PHYSICS 2204

"Good morning, and welcome to The Wonders of Physics."

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Physics 2204

Introduction To Physics

Required Items For Physics

1) You will need a ruler

2) Bring a calculator to every Class

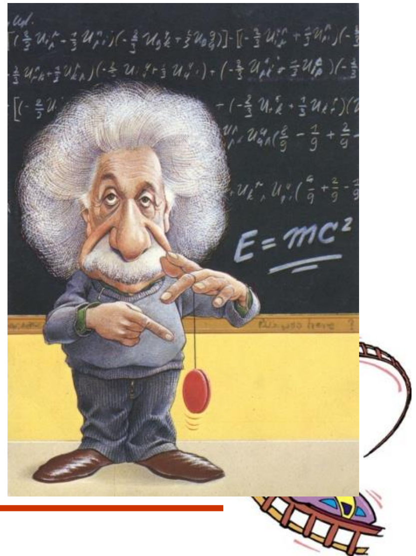
3) Pencil

Is Physics Right For Me?

- Strong in Mathematics, especially in problem solving
- Like to experiment with instrumentation & measurement
- you enjoy learning and want to REALLY understand things

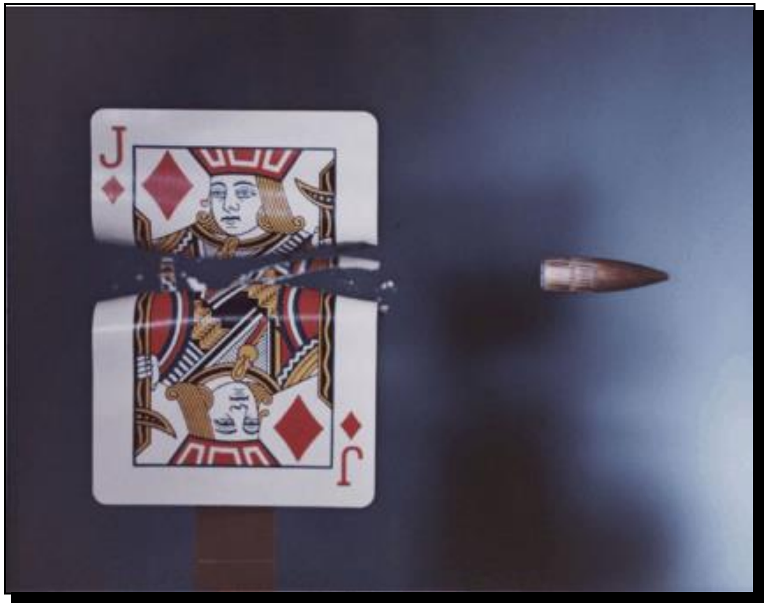
Why Study Physics?

- Most modern technology came from physics (blackberry, internet).
- Most branches of sciences contain principles obtained from physics.
- Physics classes hone thinking skills.
- The job market for people with skills in physics is strong.
- It is challenging
- To understand how things work
- Because Einstein says so????



What is Physics?

- **Physics** *is the study of motion, matter, energy, and force.*



Called the Fundamental Science

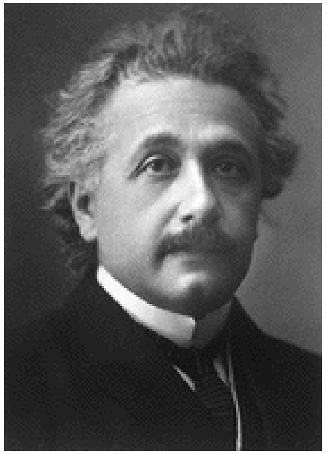
Who Are Some Famous Physicist ?

- Galileo Galilei

Sir Isaac Newton

- Stephen Hawkings

- Albert Einstein

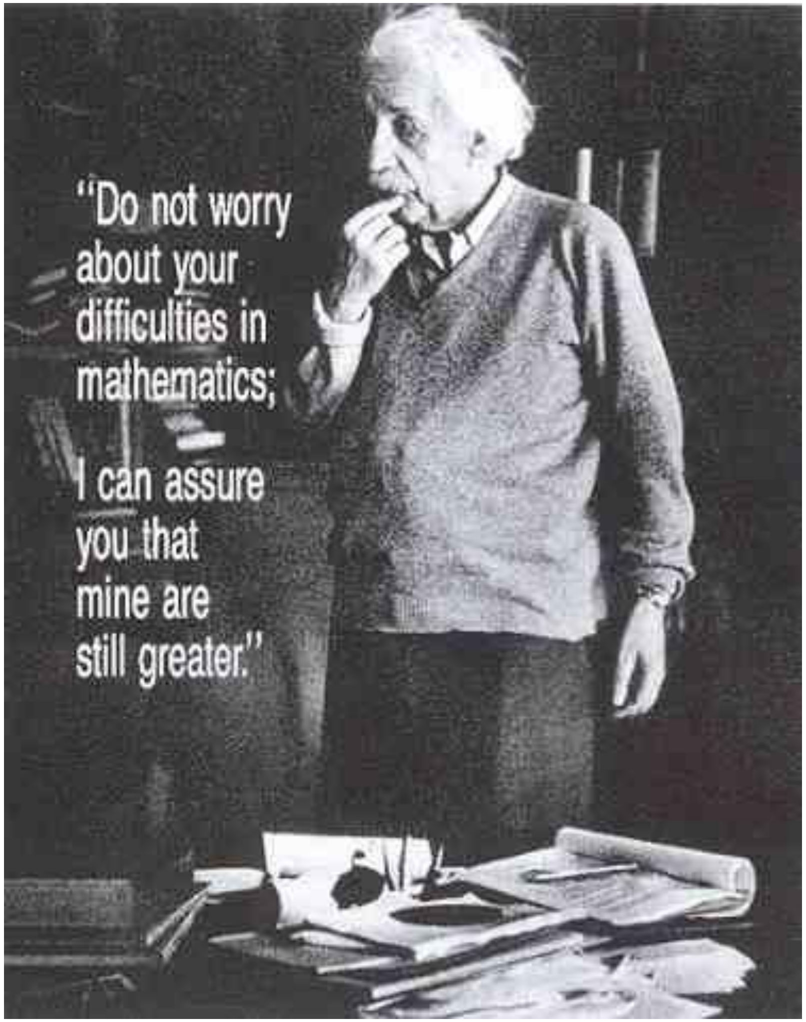


If I have seen farther than others, it is because I was standing on the shoulders of giants." Sir Isaac Newton

Physics 2204

- **Section 1:**

Measurements and Units


"Do not worry about your difficulties in mathematics;
I can assure you that mine are still greater."

What Is Measurement?

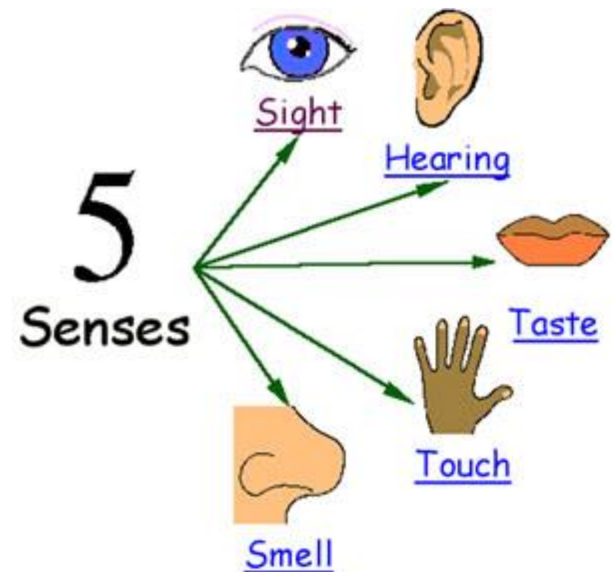
- The ability to describe an observation is important.
- A description is a statement that reports what has been observed.
- A **measurement** is a description that includes a number and a unit.

Qualitative and Quantitative Descriptions

- **QUALITATIVE DESCRIPTIONS**

  are descriptions made by observing with the 5 senses**,** such as the smell of a flower or the colour of someone's eyes. They include observations which cannot be measured.

This bird has a large wingspan



- **QUANTITATIVE DESCRIPTIONS**

  are descriptions that are based on measurements or counting (i.e. they are numerical), such as the number of petals a flower has or how tall a person is. They deal with quantities.

This bird has a wingspan of two meters.

International System Of Measurement

The International System of Units, or SI, is a system of measurement that scientists use when they collect data

This system of measurement has two benefits:

1) Scientists around the world can easily share and compare their data because all measurements are made in the same units.

2) SI units are based on the number 10. This makes it easy to change from one unit to another.

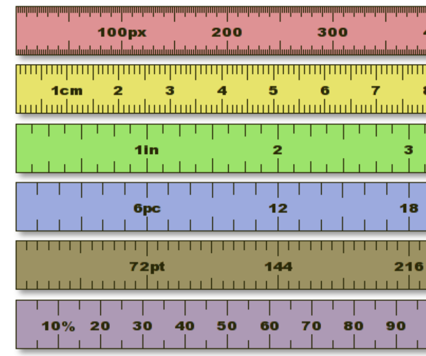
WHAT IS A BASE UNITS?

- **Base units** *are the 7 units of measure agreed upon by the international system of units*

SI Base Units		
Quantity	**SI base unit**	**Symbol**
Length	meter	m
Mass	kilogram	kg
Temperature	kelvin	K
Time	second	s
Amount of substance	mole	mol
Luminous intensity	candela	cd
Electric current	ampere	A

The Most Common Base Units Used In Physics

Meter is the unit of length. Length is measured with a meterstick, ruler, or measuring tape.



Kilogram is the unit for mass. Mass is measured with a balance

Second is the unit for time. Time is measured using a stopwatch

What Are Derived Units?

Derived units *are ones that we "figure out" by using base units.*

For example:

The length and width of a rectangle

Area = length´x width

$= m \times m = m^2$

=(base unit) x (base unit) = (Derived unit)

Derived quantity	Name	Symbol
	Table 2. Examples of SI derived units	
	SI derived unit	
area	square meter	m^2
volume	cubic meter	m^3
speed, velocity	meter per second	m/s
acceleration	meter per second squared	m/s^2

The SI System Uses The Following Prefixes:

Kilo	1000
Hecto	100
Deca	10
UNIT	1
Deci	1/10
Centi	1/100
Milli	1/1000

This system works with any SI measurement.

The UNIT becomes whichever type of measurement you are making. (mass, volume, or length)

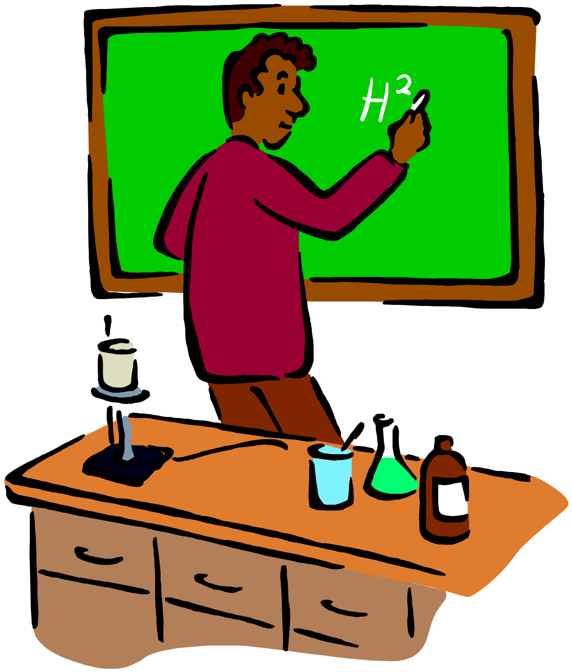
It is the same system regardless if you are measuring length, mass, or volume.

