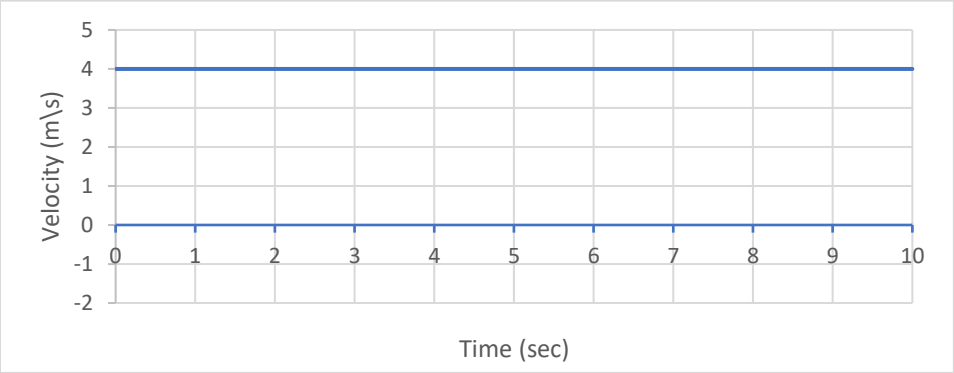
Example:



When is the object moving in the positive direction?	When is the object moving in the negative direction?
When is the object stationary?	When is the object's acceleration positive?
When is the object's acceleration negative?	What is the object's acceleration from t=0 to t=2?
What is the object's velocity between t=2 and t=5?	What is the object's instantaneous velocity at t=9.5?
Sketch a position time graph for this motion	

Displacement from a Velocity-Time Graph

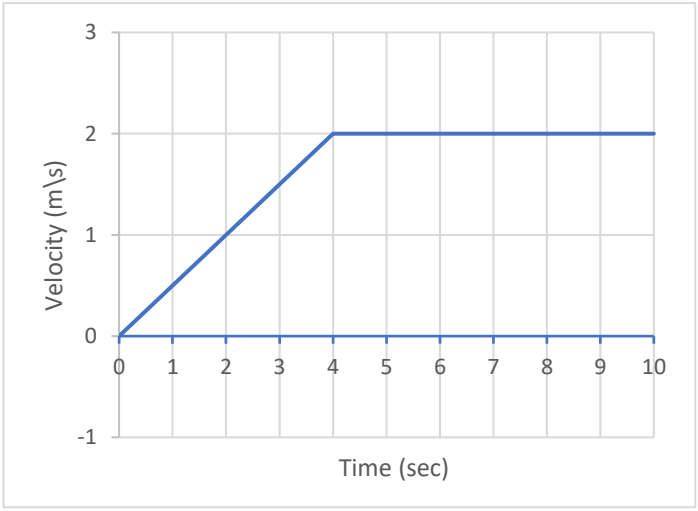
1. Consider the following graph



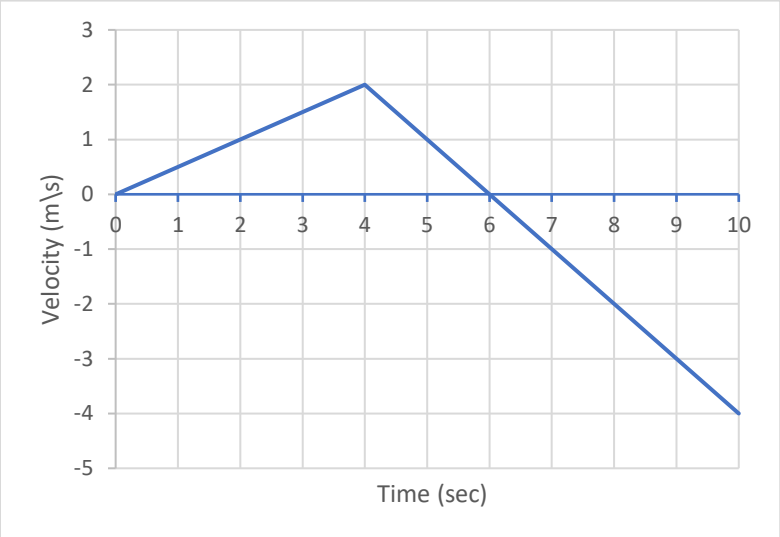
   a. Describe the motion:

   b. The displacement during the 10 seconds shown is

2. Determine the displacement during the 10 seconds shown



3. Determine the displacement during the 10 seconds shown



Kinematics Formulas

When dealing with objects moving at a **constant velocity**, we can determine

Displacement:

Velocity:

Time:

Consider an object that starts out moving a certain velocity, then accelerates to go faster.

We need to differentiate 3 different velocity measures.

$v_0 =$

$v_f =$

$v_{avg} =$

When dealing with objects moving with a **constant acceleration,** we can use the following formulas.

$v_f = v_0 + at$ derivation

$d = v_0 t + \frac{1}{2} a t^2$ derivation

EXAMPLE:

1. A marble is accelerating down a ramp at a rate of $3.5\ m/s^2$. If it started with an initial velocity of $0.50\ m/s$. How far does it travel in 5.0 seconds?

2. How long will it take a stone to fall from a 20.0 metre building to the ground if it accelerates at a constant rate of $9.8\ m/s^2$?

3. A skier, initially at rest, begins accelerating down a hill at $1.6\ m/s^2$. How fast will they be travelling after a distance of 58 m?

4. A parachutist falls 215 m in 7.0 seconds after leaving the place. If she is constantly accelerating what is her speed after 7.0 seconds?

5. A car accelerates from rest to a top speed of $42\ m/s$ in 4.0 seconds and then drives at that speed for 25 seconds. How far will they have travelled in total?

