Unit 1: Kinematics in 1D

1 – Vector and Scalar, Distance and Position

There are two types of measurement: with _____ or without.

Scalars: Magnitude only	**Vectors**: Magnitude and direction

- **Kinematics**: The study of an object's _____.

Position, Distance and Displacement

- **Distance** ( ): the separation between two points. Ex, the length of an object. Usually measures in _____. No _____ needed

  ex)

- **Displacement** (or): A measure of the change in *position*. Needs _____

  Δd = final position – initial position.

  The _____ of the value for indicates the direction.

  ex)

Traditionally we assign _____ and _____ as positive (+) and _____ and _____ as negative.

Ex 1: A student walks 5 m east and then 3 m west.

a) What is the distance (scalar) travelled?

b) What is the student's displacement (vector)?

Ex 2: A cat walks 5 m left to get a snack (gold fish?) and then 5 m right to go back to bed.

a) What is the distance (scalar) travelled?

b) What is the displacement (vector)?

Worksheet 1a – Distance and displacement

1. Frank is driving along a straight highway when he notices a marker that says "260km". He continues to the 150-km marker and then turns around and goes back to the 175-km marker.
   a) What is the total distance travelled?
   b) What is the total displacement for the whole trip?

2. A physics book is moved once around the perimeter of a table of dimensions 1.0 m by 2.0 m.
   a) What is the resultant displacement of the book?
   b) What is the distance travelled by the book?

Answer: 1) 135 km, 85km forward 2) 0 m, 6 m

Speed vs Velocity

Speed (v): change in _____ per _____

- Speed is a _____

Velocity ($\vec{v}$): change in _____ per _____

- Velocity is a _____

Ex1): A student travels 11 m north and then turns around and travels 25 m south. If the total time of travel is 12 s, find:

a) The student's average speed.

b) The student's average velocity.

1) How long does it take a car traveling at 45km/h to travel 100.0 m?

2) How far does a skateboarder travel in 22 s if his average velocity is 12.0 m/s?

3) A shopping cart moves from a point 3.0 m West of a flagpole to a point 18.0 m East of the flagpole in 2.5 s. Find its average velocity.

Worksheet 1b – Average Speed and Velocity

1. A high school bus travels 240 km in 6.0 h. What is its average speed for the trip? (in km/h)
2. A spider travels across a driveway 3.6 m wide with a speed of 14 cm/s. How long will it take to cross the driveway?
3. A basketball player steals the ball and runs the length of the court in 8.5 sec at a speed of 5.0 m/s. How long is the court?
4. if a car is traveling at 25 m/s, how far does it travel in 1.0 hour?
5. A caterpillar travels across the length of a 2.00 m porch in 6.5 minutes. What is the average velocity of the caterpillar in m/s?

Worksheet 1b – Average Speed and Velocity

6. A motorist traveling on a straight stretch of open highway sets his cruise control at 90.0 km/h. How far will he travel in 15 minutes?

7. A motorcycle travels 90.0 km/h. How many seconds will it take the motorcycle to cover $2.10\ x\ 10^3\ m$?

8. *A hiker is at the bottom of a canyon facing the canyon wall closest to her. She is 280.5 m from the /wall and the sound of her voice travels at 340.0 m/s at that location. How long after she shouts will she hear her echo?

9. **A woman from Pasadena makes a trip to a nearby shopping mall that is located 40.0 km from her home. On the trip to the mall she averages 80.0 km/h but gets a speeding ticket upon her arrival. On the return trip she averages just 40.0 km/h. What was her average speed for the entire trip?

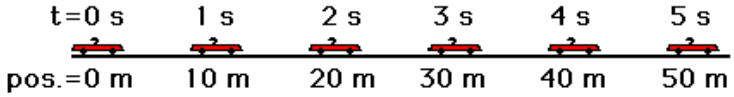
10. ***A cross-country rally car driver sets out on a 100.0 km race. At the halfway marker (50.0 km), her pit crew radios that she has averaged only 80.0 km/h. How fast must she drive over the remaining distance in order to average 100.0 km/h for the entire race?

Ans 1) 40 km/h 2) 26 s 3) 43 m 4) 9×10^4 m 5) 5.1×10^{-3}m/s 6) 23000 m 7) 84 s 8) 1.650 s 9) 53.3 km/h 10) 133 km/h

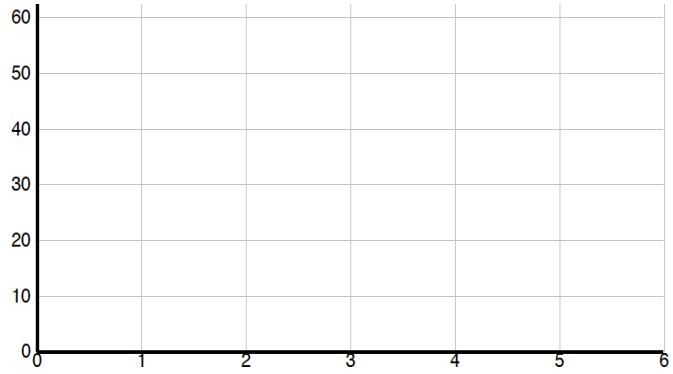
Physics 11 **Unit 1: Kinematics in 1D**

2 – Position-time graph and Velocity-time graph

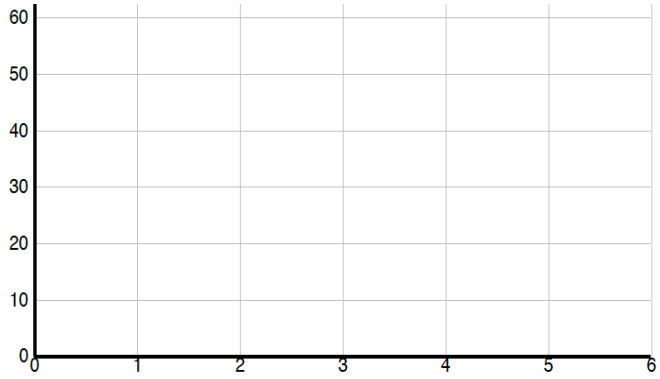
Position-time ($\vec{d}$-t) graphs show an object's _____ as a function of time.
Independent variable (x-axis) is _____. The dependent variable (y-axis)is _____.