Some Other Common SI Prefixes

Commonly Used Metric Prefixes			
Prefix	**Symbol**	**Meaning**	**Factor**
mega	M	1 million times larger than the unit it precedes	10^6
kilo	k	1000 times larger than the unit it precedes	10^3
deci	d	10 times smaller than the unit it precedes	10^{-1}
centi	c	100 times smaller than the unit it precedes	10^{-2}
milli	m	1000 times smaller than the unit it precedes	10^{-3}
micro	μ	1 million times smaller than the unit it precedes	10^{-6}
nano	n	1 billion times smaller than the unit it precedes	10^{-9}
pico	p	1 trillion times smaller than the unit it precedes	10^{-12}

Things to Remember

- All measurements need a number and a unit!
- Basic units of Measurement (meter, liter, gram)
- How to convert metric units
- Vocabulary words



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- **Section 2:**

Converting Base and Derived Units

litres

metres

grams

Converting Base Units

kilometres

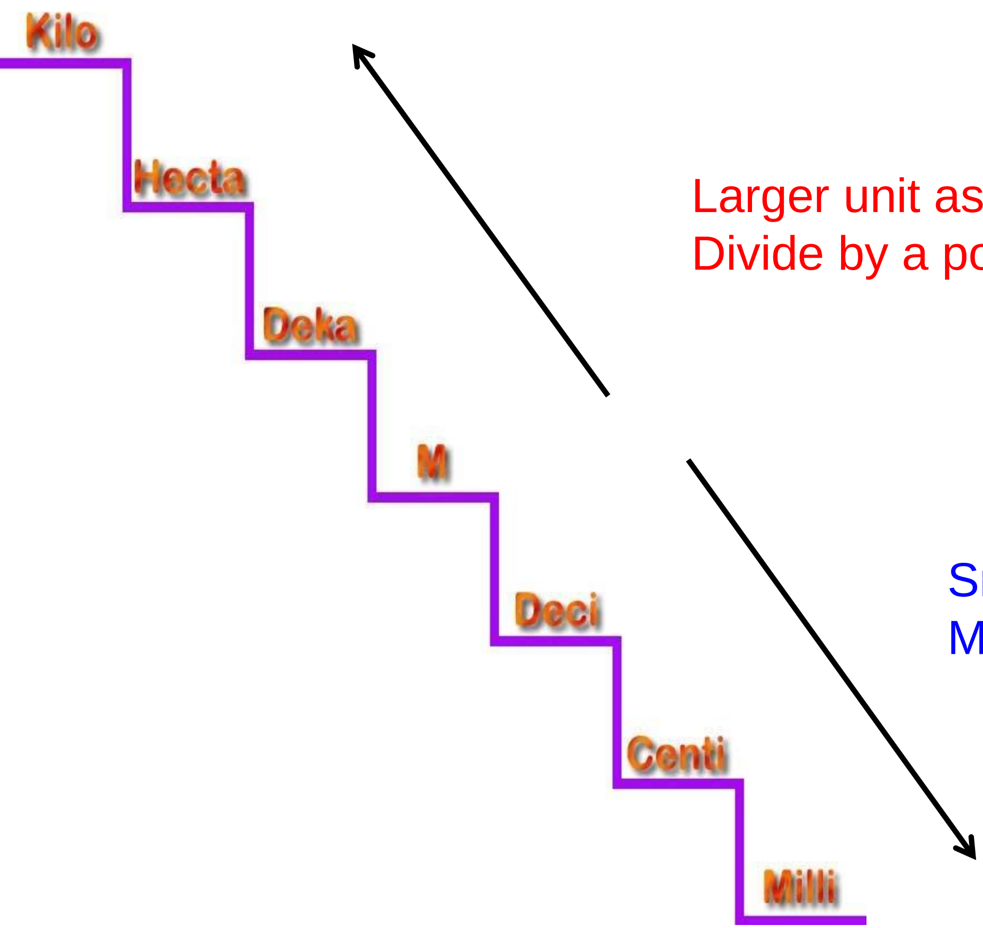
centimetres

kilograms

Joanne Smithies - Our Lady & St. Gerards

Converting measurements is a skill that will be tested in high school math and science classes, as well as in some college classes

The **Step Stair Method** is a simple trick to converting these units.



Larger unit as you go up the steps!
Divide by a power of ten 10

Smaller unit as you go down the steps!
Multiple by a power of ten 10

You Try!

Converting units is not a hard thing to do. In fact, it really just involves multiplying and dividing. Last day we multiplied or divided by some power of 10

Convert the following measurements:

a) 125 cm => m

b) 2.234 km => m

c) 23 cm => mm

d) 45 g => kg

e) 300 kl => l

Converting Base Units
Part 2

To convert units sometimes, we need to multiply the quantity we want to convert by a conversion factor. The conversion factor basically tells us how to convert one unit into another.

Example 1

- **12 feet = ? meters**

- **Note : 1 feet = 0.3048 meters**

- **therefore:**

$$12\,\text{feet}\overbrace{\left(\frac{0.3048\,\text{meters}}{1\,\text{feet}}\right)}^{\boxed{\text{Conversion factor}}} = 3.6576\,\text{meters}$$

Example 2

- **7 a (years) = ? seconds**

$$7a \times \frac{365 day}{1a} \times \frac{24 hours}{1 day} x \frac{60 \min}{1 hr} \times \frac{60}{1 \min} =$$ **220 752 000 s**

You Try!

Convert the following measurements:

a) 120 sec	=>	min
b) 2.5 hours	=>	sec
c) 3.5 years	=>	hours
d) 183 min	=>	hours
e) 1.5 years	=>	sec

Converting Derived Units

Example 3:

$$\frac{30km}{hr} = ?m/s$$

$$30\frac{km}{1hr} \times \frac{1hr}{60\min} \times \frac{1\min}{60\sec} \times \frac{1000m}{1km} = 8.3m/s$$

General Rule:

To change from km/hr = m/s ÷ 3.6

To change from m/s to km/hr x 3.6

You Try!

Convert the following measurements:

a) 360m/s => km/hr

b) 50 km/hr => m/s

c) 23 cm/s => m/s

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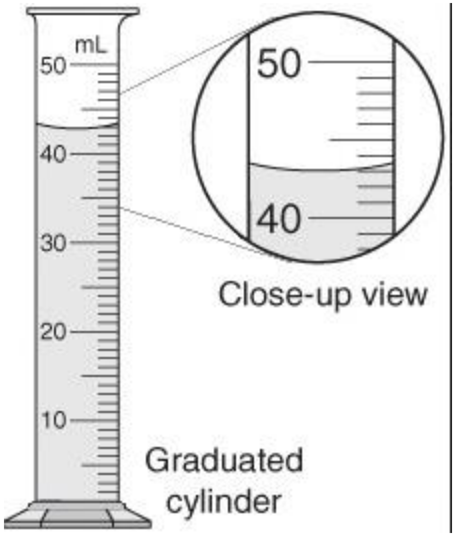
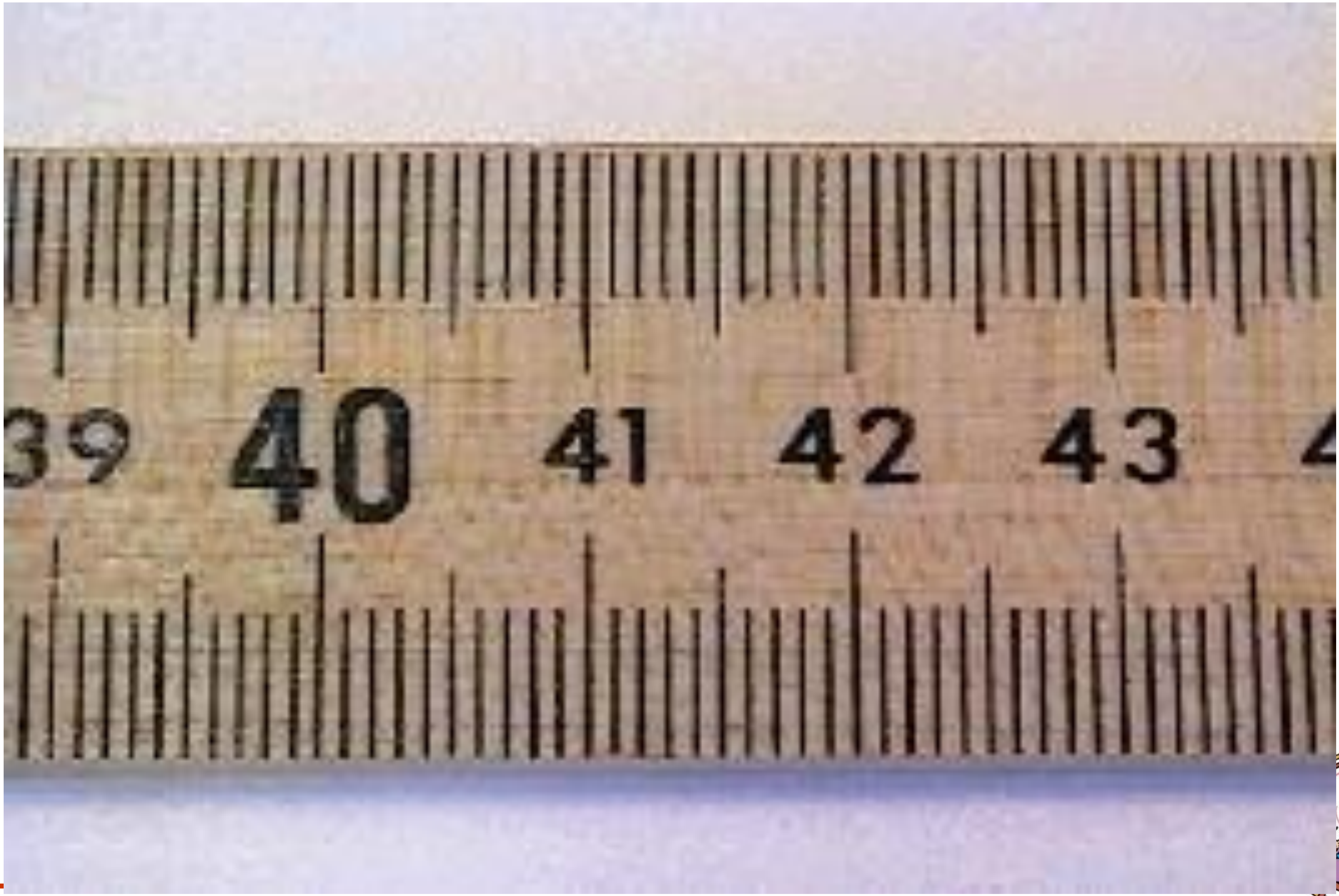
- **Section 3:**

Significant Digits



It All Starts With A Ruler!!!

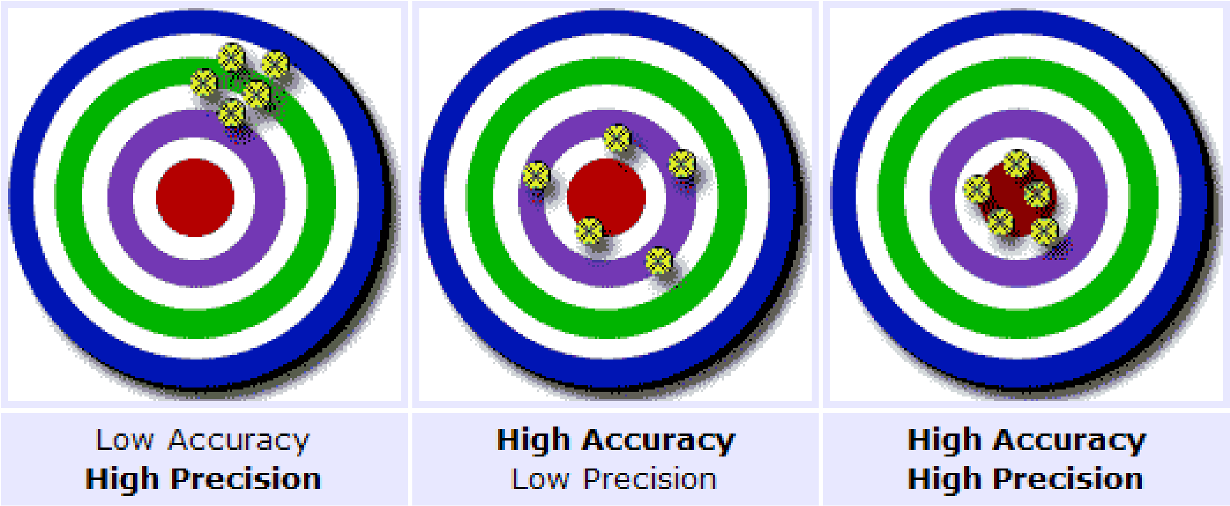


ACCURACY AND PRECISION

Accuracy refers to the closeness of measurements to

is how close a measured value is to the actual (true) value.

Precision is how close the measured values are to each other.



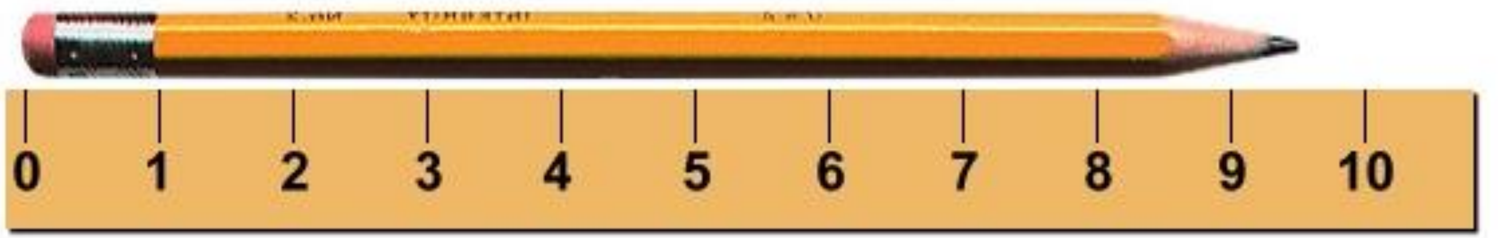
Why Are Accuracy And Precision Important?