Quadratic formula problems

If we are solving for time using the equation $d = v_o t + \frac{1}{2}at^2$ and initial velocity is not zero, then we need to use the quadratic formula to solve the problem.

Example:

How long will it take a stone to fall from a 20.0 metre building to the ground if it accelerates at a constant rate of $9.8\ m/s^2$ downwards and it was thrown upwards initially with a velocity of 15.0 m/s ?

Fee Fall

Key Facts:

1. Under the force of gravity objects fall towards the centre of the Earth (down) at a _____ acceleration.

2. Air resistance causes objects to fall at different speeds depending on their mass and shape but we will generally _____ air resistance in this course.

3. On the surface of Earth the gravitational field strength (the acceleration of objects) is _____. Unless stated otherwise this is the value we will use in this course.

4. An object which is thrown upwards will have velocity of _____ at its highest point.

5. On level ground an object thrown up will have _____.

Example Problem #1: A coin is dropped in a wishing well and hits the bottom after 2.4 seconds. How deep is the well?

Example Problem #2: A football is kicked up in the air at 15.0 m/s. How high does it go?

What is its total hangtime?

Example Problem #3:

A student stands on the edge of a cliff and throws a ball in the air at 12.0 m/s

How long does it take for the ball to come back down to the same height as the student?

If it falls all the way to the bottom of the cliff, how fast is it traveling when it hits the ground?

Pythagorean Theorem Review

You can determine the length of the hypotenuse of a right triangle if you have the legs.

You can determine the length of one of the legs of a right triangle if you have one of the legs and the hypotenuse.

Right Angle Trig Review

Remember $\sin\theta =$ $\cos\theta =$ $\tan\theta =$

You can determine the length of the unknown side of a right triangle using trig:

You can determine an unknown angle of a right triangle using trig:

2-D Vectors

Recall a _____ has only _____ where as a _____

has both _____ and _____.

Sketch the following displacements

5 metres North 5 metres East 5m SW 5m 25° N of E

To add vectors we put them tail to tip. Frank walks 5 metres North and 8 metres East. What is their displacement?

To subtract vectors we add the opposite. Consider 5m North minus 4m East, What is the result?

Vector Components

We can break a vector into its horizontal and vertical _____

Someone walks 25m 35° North of East. How far to the North have they gone? How far to the East?

We can use components to add (or subtract) vectors which are not at right angles.

A plane is pointed 50° North of East and is flying at 150 m/s relative to the air. There is a wind blowing 20 m/s due south. How fast and in what direction does the plane travel?

Practice: Roughly sketch 65m, 36° N of E. Then break it into its North component and East component.

Roughly sketch 65m/s, 12° above the horizontal, and break it into its vertical and horizontal components.

Use components to add: 56 m NW + 98 m SW

Navigation Problems

A speed boat is trying to travel North across a 350 m wide river. The boat can travel at a speed of 25 m/s in still water and the river flows to the East at 11 m/s.

Part 1: They point the boat directly north across the river

a) What is their total (resultant) velocity?

b) How long does it take to cross the river?

c) How far down the river to they end up?

Part 2: They point the boat, so they travel directly across the river

a) What heading should they point the boat?

b) How long will it take them to cross?

Practice: An airplane is pointed due North and flying at 160 m/s. A wind is blowing 45m/s to the West. What is the actual velocity of the airplane?

An airplane, which has an airspeed of 280 km/hr wants to fly to an airport 500 km to the North. A wind is blowing 87km/hr in the direction 25° North of West. What direction should they point the plane in and how long will the flight take?

Projectile Motion

An object launched and falls to the ground, and we ignore air resistance. This is projectile motion.

The key to solving projectile motion problems is the fact that horizontal and vertical components are _____.

Horizontal (x) components	**Vertical (y) components**
Acceleration is always	Always a constant acceleration
The only equation you ever need is	Need to use constant acceleration formulas

The only value connecting both components is _____

<u>Horizontal Launch Problems</u>

An object is launched at 25 m/s horizontally from a height of 12 m.

How long will it be airborne? How far will it travel?

How long it is airborne depends only on the _____

How far it travels in the x-direction depends only on: _____

An object is launched at 35 m/s horizontally from a height of 42 m.

How long will it be airborne? How far will it travel? What is the final velocity of the object?

A gun is pointed directly at the centre of a target 50.0 m away. The bullet's velocity is 450 m/s.

How long will it take for the bullet to hit the target? How far below the bullseye will the bullet be?

A helicopter is flying horizontally at 45 m/s at an altitude of 250m. They drop an aid package to a town.

How long will it take for the package to fall to the ground? How far horizontally should the helicopter be from the town when it drops the package?

A gun pointing directly at a target 40.0 m away fires and the hits 4.0 cm below the bullseye.

What was the initial velocity of the bullet?

Type 2 Projectile Motion Problems: Angled launch

A baseball player throws a ball to a teammate at 18m/s at an angle of 25° above the horizontal.

What are the initial horizontal and vertical velocities? What is the maximum height the ball reaches? How far away horizontally is the ball caught?

Problem: A cannonball is launched at 275 m/s at an angle of 25° above the horizontal.

What are the initial horizontal and vertical velocities? How long is the cannonball airborne? How far horizontally does the cannonball travel? What is the final velocity of the cannonball?

Type 3 Projectile Motion Problems: Angled launch from a height

A cannonball is launched from a cliff 45m tall at 28 m/s an angle of 64° above the horizontal.

What are the initial horizontal and vertical velocities? What is the final velocity? How long it the cannonball airborne? What is the maximum height relative to the ground below?

An archer standing on a castle 12 m tall shoots an arrow at a velocity of 68 m/s 15° above the horizontal. It hits a wall 200.0 m horizontally away.

At what height on the wall does the arrow hit?