Position vs Time Graph



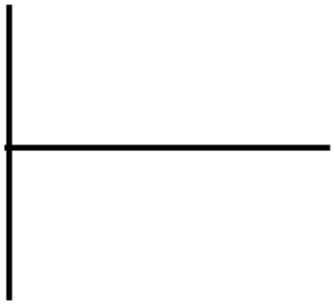
Velocity vs Time Graph



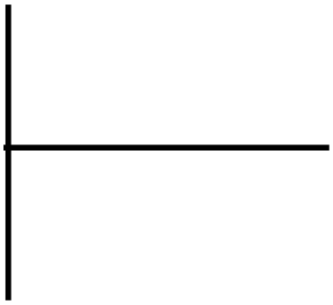
Lets calculate the **slope** for the line made by the dots:	**Slope of d-t graph = _____** **If d-t graph shows a straight line →**

Relating Position-Time Graph to Velocity-Time Graph

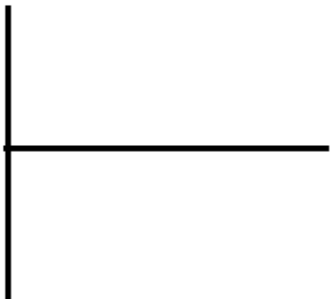
D-T Graph 1

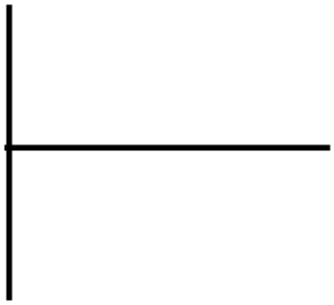


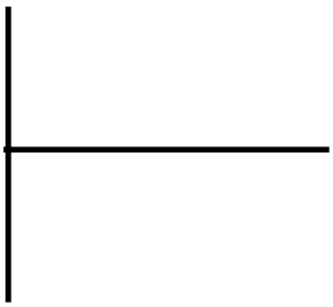
D-T Graph 2

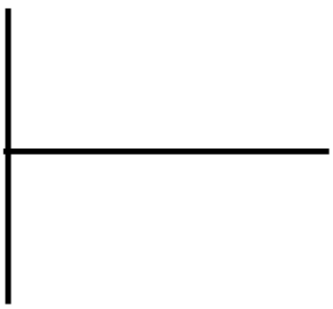


D-T Graph 3

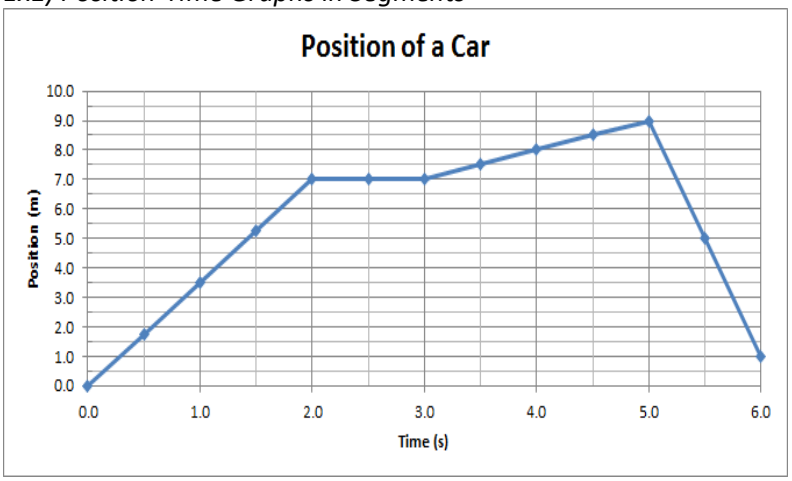


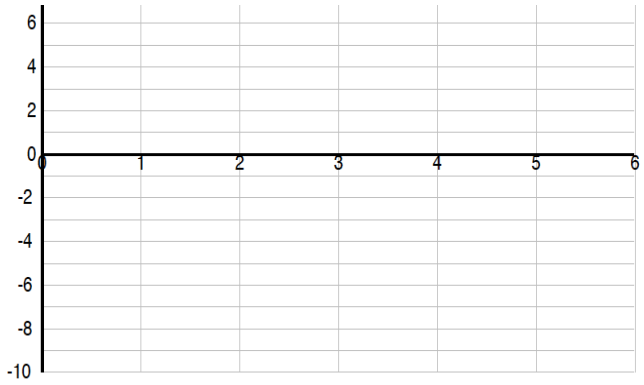






Ex1) Position-Time Graphs in Segments





For practice, find **average velocity** from:

t = 0s to t = 2s

t = 2s to t = 3s

t = 3s to t = 5s

t = 5s to t = 6s

t = 2s to t = 6s

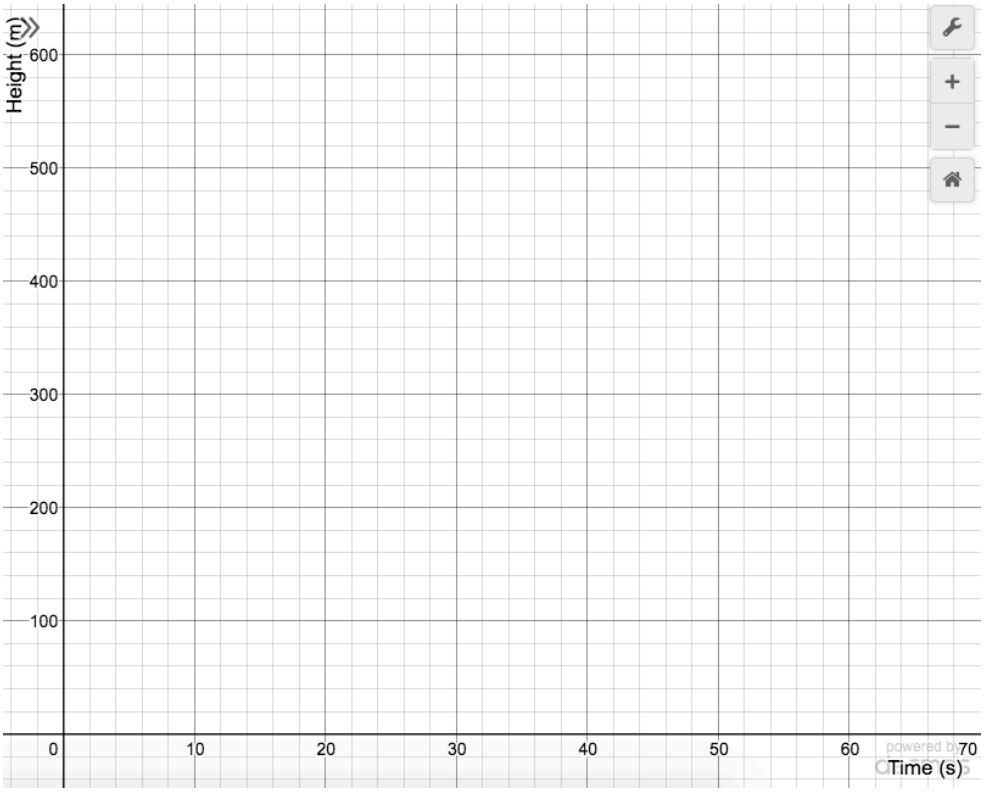
t = 3s to t = 6s

Ex2) A rocket takes off and the height is recorded as follows.

a) Find the average velocity.

b) Graph the position vs time and find the **<u>instantaneous velocity</u>** at 20 and 40 seconds.

h (m)	t (s)
0	0
15	10
60	20
135	30
240	40
375	50
540	60

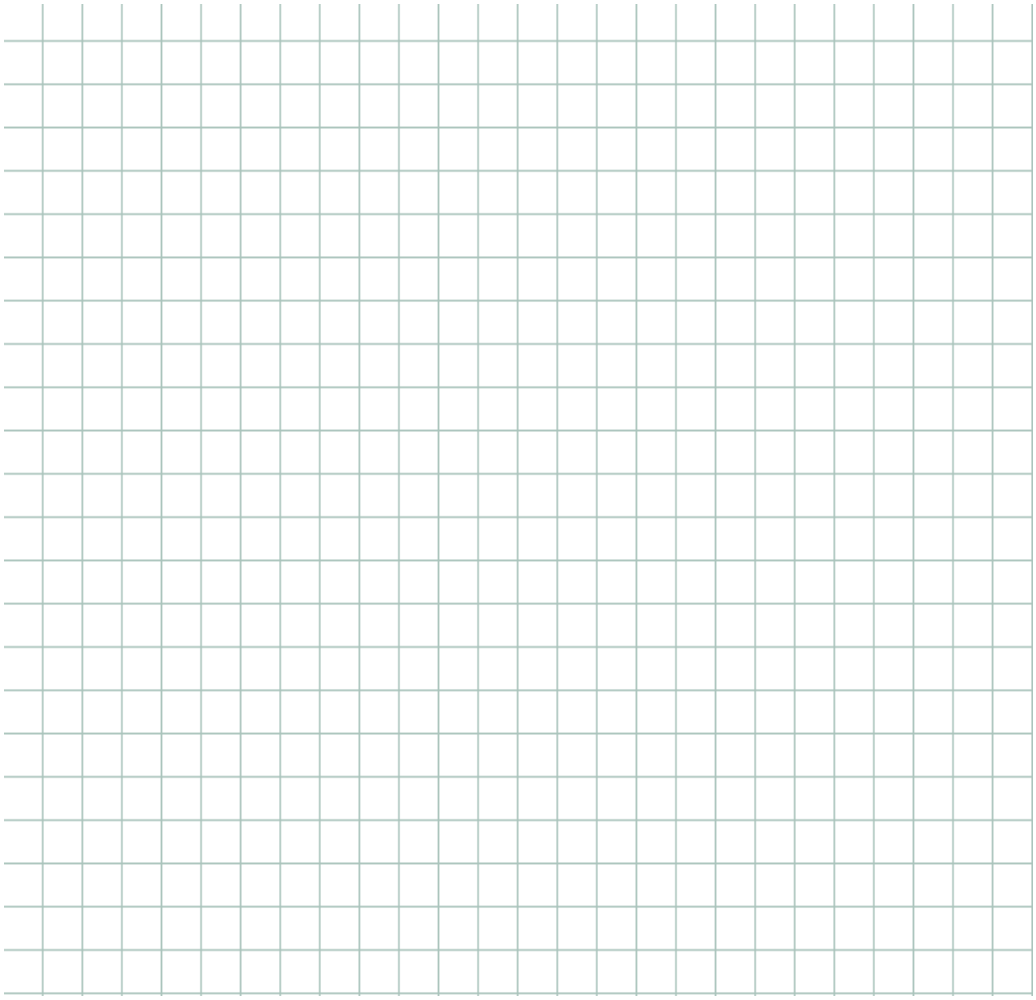


Worksheet 1.2 - Graphing Exercise: D-t graph to Velocity

Part 1: Graph the data (d-t graph)

Data:

d(m)	t(s)
0	0
5	10
20	20
45	30
80	40
120	50
180	60
240	70
320	80
410	90
500	100



Questions:

1. Find the **average velocity**
   a) in the first 20 seconds
   b) from 20 seconds to 80 s
   c) for the whole trip

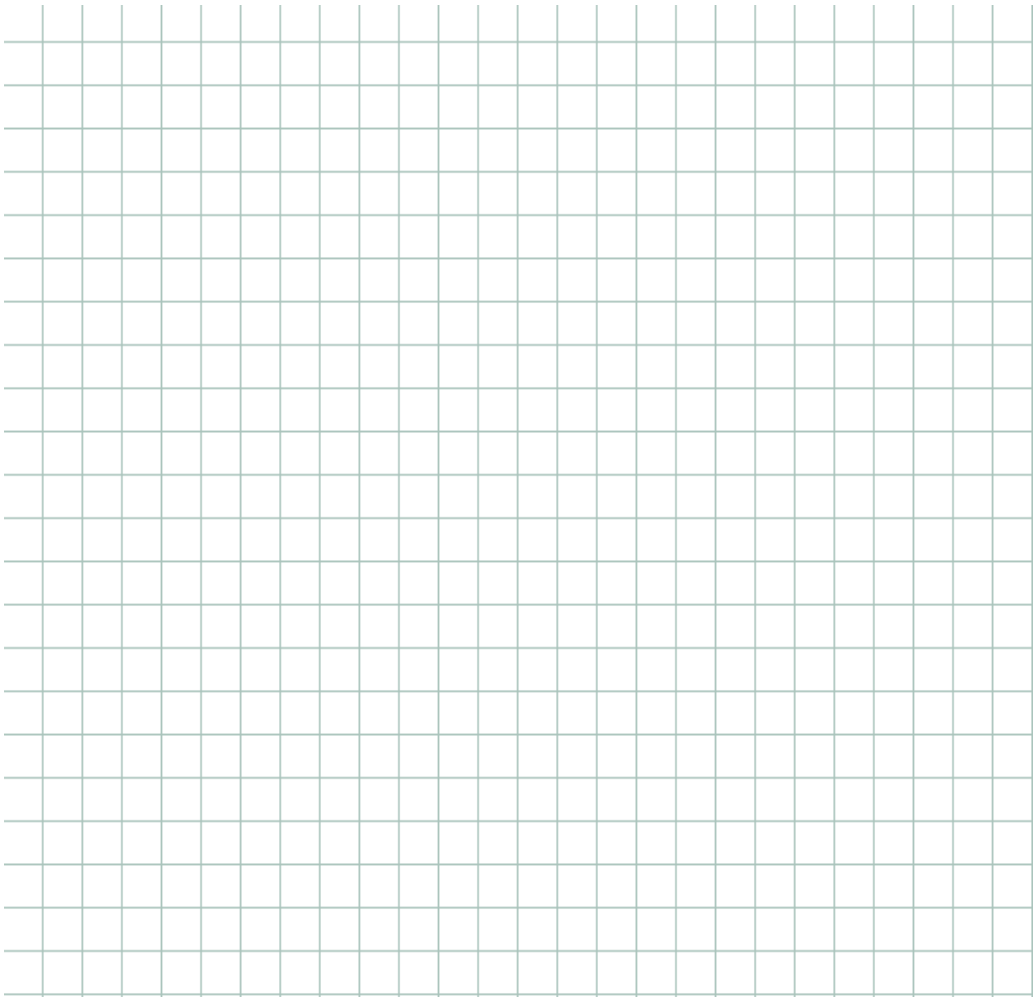
2. Find the **instantaneous velocity** at
   a) 20 seconds,
   b) 40 seconds,
   c) 73 seconds

Answer: 1a) 1m/s b) 5 m/s c) 5 m/s 2a) 2 m/s b) 4 m/s c) 7.3 m/s

Part 2: Graph the data (d-t graph)

Data:

d(m)	t(s)
10	0
13.1	0.5
16	1
18.1	1.5
19.5	2
20	2.5
19.5	3
18.1	3.5
15.9	4
13.1	4.5
10	5
6.9	5.5
4.1	6
1.9	6.5
0.5	7
0	7.5
0.5	8
1.9	8.5
4.1	9
6.9	9.5
10	10



Graph the data

1. Find the average velocity a) in the first 2 seconds, b) from 2 seconds to 8 s, c) for the whole trip

2. Find the instantaneous velocity at a) 1.0 seconds, b) 3.0 seconds, c) 5.0 seconds and d) 1.7 seconds

3. When is the object at rest?

4. When is the object speeding up?

5. Describe the motion of the object in detail

Answer: ***1a) 4.8 m/s. b) -3.2 m/s c) 0*** ***2a) 5 m/s b) -2 m/s c) -7 m/s d) 1.7 m/s***
3) 2.5s and 7.5 s ***4) 2.5 → 5 s and 7.5 → 10 s***
5. – slows down, stops -speeds up backwards - slows down backwards, stops -speeds up forwards

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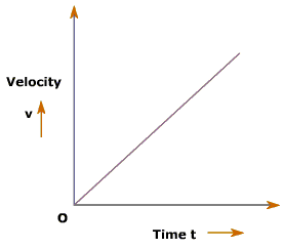
3 – Velocity and Acceleration Time Graph

Acceleration	
A vector quantity that describes _____. Denoted **a** or $\vec{a}$.	$\vec{a}_{avg} =$
• Conceptually, acceleration is to velocity as velocity is to _____.	
• For this class we will always assume that acceleration is _____	$\vec{v}_{avg} =$
• Note that any object with zero acceleration has _____ velocity.	
• The units of acceleration: _____. This is usually written as_____.	unit

Example: A child rolls a ball up a hill at 4.5 m/s [forward]. After 5.00 seconds, the ball is rolling back with a velocity of -1.5 m/s [forward]. What is the ball's acceleration?

Velocity-Time Graphs



Lets look at the slope calculation for such a graph

$$m = \frac{rise}{run} = \frac{\Delta y}{\Delta x} =$$

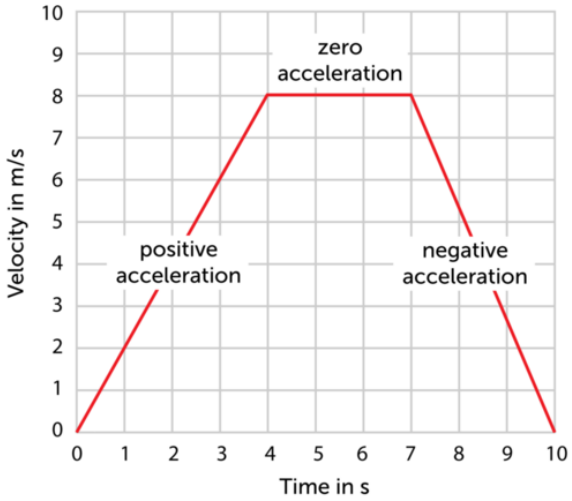
Slope of V-T graph =

Example: Use the graph to determine…

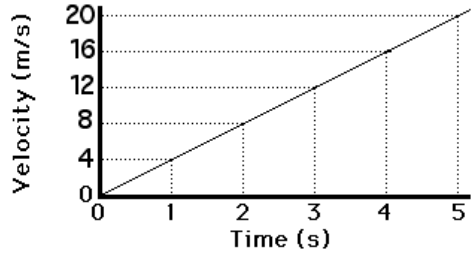
a) Velocity at t = 2s, 5s, 8s?