- How do these diagrams represent accuracy and precision?

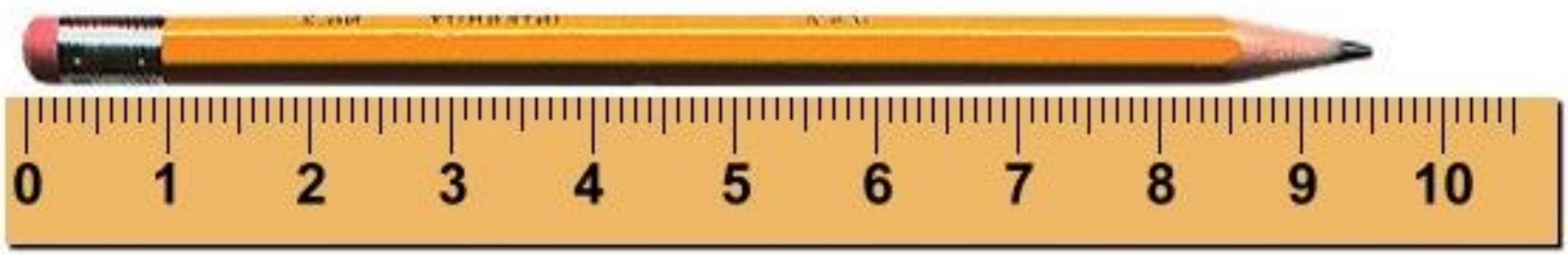
So, if you are playing soccer and you always hit the left goal post instead of scoring, then you are **not** accurate, but you **are** precise

Which ruler is more precise?

Pencil A:

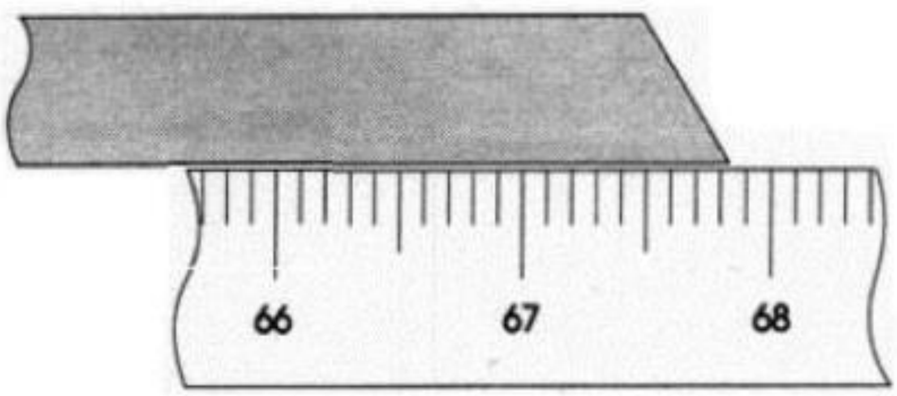


Pencil B



The smaller the unit you use to measure with, the more precise the measurement is.

MEASUREMENTS AND SIGNIFICANT DIGITS p. 344-349



What is the measurement of the Stick?

- The # of significant digits in a value includes all digits that are certain and one that is uncertain

Therefore significant digits are digits that are statistically significant

What are significant digits?

The significant digits in a measurement consist of all the digits known with certainty plus one final digit, which is uncertain or is estimated.

What is the length of the wooden stick?

1) 4.5 cm
2) 4.54 cm
3) 4.547 cm

Rules For Determining The Number of Significant Digits:

- 1. All non-zero digits (1-9) are to be counted as significant.
- Ex. 517, 51.7 and 5.17 all have 3 sig figs
- 2. For any decimal number, any zero that appears after the last non-zero digit(or between 2 non-zero digits) are significant.
- Ex. 0.05057 , 5057 and 56.50 all have 4 sig figs

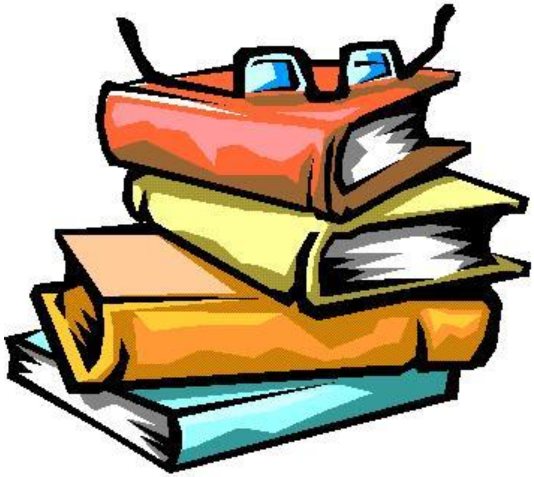
3. For a whole numbers, only zeros between two non-zero digits are significant

Ex,   47, 470, 4700 all have 2 sig fig

Note: A good way to remember Rule Number 3:

Zeros that have any non-zero digits anywhere to the Left of then are considered significant zeros. However, for a whole number, only zeroes between two significant digits are considered significant.

EXAMPLE



45.8736

.000239

.00023900

48000.

48000

1.00040

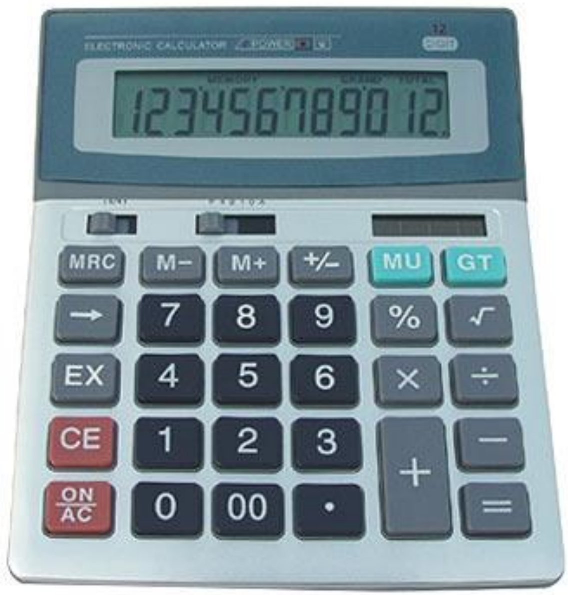
- All digits count
- Leading 0’s don’t
- Trailing 0’s do
- 0’s count in decimal form
- 0’s don’t count w/o decimal
- 0’s between digits count as well as trailing in decimal form

How Many Significant Figures?

1.	3	2.83
2.	4	36.77
3.	3	14.0
4.	2	0.0033
5.	1	0.02
6.	4	0.2410
7.	4	2.350×10^{-2}
8.	6	1.00009
9.	1	3.
10.	5	0.0056040

ROUNDING

- Often when doing arithmetic on a pocket calculator, the answer is displayed with more significant figures than are really justified.



How do you decide how many digits to keep?

Rules to be used in Rounding

#1. If the leftmost digit is 5 or greater, add 1 to the last digit to be kept and drop all other digits farther to the right.

Ex: Rounding 1.2151 to 3 significant figures gives 1.22

#2. If the digit is less than 5, simply drop it and all digits farther to the right.

- **Ex: Rounding 1.2143 to 3 significant figures gives 1.21**

• THE GOLDEN RULE

IF THE DIGIT IS 5 OR MORE

ROUND UP

IF THE DIGIT IS LESS THAN 5

ROUND DOWN

EXAMPLE 1

Make the following into a 3 Sig Fig number

1.5587	**1.56**
.0037421	**.00374**
1367	**1370**
128,522	**129,000**

Your Final number must be of the same value as the number you started with, 129,000 and **not** 129

EXAMPLE 2

For example you want a 4 Sig Fig number

4965.03	**4965**	0 is dropped, it is <5
780,582	**780,600**	8 is dropped, it is >5; Note you must include the 0's
1999.5	**2000.**	5 is dropped it is = 5; note you need a 4 Sig Fig

Using Scientific Notation :

- There are at least two reasons for being familiar with scientific notation.

1) Method of writing numbers that are very big and very small. It works like this:

- a big number

  Speed of light => 300,000,000m/s = 3.0×10^8

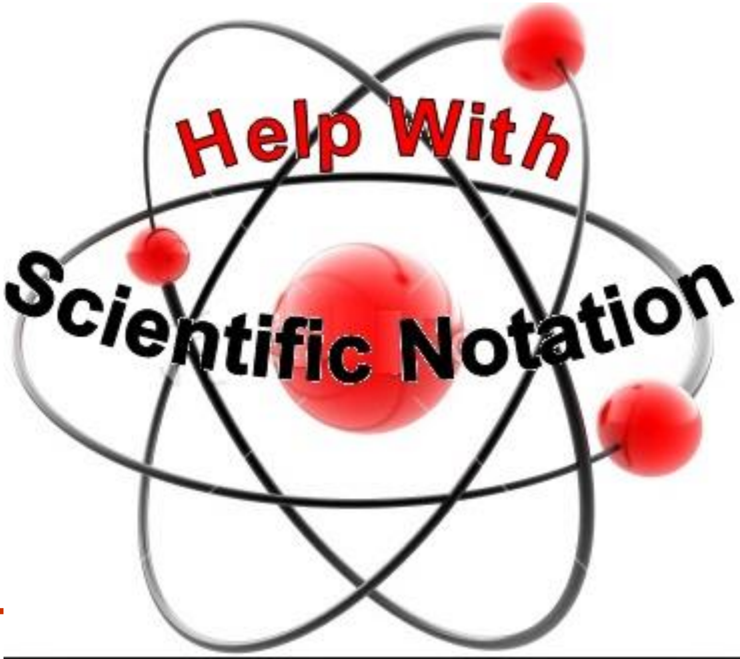
- a small number

Charge on an electron => 0.0000000000000000001602 C

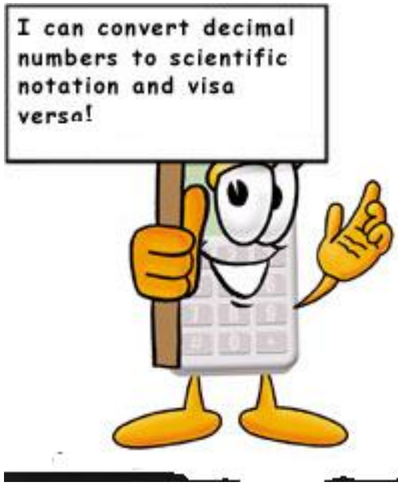
=> 1.602×10^{-19}

2) helpful for indicating how many significant figures are present in a number

100 cm as **1.00×10^2 (3 sig fig)cm**
1.0×10^2 (2 sig fig)cm
1×10^2 (1 sig fig)cm



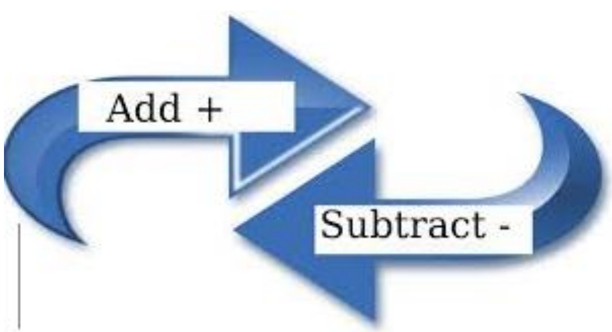
- **Complete The Chart Below**



Decimal notation	Scientific notation
127	1.27×10^{2}
0.0907	9.07×10^{-2}
0.000506	5.06×10^{-4}
2 300 000 000 000	2.3×10^{12}

ADDING OR SUBTRACTING SIGNIFICANT FIGURES

Rule: When adding or subtracting sig fig, the answer should have the same number of decimal places as the smallest number of decimal paces in the numbers that were added or subtracted.



Example:

$$\begin{array}{r} 3.447 \\ 637.56 \\ +\ \ 0.6279 \\ \hline 641.6349 \end{array}$$

Answer is 641.63

ADDITION/SUBTRACTION

```
  25.5
+34.270
-------
  59.770
  59.8
```

ADDITION AND SUBTRATION

.56 + .153 = .713	**.71**	**Look for the last important digit**
82000 + 5.32 = 82005.32	**82000**	
10.0 - 9.8742 = .12580	**.1**	
10 – 9.8742 = .12580	**0**	

i)

$$\begin{array}{r} 83.25\text{s} \\ -\ 0.1075\text{s} \\ \hline 83.14\text{s} \end{array}$$

ii)

$$\begin{array}{r} 4.02\text{m} \\ +\ 0.001\text{m} \\ \hline 4.02\text{m} \end{array}$$

iii)

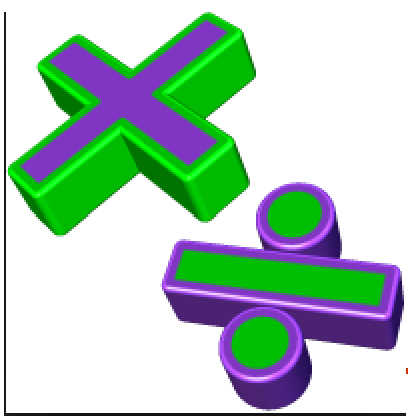
$$\begin{array}{r} 0.2983\ \text{kg} \\ +\ 1.52\text{kg} \\ \hline 1.82\ \text{kg} \end{array}$$

MULTIPLYING OR DIVIDING SIGNIFICANT FIGURES

- **When multiplying and dividing sig, fig. the answer will contain the same number of digits as in the original number with the least number of digits**

$$26.13 \times 2.56 \times 1.5346 = 102.654 = 103$$

$$103\,m \times 52.3\,m = 5386.9\,m^2 = 5.39 \times 10^3\,m^2$$



MULTIPLICATION AND DIVISION

$32.27\text{m} \times 1.54\text{m} = 49.6958\text{m}^2$ **49.7m^2**

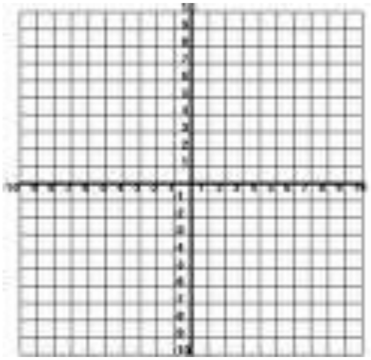
$3.68\text{g} \div .07925\text{ml} = 46.4353312 \text{ g/ml}$ **46.4 g/ml**

$1.750\text{kg} \times .0342000\text{m/s} = 0.05985 \text{ kg m/s}$ **.05985 kg m/s**

Physics 2204

- **Section 4:**

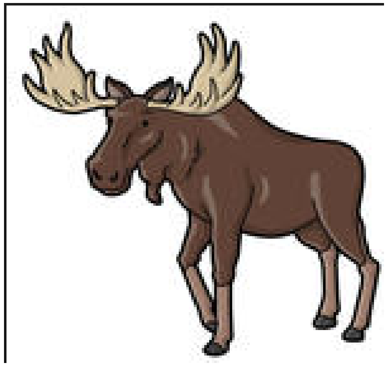
PHYSICAL & MATHEMATICAL RELATIONSHIPS



Example: A Running Moose

The Table below was recorded for a moose running in a forest after seeing Mr Fifield on the first day of hunting. Use the following data to:

i) Create a graph
ii) Draw a line of best fit
iii) Calculate the slope



TIME (s)	DISTANCE (m)
0.0	0
1.0	16
2.0	34
3.0	42
4.0	63
5.0	74
6.0	82

Step 1. Identify Dependent Variable And Independent Variable

INDEPENDENT VARIABLE

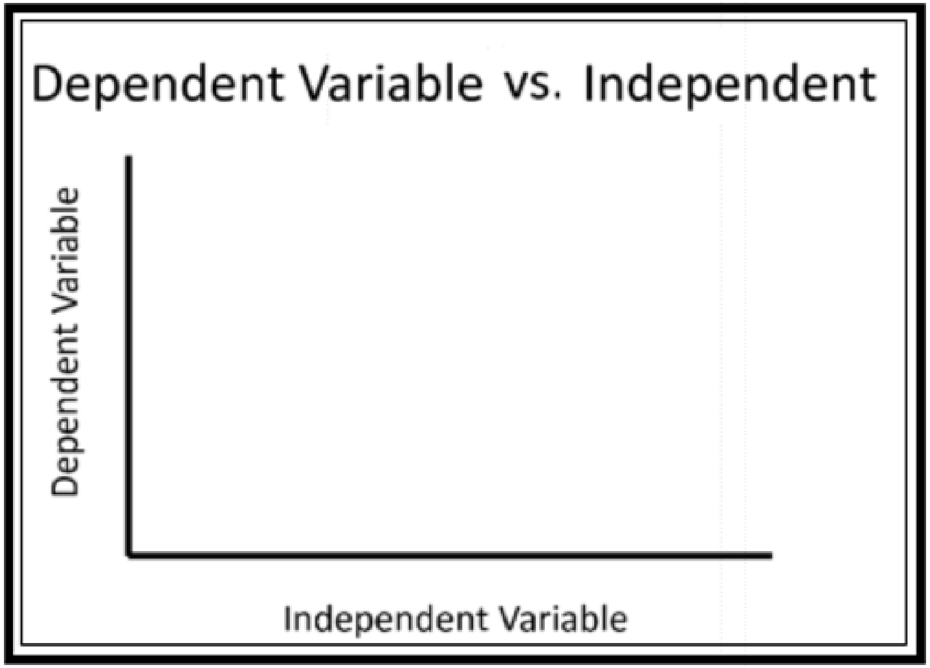
- is the one whose values the experimenter chooses. (Often in nice, even intervals)
- Also called the manipulated variable
- is always plotted on the x-axis
- Ex: time

- **DEPENDENT VARIABLE**

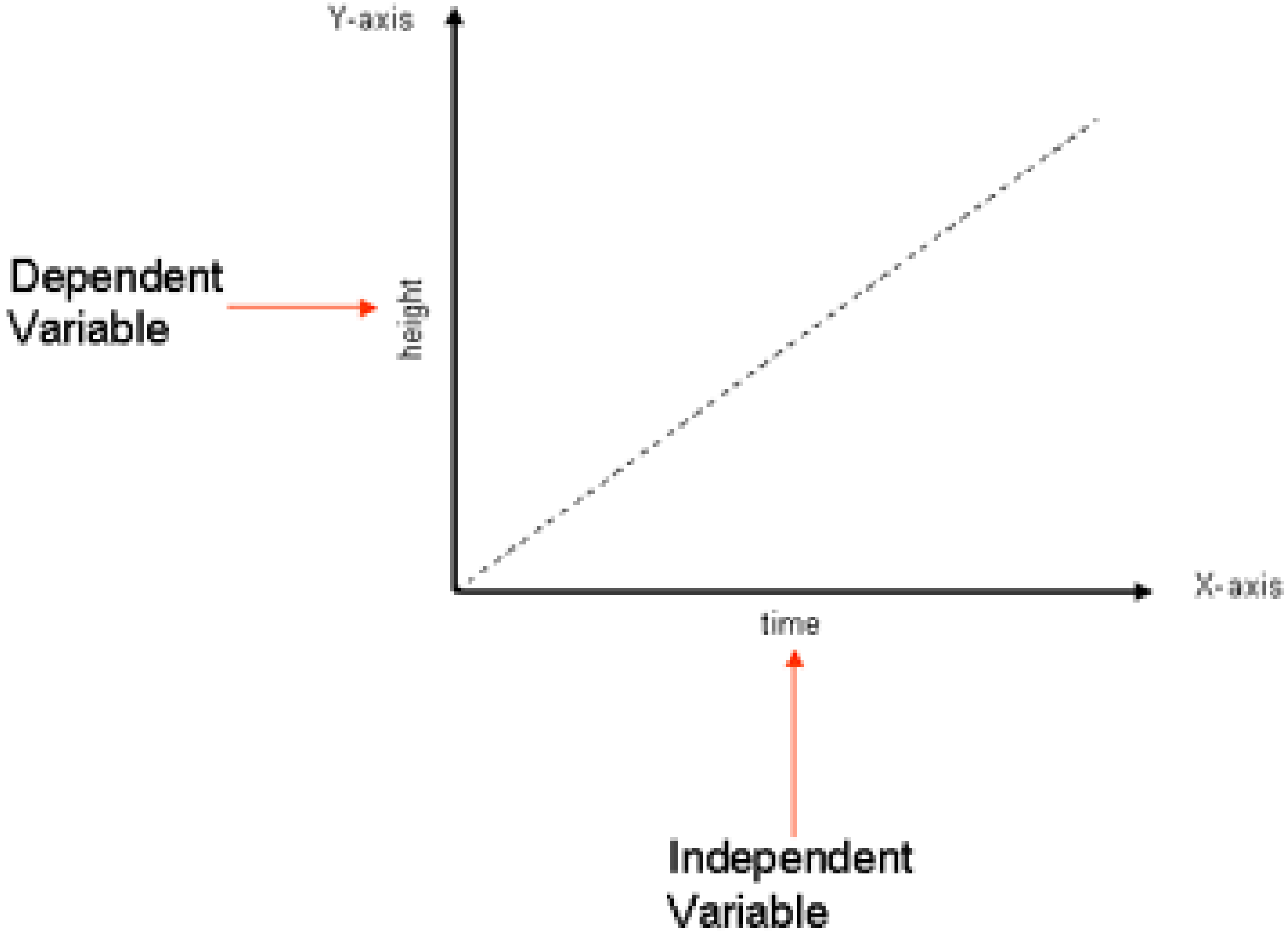
- is the one which responds to changes in the independent variable.
- Also called the responding variable

- is always plotted on the y-axis

Ex: distance



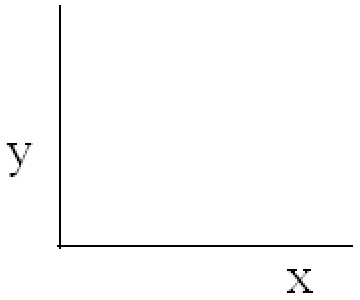
REMEMBER DID



Step #2: Prepare the Grid for your Graph

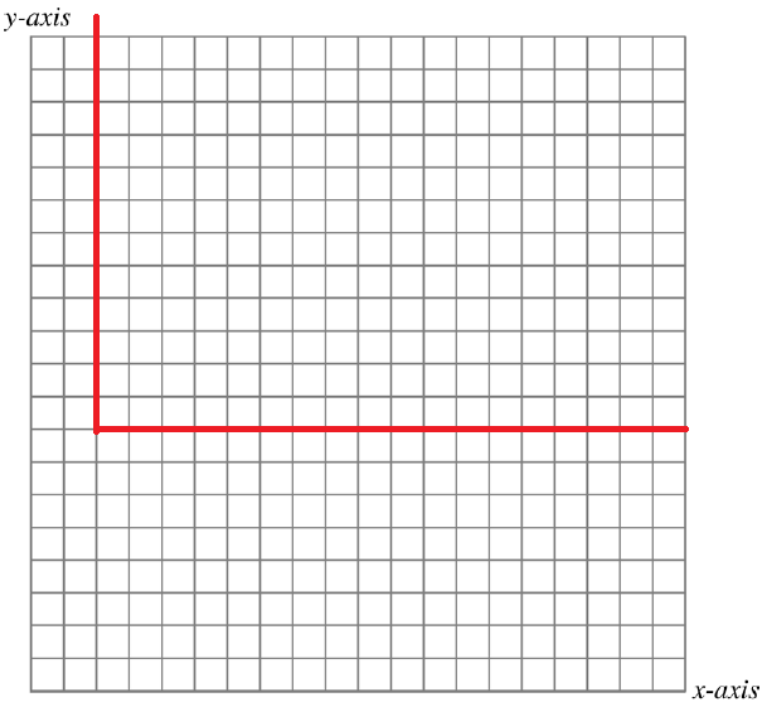
- On graph paper, construct a grid for your graph. The horizontal bottom edge is the x-axis and the vertical edge on the left is called the y-axis.

- Be sure to use the majority of your sheet of paper- DO NOT try to fit the graph into one corner of the paper!