b) Acceleration from

t = 0.0 – 4.0s	t = 4.0 – 7.0s	t = 7.0 – 10.0s



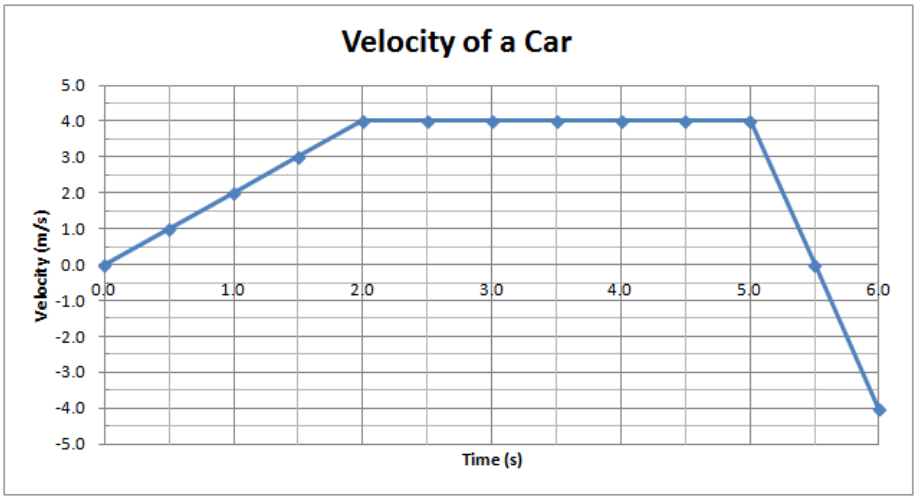
Calculating Displacement from Velocity-Time Graphs



Let's calculating the total area under the curve for the **v**-t graph.

Area under the V-T graph to the x-axis =

$A_{rectangle} = l \cdot w$ $A_{triangle} = \frac{1}{2} b \cdot h$



Important‼ if part of the graph is below the x-axis under the 0 m/s line (that is, the velocity is negative), the _____ for that segment is also negative.

Example: Find the total displacement of the car whose velocity-time graph is shown above between:

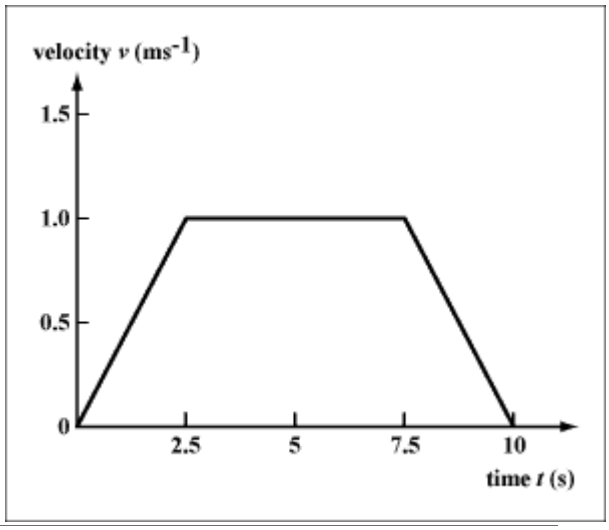
t = 0.0 and t = 2.0	t = 2.0 and t = 5.0	t = 5.0 and t = 6.0	t = 0.0 and t = 6.0

From Velocity-Time Graph to Displacement-Time Graph and Acceleration-time graph

	x (m)	v(m/s)	a(m/s^2)
Stationary Object	t(s)	t(s)	t(s)
Uniform Motion	t(s)	t(s)	t(s)
Motion with Constant Acceleration	t(s)	t(s)	t(s)

Worksheet 1.3 - V-t graph and acceleration

1. Given the following velocity vs time graph



Find

a) acceleration at 1.0 seconds

b) acceleration at 3.0 seconds

c) acceleration at 7.7 seconds

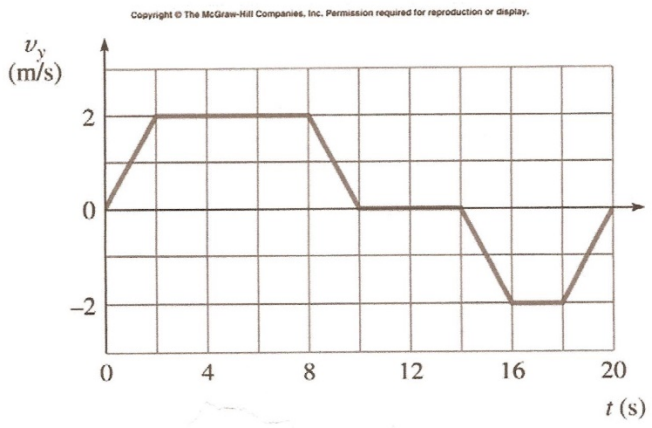
d) total displacement

e) displacemeny after 5 seconds

f) describe the motion

g) draw a position vs time graph for the motion

2. Given the following velocity vs time graph



Find

a) acceleration at 1.0 seconds

b) acceleration at 3.0 seconds

c) acceleration at 15 seconds

d) total displacement

e) displacemeny after 5 seconds

f) displacemeny after 16 seconds

g) describe the motion

h) draw a position vs time graph for the motion

3. Draw velocity and displacement vs time graphs for the following scenarios

a) A car accelerates from rest then decelerates to a slower constant speed

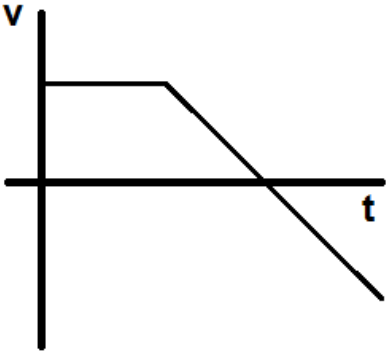
b) An object is thrown upwards and caught on the way down

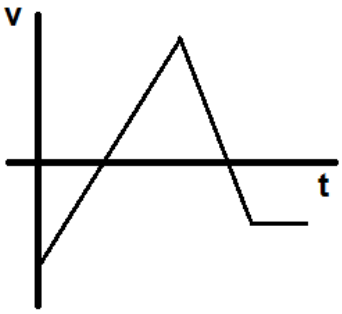
c) A baseball is pitched and hit

d) A wingsuit base jumper makes his jump

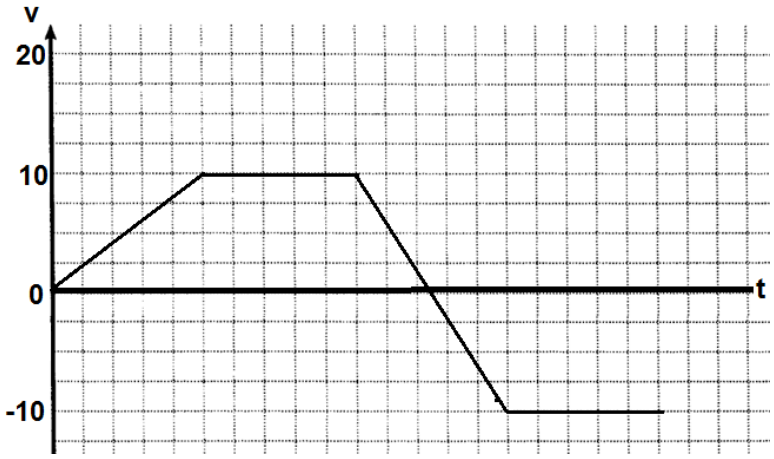
e) An object is dropped from a great height