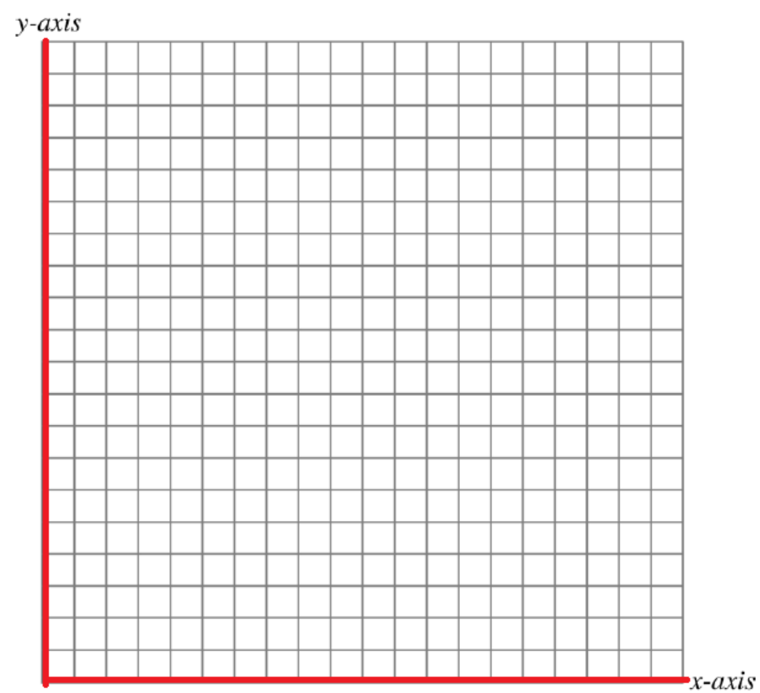


Make sure to use as much of the graphing paper as possible

Incorrect



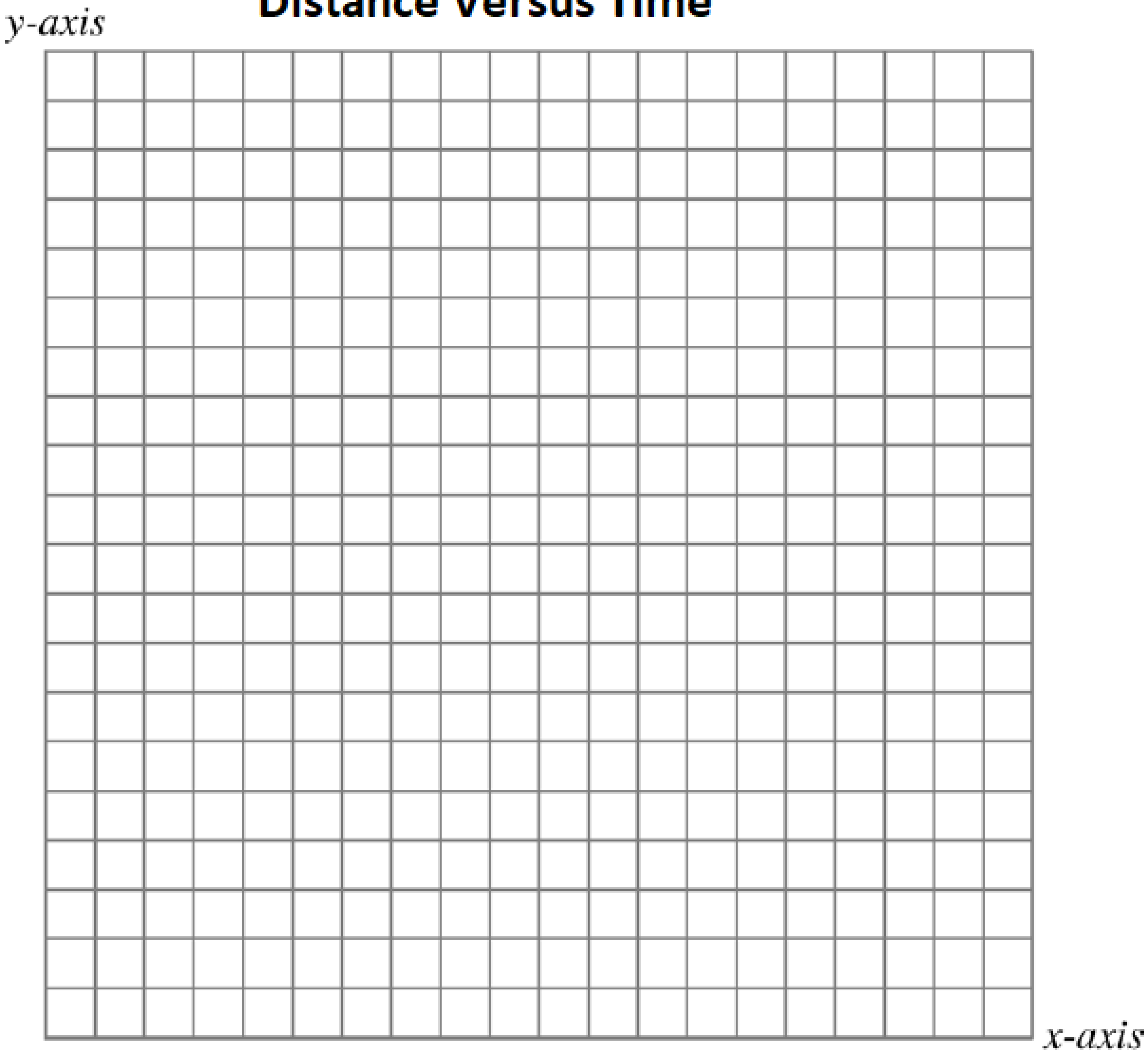
Correct



Step #3: Put a title on the graph

Titles of graphs are usually "Y versus X" or Dependent Variable versus Independent Variable. For example. A graph will be given the title "distance versus Time." (NOT distance divided by time, or distance minus time.)

Distance Versus Time



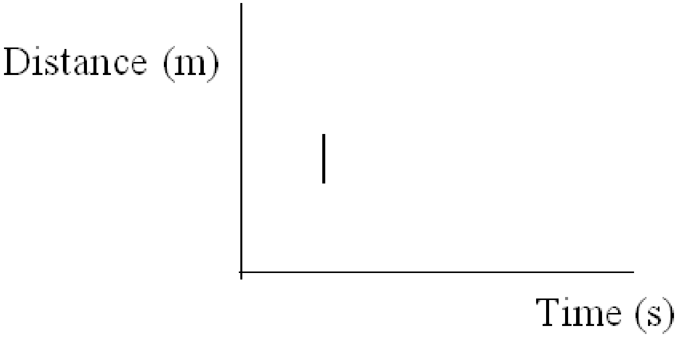
Step #4: Choose the Axes

- Recall that the independent variable is plotted on the x-axis and the dependent variable is plotted on the y-axis.

- Time is USUALLY plotted on the x-axis.

- Putting numbers on the x and y-axes is something that everybody always remembers to do (after all, how could you graph without showing the numbers?).

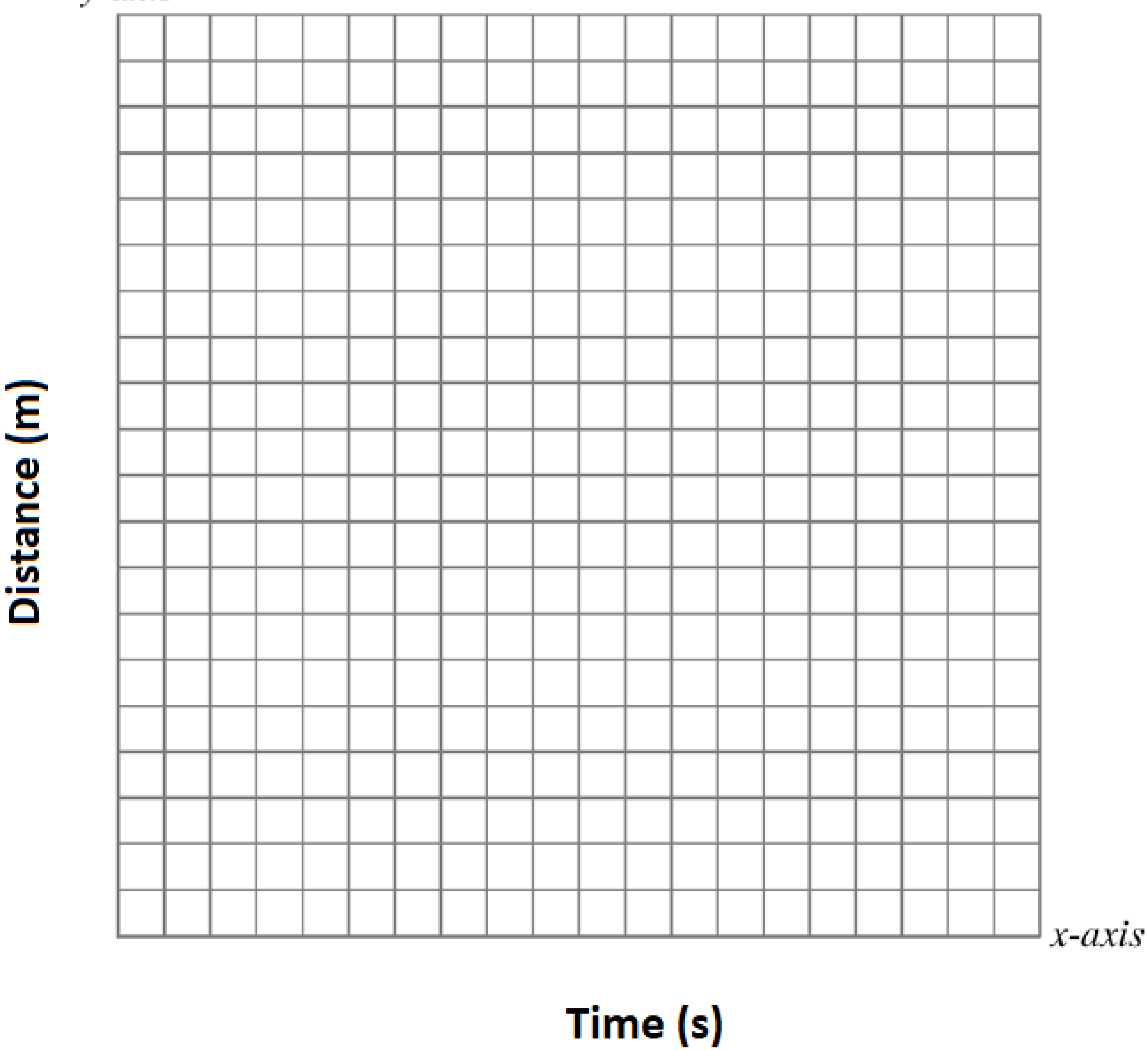
i.e.



However, people frequently forget to put a label on the axis that describes what those numbers are, and even more frequently forget to say what those units are.

- .

Distance Versus Time



Step #5: Determine the Range of Values

- For each variable in the table, find the difference between the largest value and the smallest value- this is the range.

For Time:

Range = Maximum Value - Minimum Value
= 6.0s – 0.0s
= 6.0 s

For Distance:

Range = Maximum Value - Minimum Value
= 82m – 0 m
= 82 s

Step #6: Choose a Scale for Each Axis

- The scale you choose depends on the range of values, and the amount of space you have.

- &Each line on the grid usually increases by equal divisions, such as 1, 2, 5, 10, etc. and leaves a little extra space to avoid “crowdedness”

- i.e. For the x-axis: Each line equals 1 second

  For the y-axis: Each line equals 10 m

Calculate the scale:

Distance

Scale = $\frac{\text{Range}}{\text{\# of lines on grid}}$

Scale = $\frac{82}{20}$

Scale = 4.1

Time

Scale = $\frac{\text{Range}}{\text{\# of lines on grid}}$

Scale = $\frac{6}{20}$

Scale= 0.3

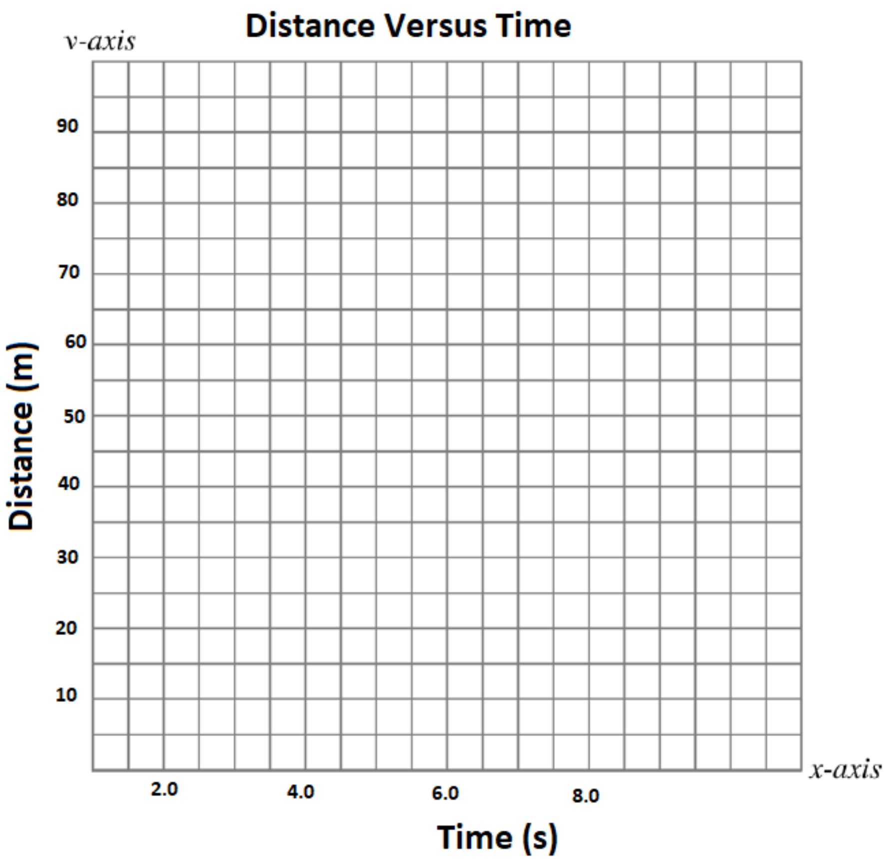
NOTE:

For Distance, I will not use a scale of 4.1 because I will not have enough room to graph the data. Therefore, I will use a scale of 5