4. For each v vs t graph: describe the motion in detail and draw the corresponding d vs t graph





5. In the following v vs t graph where each square is 1.0 seconds on the time axis, and v is in m/s



a) the velocity at 2, 7, 10 and 17 seconds

b) the acceleration at 2, 5, 10 and 17 seconds

c) the displacement for the first 5 seconds

d)) the displacement for the first 20 seconds

e) the displacement over the final 10 seconds

f) the average velocity

g) draw the corresponding d vs t graph assuming the object starts at d=0

Physics 11 **Unit 1: Kinematics in 1D**

4 – Kinematic Equations: The big three

Lets summarize what we have learned about d-t, v-t and a-t graph so f

If an object is accelerating then the formula:	In order to solve problems with uniform acceleration we need to use 3 formulae. These 3 formulae use the variables:
[ ] Gives us only the _____	$v_f =$ **d =**
We can also find the average velocity using: [ ]	$v_f =$ **t =**
	a =

1) [ ]

Ex: a car traveling at 7.0 m/s East speeds up to 22.0 m/s East in 1.7 s. What is its acceleration?

2) [ ]

Ex: A sprinter starts from rest and accelerates uniformly. He travels 100.0 m south in 9.69 s. What was his acceleration?

3) [ ]

Ex: A banana boat accelerates from 15.0 km/h at $2.00\ m/s^2$. How far has it traveled when it reaches 30.0 km/h?

Ex 1: A Rocket Truck is traveling at 16.0 m/s when a plane passes it. It immediately hits the jets and accelerates at 14.0 m/s^2 for 3.25 s

a) What final velocity does it reach?

b) how far does it travel in this time?

Ex 2: An arrow strikes a can at 32.0 m/s and exits at 31.0 m/s. If the arrow is 42 cm long find its acceleration as it pierced the can. Ignore the width of the can.

Ex 3: A BMW and an F1 car both cross the finish line traveling at 200.0 km/h. The BMW comes to a stop in 4.05 s and the F1 in 2.12 s. How much further did the BMW travel while stopping than the F1 car?

Worksheet 4 - Kinematic Equations

1. A ball rolling down a hill was displaced 19.6 m while uniformly accelerating from rest. If the final velocity was 5.00 m/s. what was the rate of acceleration?

0.638 m/s²

2. A car starts from rest and accelerates uniformly to reach a speed of 21 m/s in 7.0 s. What was the speed of the object after 2.0 seconds?

6.0 m/s

(!!) 3. A bike rider accelerates uniformly at 2.0 m/s² for 10.0 s. If the rider starts from rest, calculate the distance traveled in the **fourth** second.
(i.e. between t = 3 s and t = 4 s).

7 m

4. If a bullet leaves the muzzle of a rifle at 600.0 m/s, and the barrel is 0.90 m long, what was the acceleration of the bullet while in the barrel?

$2x10^5$ m/s

5. The Jamaican bobsled team hit the brakes on their sled so that it decelerates at a uniform rate of 0.43 m/s². How long does it take to stop if it travels 85 m before coming to rest?

20 sec

Bonus: A driver of a car going 90 km/h suddenly sees the lights of a barrier 40.0 m ahead. It takes the driver 0.75 s before he applies the brakes (this is known as reaction time). Once he does begin to brake, he decelerates at a rate of 10.0 m/s².

a) Does he hit the barrier?

b) SUPER-BONUS: What would be the maximum speed at which the car could travel and NOT hit the barrier 40.0 m ahead?

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5 – Acceleration Due to Gravity

• In the absence of air friction… • Near Earth's surface the acceleration is 	Example: A student drops their homework down a wishing well. After 2.4 s it hits the water at the bottom. How deep is the well?

Example:
A football is kicked straight up in the air at 15 m/s.

a) How high does it go?

b) What is its total hangtime?

Example: A student stands on the edge of a 45.0 m high cliff. They throw their physics homework straight up in the air at 12.0 m/s.

a. How long does it take to come back down to the same height as the student?

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

Worksheet 1.5 – Uniform Accelerated Motion

1) Bumblebee jumps straight upwards with a velocity of 14.0 m/s. What is his displacement of after 1.80 s?

(9.32 m)

2) A surprisingly spherical decepticon is rolled up a constant slope with an initial velocity of 9.3 m/s. What is the acceleration of the decepticon if its displacement is 1.9 m up the slope after 2.7 s?

(-6.4m/s^2)

3) Optimus Prime coasts up a hill initially at 11.0 m/s. After 9.3 s he is rolling back down the slope at 7.3 m/s. What is his acceleration?

(-2.0 m/s^2)

4) Sonic (you know, the Hedgehog) rolls up a slope at 9.4 m/s. After 3.0 s he is rolling back down at 7.4 m/s. How far up the hill is he at this time?

(3.0 m)

5) Luigi jumps straight upwards at 15.0 m/s. How high is he when he is travelling at:

a) 8.0 m/s upwards?

(8.2 m)

b) 8.0 m/s downwards?

(8.2 m, weird huh?)

6) Sick of his guff, Optimus decides to throw Megatron down off the top of a building at 5.0 m/s. Megatron hits the ground traveling at 32.0 m/s.
a. How long does it take to hit the ground?

(2.8 s)

b. How far does he fall?

(- 51 m)

7) Mario rolls a coin up a slope at 2.0 m/s. It travels 2.7 m, comes to a stop and rolls back down. What is the coin's entire time of travel?

(5.4 s)

8) While strolling along on Planet X an astronaut decides to throw a hammer and a feather upwards at 5.0 m/s. They both return to the point of release in 3.0 s. What is the acceleration due to gravity on Planet X.