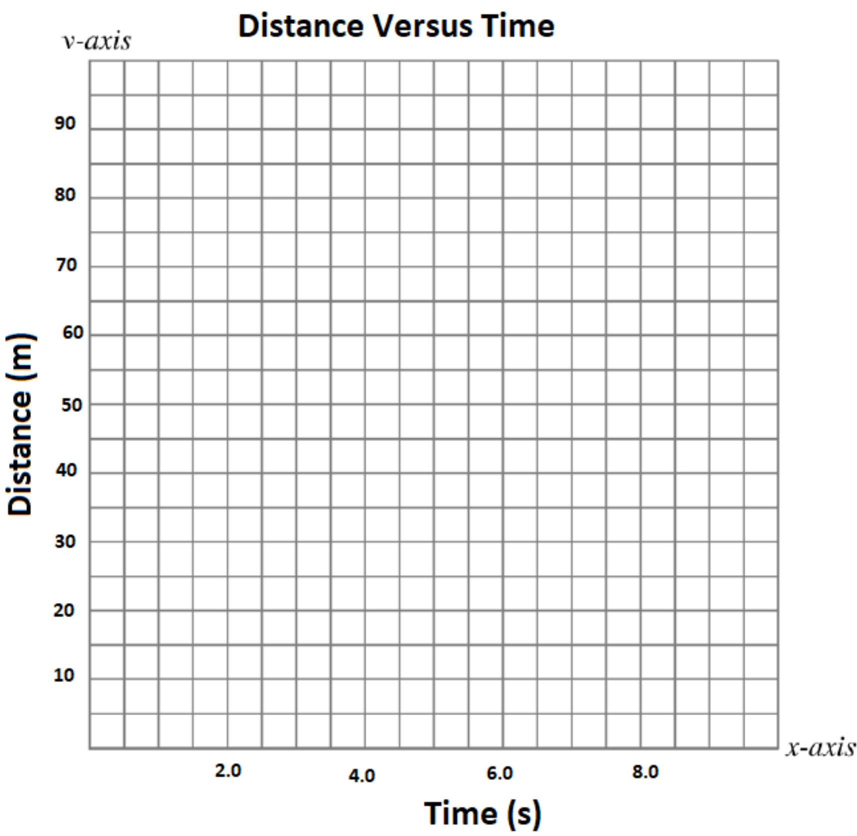
For Time: I will use a scale of 0.5

Make sure to keep an even scale

Incorrect



Correct



Note: Use at least half of your graphing paper

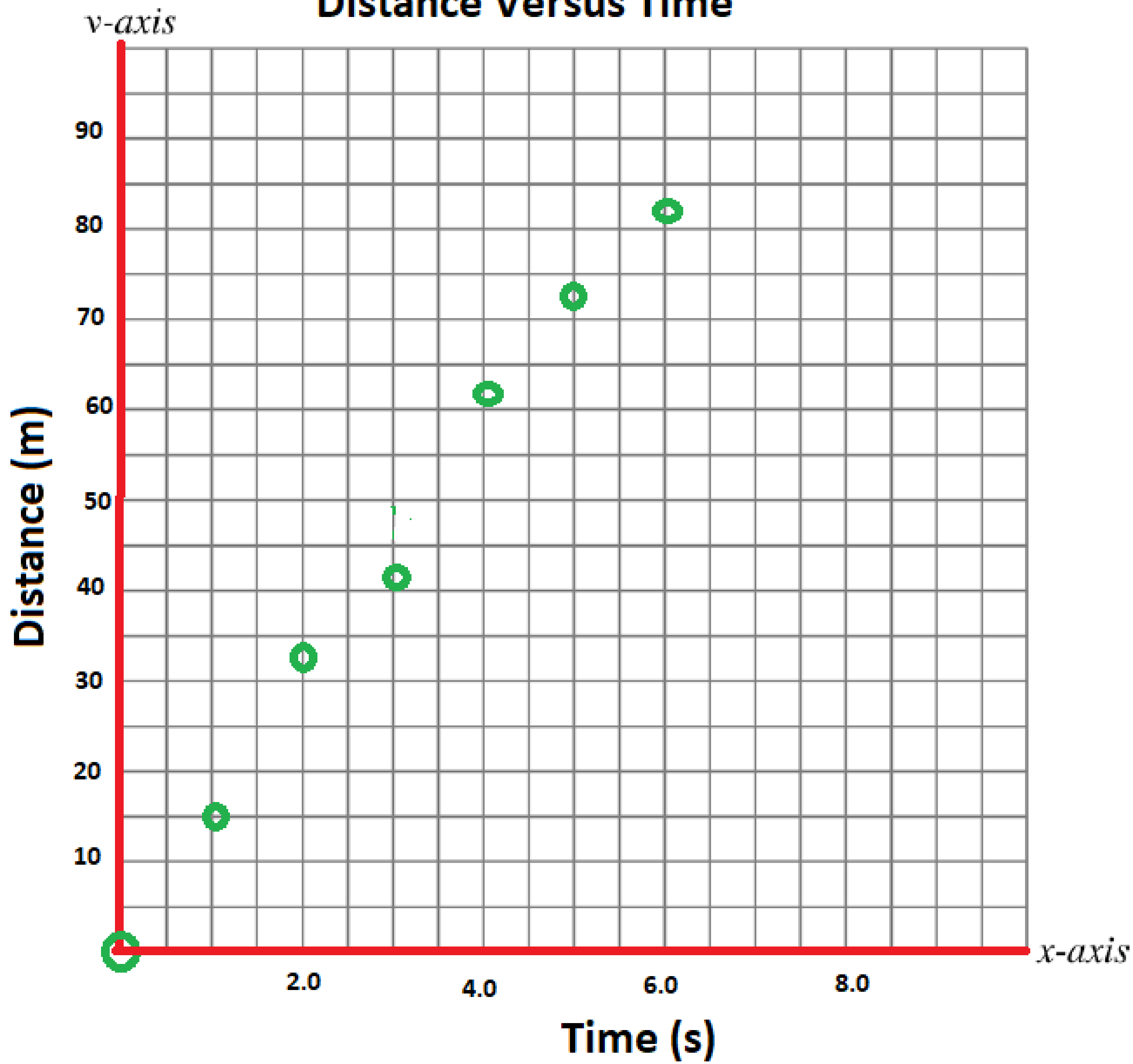
Step #7: Plot the Points

- Start with the first pair of values from the data table, in this case 0 s and 0 m.

- .Place the point where the line starting at 0 s on the x-axis meets the line starting at 0 m on the y-axis. Continue this for all points in the table.

- Do not make your dots as big as Pizzas.

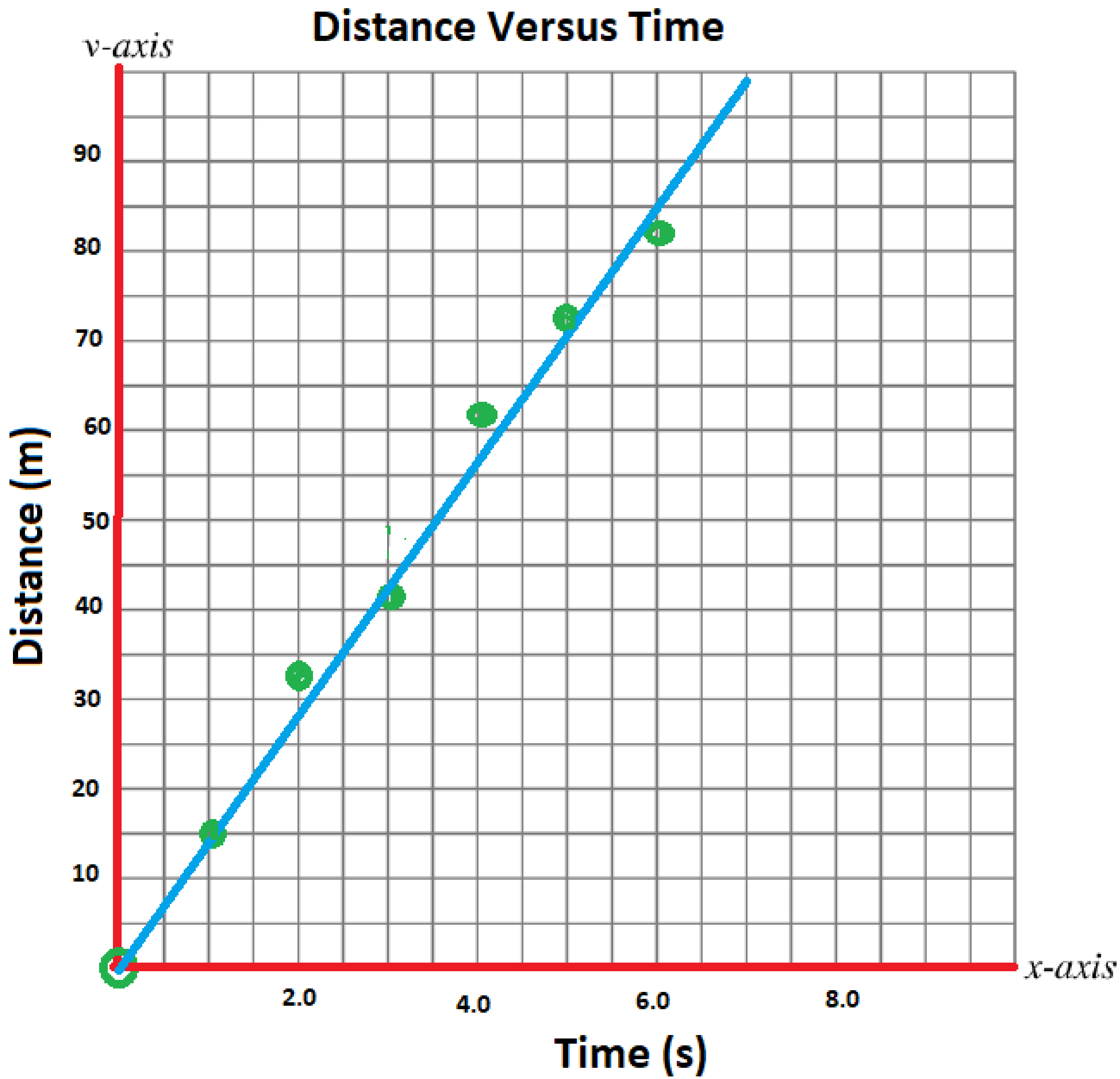
Distance Versus Time



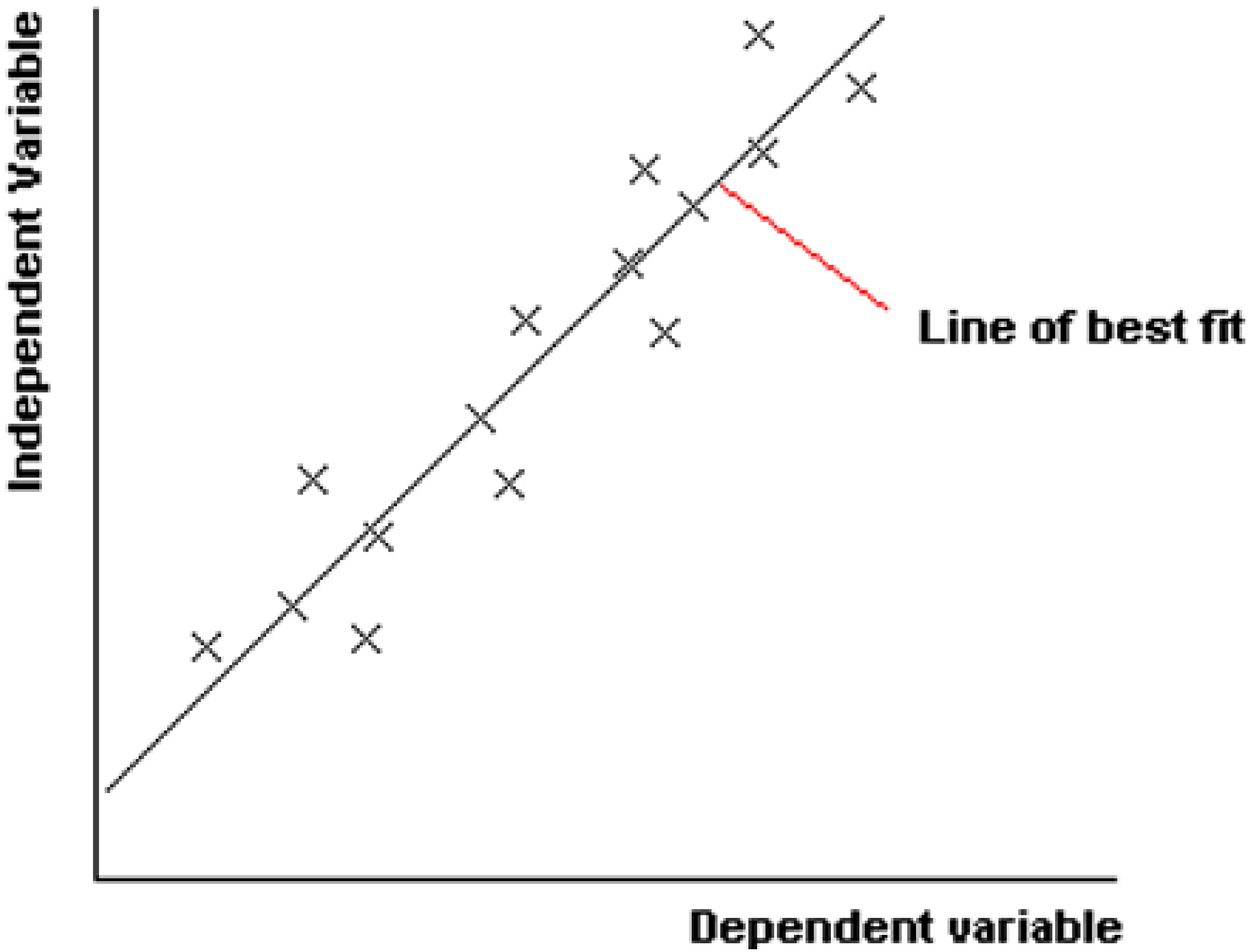
Step #8: Draw a Line through your Data Points and Title your Graph

- If possible, draw a straight line through your data which lies closest to the most points- DO NOT connect the dots.
  - .This line which passes through the majority of the points on a graph is called the **line of best fit**.
  - .The title of your graph should be meaningful, and i.e. NOT
- distance versus time, UNLESS no other information is given about the data being graphed.

Your Finished Graph!

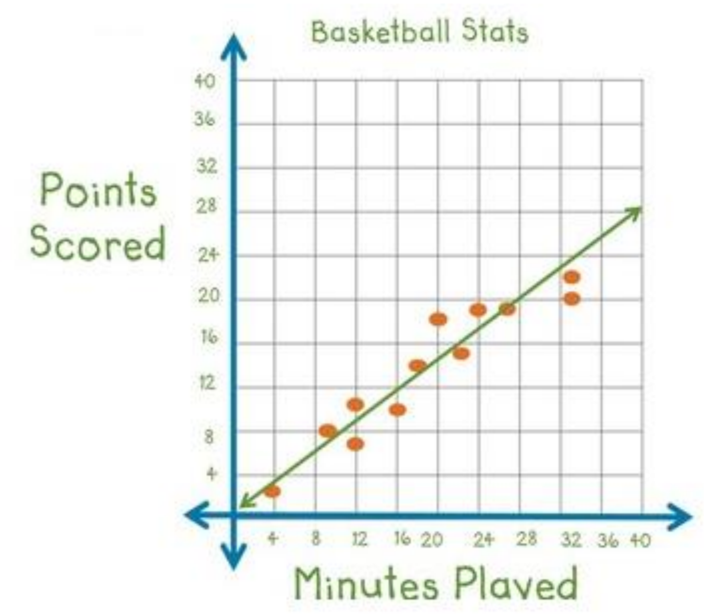


Note: The line of best fit does not have to leave the origin

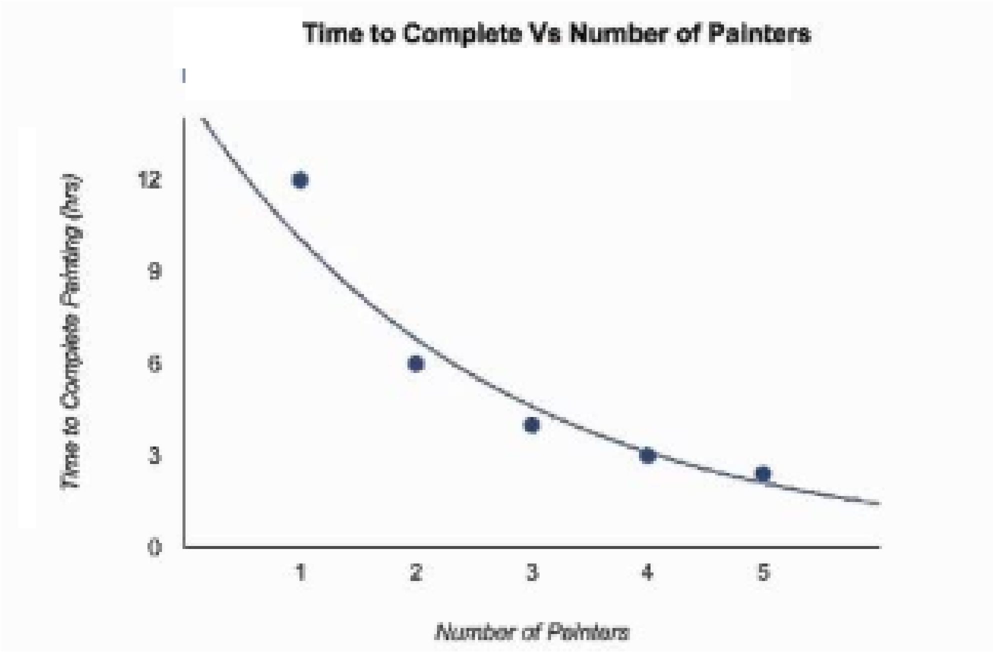


Note, the line of best fit does not always of to be a straight line

Line



Parabola

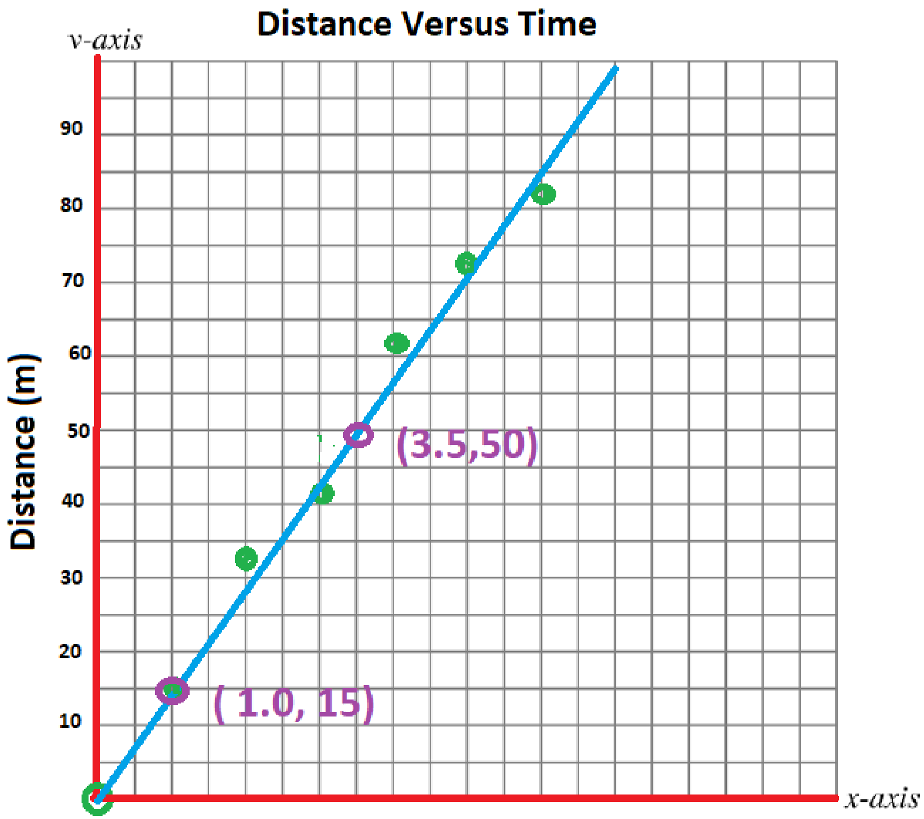


Step # 9 Calculate the slope

- The slope of a graph represents a mathematical relationship between the variables, and can be calculated by

$$\text{Slope} = \frac{\text{Rise}}{\text{Run}} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{\Delta y}{\Delta x}$$

- The values of x and y can be determined using any 2 points along the straight line graph.



The line of best fit now represents the data.

Pick any two points on the line. Try to pick points where the grid meets. This helps with estimating values. I will be using (0.5s, 16m) and (3.5s, 50m)

$$\text{Slope} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{d_2 - d_1}{t_2 - t_1} = \frac{(50\ \text{m} - 15\ \text{m})}{(3.5\ \text{s} - 1.0\ \text{s})}$$

$$= \mathbf{14\ m/s}$$

Recall: Slope can be calculated using the formula

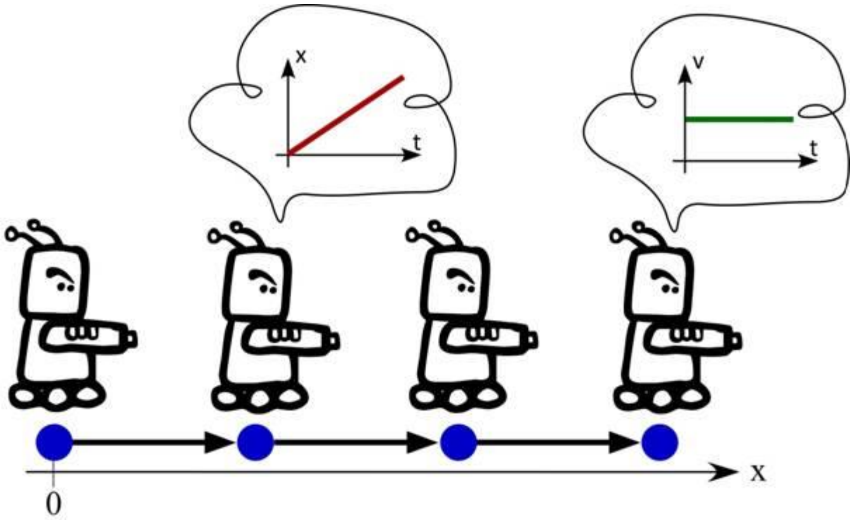
$$\mathbf{m} = \text{Slope} = \frac{d_2 - d_1}{t_2 - t_1} = \mathbf{14\ m/s}$$

m/s is the unit for SPEED (v). The SLOPE OF A d-t GRAPH IS SPEED (v)!

$$\text{SPEED (v)} = \frac{\Delta d}{\Delta t}$$

- **Section 5:**

Uniform Motion



What is Kinematics ?

Kinematics is the study of how objects move. It makes up a large part of introductory physics.


SPEED
MATTERS
the business, psychology and technology

What is Uniform Motion?

Time t (s)	0	1	2	3	4	5	6	...
Distance (m)	0	3	6	9	12	15	18	...

Uniform motion refers to motion at a constant speed in a straight line

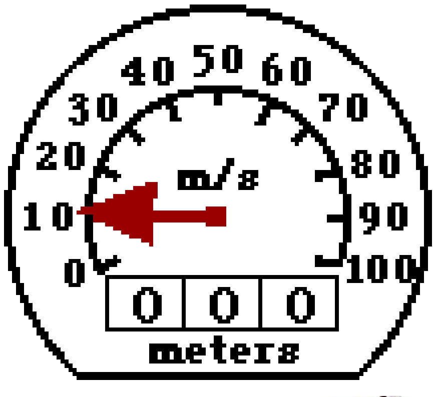
Example: A car with the cruise control set at 100 km/hr

Instantaneous Speed

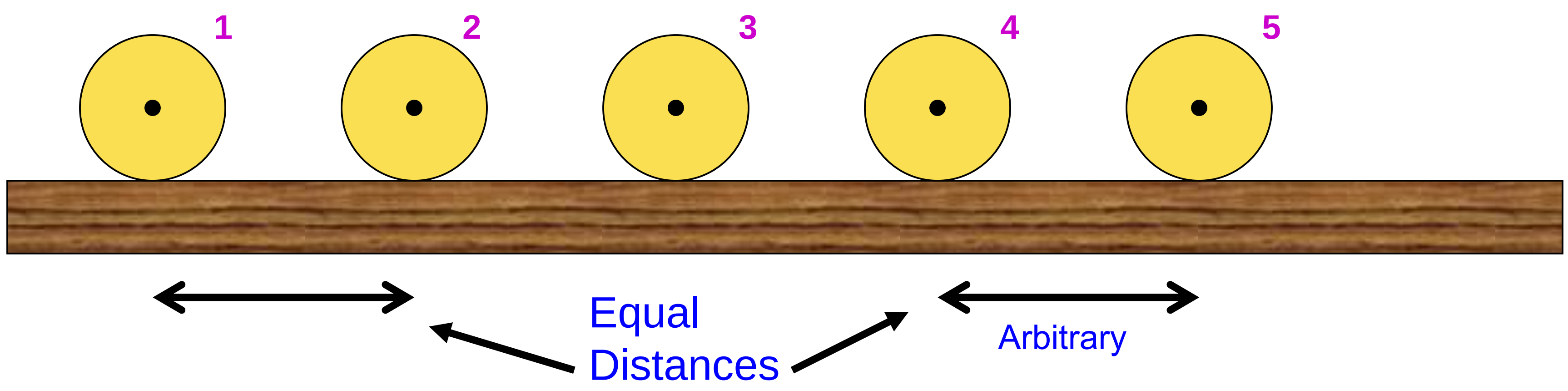
- **Instantaneous Speed** refers to the speed at which an object is moving at a particular moment in time

- it is NOT affected by the object's previous speed, or how long it has been moving.