(-3.3 m/s^2)

9) Princess Toadstool stands on the edge of a 30.0 m high cliff. She throws Bowser upwards at 20.0 m/s. If Bowser falls all the way to the bottom of the cliff, find:
a. his velocity when he hits the ground.

(-31.4 m/s)

b. the time it takes to hit the ground.

(5.24 s)

Unit 1: Kinematics in 2D

6 – Vector Addition and Subtraction

When we draw vectors we represent them as _____.

Whenever we add vectors we use...

To find the total or resultant vector, simply draw...

Vector Addition Methods:

1. Tip-to-Tail (for drawing general direction)
2. Adding Components (for magnitude) and Trigonometry (for accurate direction)

Add the vectors and find their resultant magnitudes and directions

1) 2.2 m South and 1.8 m North

2) 220 m North and 80 m West

When adding vectors does it matter which one you add first?

Ex1) : A student in a canoe is trying to cross a 45 m wide river that flows due East at 2.0 m/s. The student can paddle at 3.2 m/s.

a. If he points due North and paddles how long will it take him to cross the river?

b. What is his total velocity relative to his starting point in part a?

c. If he needs to end up directly North across the river from his starting point, what heading should he take?

d. How long will it take him to cross the river at this heading?

Vector Addition – Trig Method

In the previous example we added perpendicular vectors which gave us a nice simple right triangle. In reality it's not always going to be that easy.

E*x2) A bird flies at 15 km/h 30° N of E for 2.5 hr and then changes heading and flies at 20 km/h 70° W of N for 1.5 hr. What was its final displacement?*

In order to solve non-right angle triangles, we will need to be familiar with the Sine Law and the Cosine Law.

Sine Law:

Cosine Law:

Vector Addition – The Component Method

There is another method that we can use when adding vectors. This method is a very precise, stepwise approach; however, it is the only way we can add 3 or more vectors.

- **Draw** each vector
- **Resolve/break** each vector into x and y components
- Find the **total sum** of x and y vectors
- **Add** the x and y vectors
- **Solve** using trig

REMEMBER: When using x and y components…

Ex3. An airplane heading at 450 km/h, 30° north of east encounters a 75 km/h wind blowing towards a direction 50° west of north. What is the resultant velocity of the airplane relative to the ground?

	X-Component	Y-Component
Air Velocity		
Wind Velocity		
Resultant		

Total Resultant:

Vector Subtraction

With vectors a negative sign indicates…

When subtracting vectors we still draw them tip to tail, except…

We generally subtract vectors when dealing with a _____ in a vector quantity.

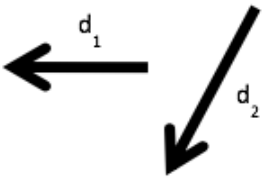
Recall:

Change =

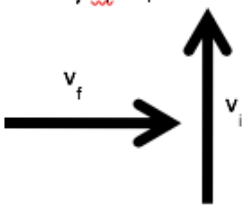
Draw the Following

1) $F_1 + F_2$

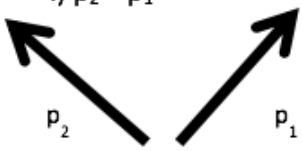
2) $d_1 + d_2$



3) $v_f - v_i$



4) $p_2 - p_1$

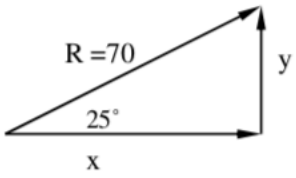


Ex 4: A cyclist is traveling at 14 m/s west when he turns due north and continues at 10 m/s. If it takes him 4.0 s to complete the turn what is the magnitude and direction of his acceleration?

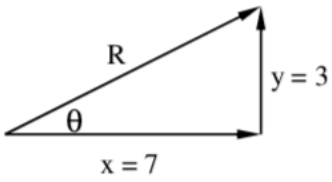
Worksheet 1.6 – Vectors and Nagvigation

For each question, find the value of x, y, R and/or theta as needed (R is the resultant vector)

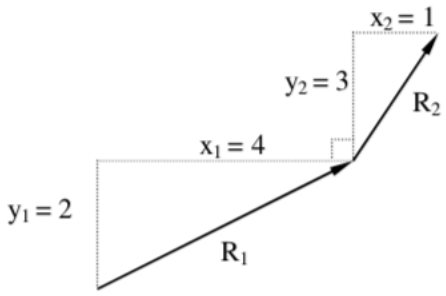
1.



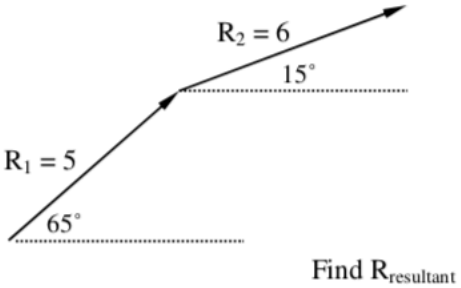
2.



3.



4.



Find $R_{resultant}$

Draw and add the vectors

5) 8m [N] and 5m 30° [N of E]

6) 200m/s 20° [W of S] and 15m/s 20° [W of N]

The Change "Δ" Of A Quantity a.k.a. Vector Subtraction

This deals with the change of a quantity, which can be solved by vector subtraction. We will deal only with $\mathbf{\Delta v = v_f - v_i}$ in these questions but the concept will appear several more times in this course. Remember that each term is a vector (therefore, do not expect to simply subtract the values!!)

7) If a car that was originally going 40. m/s towards the east took 5.0 s to turn and go 30. m/s towards the south, what is the acceleration of the car?

8) What is the acceleration of a car that changes from 60. m/s to the north to 60. m/s to an angle of 45° East of North in a time of 3.0 s?

9) What is the acceleration of a ball that bounces off a wall in 0.30 s if its incoming velocity is 60. m/s and its recoil velocity is 50. m/s?

10) A car is traveling at 100 km/h, due northwest. The driver puts on the brakes and turns the corner. Four seconds later, he is heading east at 50 km/h. What is the average acceleration?

The Across the River Problem

11) A boat can travel 2.30 m/s in still water. If the boat heads directly across a river with a current of 1.50 m/s:
   a) What is the velocity of the boat relative to the shore?
   b) At what angle compared to straight across is it traveling?
   c) How far from its point of origin is the boat after 8.0 s?
   d) At what upstream angle (compared to straight across) must the boat travel in order to the other bank directly opposite its starting point? How fast across the stream is it traveling?

Vector problems (Component or Sine-Cosine Law Solutions)

12) A plane with an air speed of 400 km/hr wants to go north but a wind of 70 km/hr is blowing west. What must be the plane's heading (to go north)? What will be its resulting ground speed?

13) A seagull flying with an air speed of 10 km/h is flying north but suddenly encounters a wind of 5 km/h at 20° south of east. What will be the new direction and airspeed of the seagull?

14) A plane that can fly at 250 km/h wishes to reach an airport that has a bearing of 25° W of N from its present location. If there is a 50.0 km/h wind blowing directly to the west what should be the heading of the plane. What will be its ground speed? How long would it take to get to the airport if it were 560 km away?

Answer key

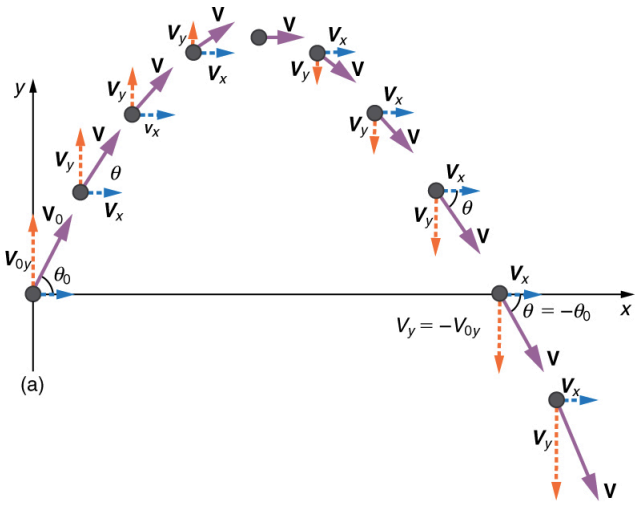
1) x=63; y=30.
2) R=7.6 and θ=23°
3) $R_1 = 4.47; R_2 = 3.16$
4) $R_{resultant} = 10.0$
5) 11.3 m 22° [E of N]
6) 188 m/s 23° [W of S]
7) $10 m/s^2$ 53° [W of S]
8) $15 m/s^2$ 68° [E of S]
9) $367 m/s^2$ back
10) $9.7 m/s^2$ 30° [S of E]
11) a. 2.7m/s 33° b. 33° c. 21.6m d. 41°
12) 10.1° [E of N], 394 m/s
13) 9.5km/h 30° [E of N]
14) 267km/h and 14.6° [W of N] ;2.1h

Vector and Kinematics Notes

7 – Projectile Motion 2D

An object launches into the air tends to follows a _____ path. If you break down the velocity into x and y components you will discover that both sides are _____ and therefore totally _____.

Fun Fact: if an object is caught at the same height as it was launched. Its landing (Vf) speed must equal to it launching speed (Vi) with opposite angle.



x-components	***y-components***
• No _____ _____ in the x direction • _____ is always zero • The only equation you can every use is	• Always a constant acceleration of _____ due to earth's gravitational pull. • Need to use the BIG 3 Equations
The only value that can ever be on both sides is _____ because it is _____ and has no _____	

Ex 1: A student sits on the roof of their house which is 12 m high. She can launch water-balloons from a slingshot at 25 m/s. If she fires a water-balloon directly horizontally:
a. How long will it be airborne?
b. How far will it travel?

* How long it is airborne only depends on: _____

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

Ex 2: A quarterback launches a ball to his wide receiver by throwing it at 22.0 m/s at 35° above horizontal.

a. How far downfield is the receiver?
b. How high does the ball go?
c. At what other angle could the quarterback have thrown the ball and reached the same displacement?

Ex 3: A cannon sits on a 65 m high cliff (typical Trask...so typical...). A cannonball is fired at 42 m/s 55° above the horizontal.

a. How long is it airborne?

b. What is its final velocity?

c. What is its maximum height relative to the ground below?

Worksheet 1.7 - Projectiles

Solve all problems on your own paper showing all work!

1. A golf ball was struck from the first tee at Lunar Golf and Country Club. It was given a velocity of 48 m/s at an angle of 40° to the horizontal. On the moon, $g = -1.6\ m/s^2$.
   (a) What are the vertical and horizontal components of the ball's initial velocity? ***(Vx = 36.85 m/s; Vyo = 30.8 m/s)***
   (b) For what interval of time is the ball in flight? ***(38.6 sec)***
   (c) How far will the ball travel horizontally? ***(1418 m)***

2. A rock is thrown horizontally from the top of a cliff 98 m high, with a horizontal speed of 27 m/s.
   (a) For what interval of time is the rock in the air? ***(4.47 sec)***
   (b) How far from the base of the cliff does the rock land? ***(121 m)***
   (c) With what velocity does the rock hit? ***(51.5m/s, 61.3° below horizontal)***

3. A batter hits a ball giving it a velocity of 48 m/s at an angle of 50° above the horizontal.
   (a) What are the vertical and horizontal components of the ball's initial velocity? ***(30.8m/s, 36.8 m/s)***
   (b) How long is the ball in the air? ***(7.50 sec)***
   (c) What is the horizontal distance covered by the ball while in flight? ***(231 m)***
   (d) What velocity does the ball have at the top of its trajectory? ***(30.8 m/s horizontal only)***

4. A ball is thrown with a velocity of 24 m/s at an angle of 30° to the horizontal.
   (a) What are the vertical and horizontal components of the initial velocity? ***(12 m/s, 20.8 m/s)***
   (b) How long is the ball in the air? ***(2.45 sec)***
   (c) How far away will the ball land? ***(50.9 m)***
   (d) To what maximum height will the ball rise? ***(7.34 m)***
   (e) With what velocity will the ball land? ***(24 m/s 30° below hoiz)***

5. A diver takes off with a speed of 8.0 m/s from a 3.0 m high diving board at 30° above the horizontal. How much later does she strike the water? ***(1.28 sec)***

6. On level ground, a ball is thrown forward and upward. The ball is in the air 2.0 s and strikes the ground 30 m from the thrower. What was the ball's initial velocity? (***17.9 m/s 33^{O} above horiz***)