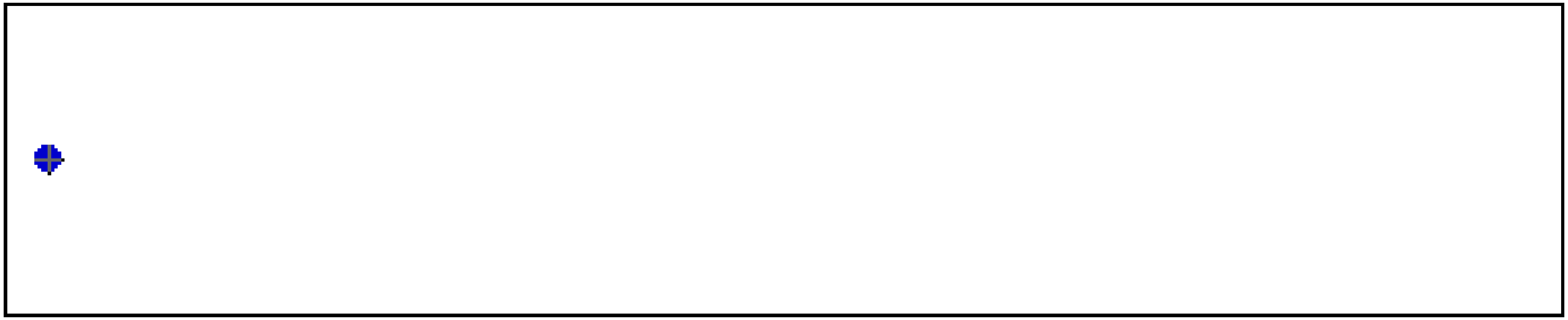
- **.For any object moving at a constant speed, the instantaneous speed is the same at any time, and equals the constant speed.**



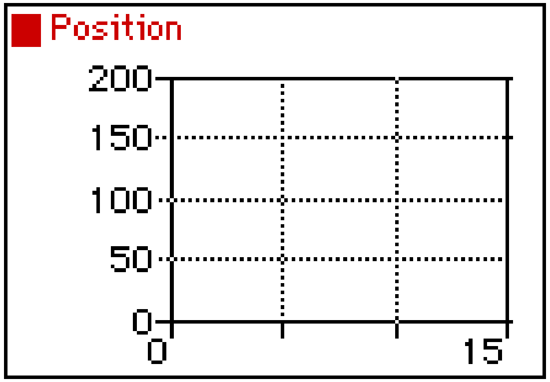
Uniform Motion



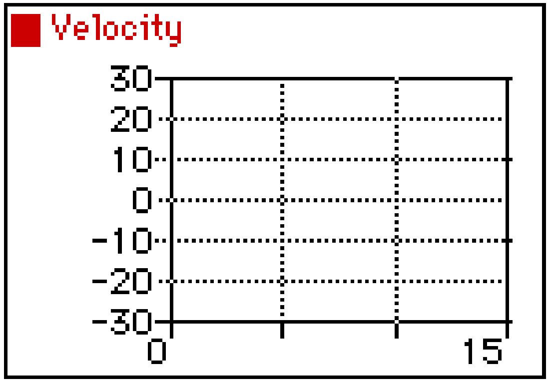
Rolling ball is an example of uniform motion.
1)Speed of the ball is constant (with no friction).
2) In a straight line



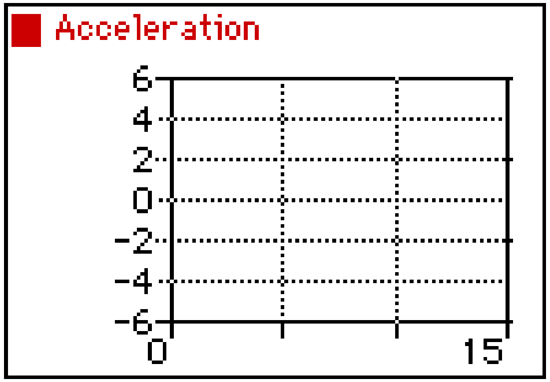
Position-Time Graph



Velocity-Time Graph



Acceleration-Time Graph

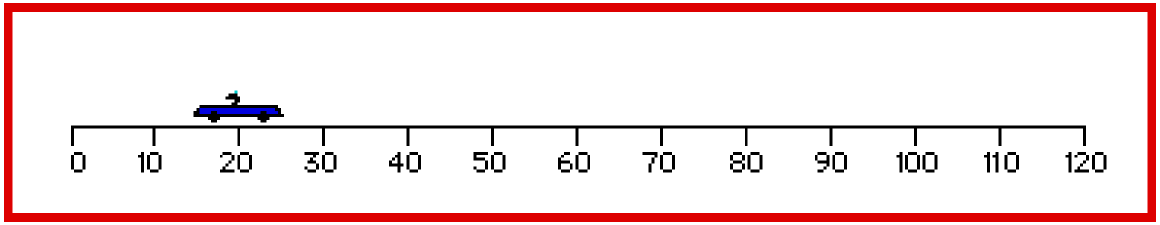


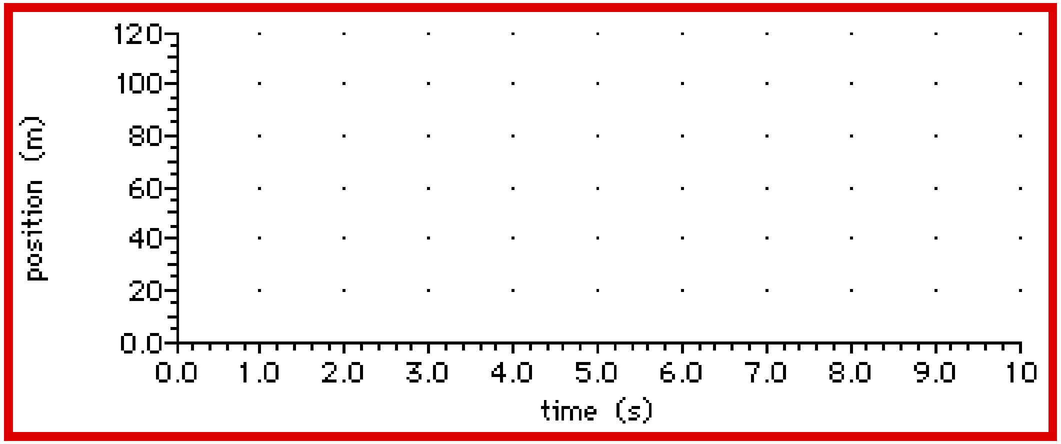
Units For Speed

- Depends, but will always be a distance unit / a time unit
  - Ex. Cars: km/h
  - Jets: km/h
  - Snails: cm/s
  - Falling objects: m/s

Constant Speed

- A moving object that doesn't change it's speed travels at constant speed
- Constant speed means equal distances are covered in an equal amount of time



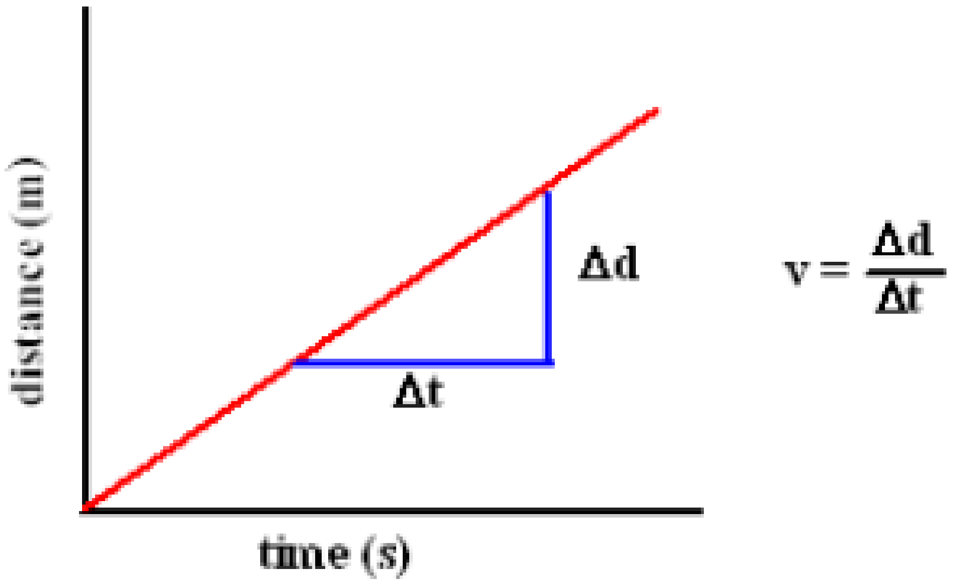


Graphing Speed
Distance vs. Time Graphs

Speed = Slope = Rise/Run

Rise/Run = 600 km/3 hr

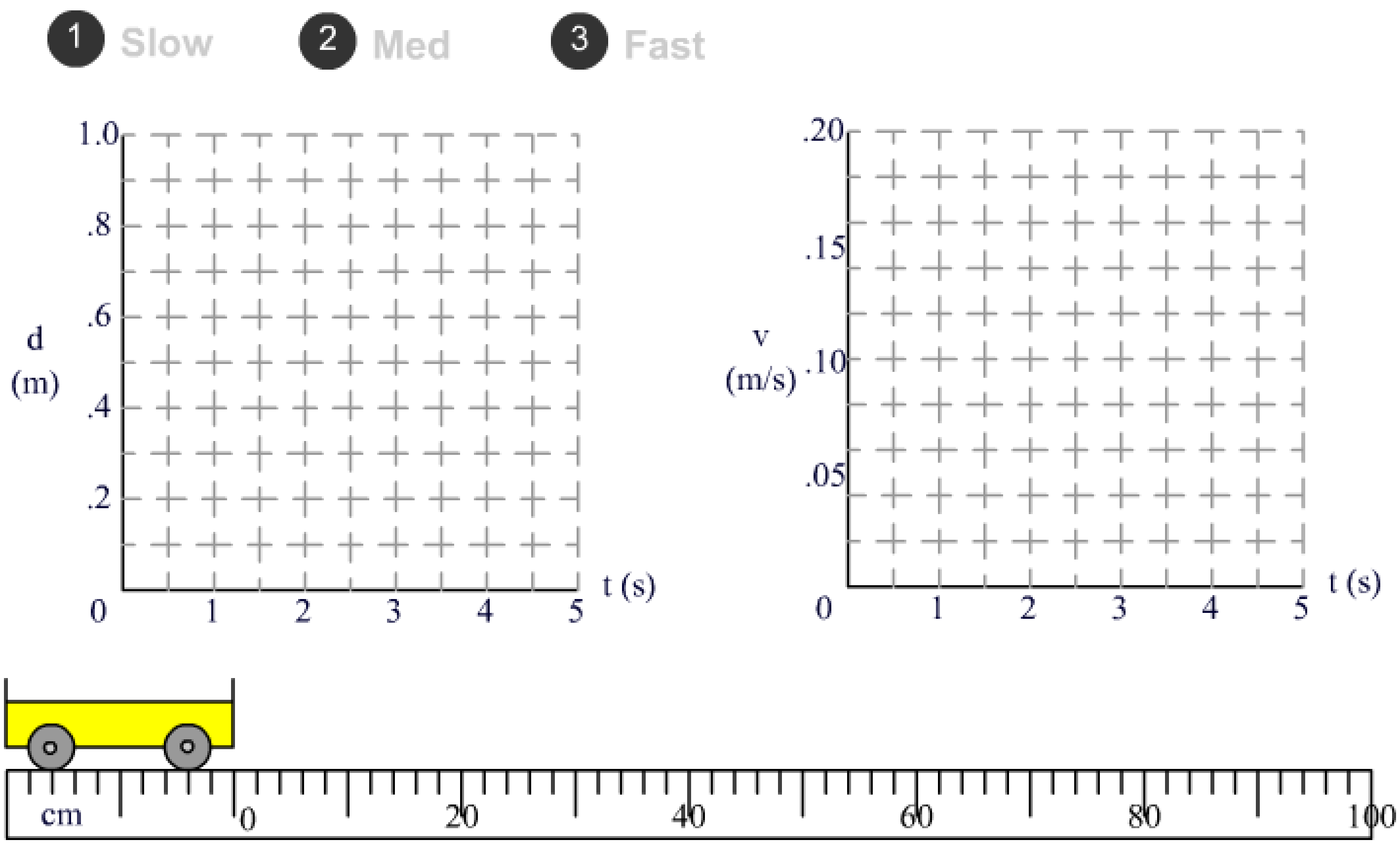
= 200 km/hr



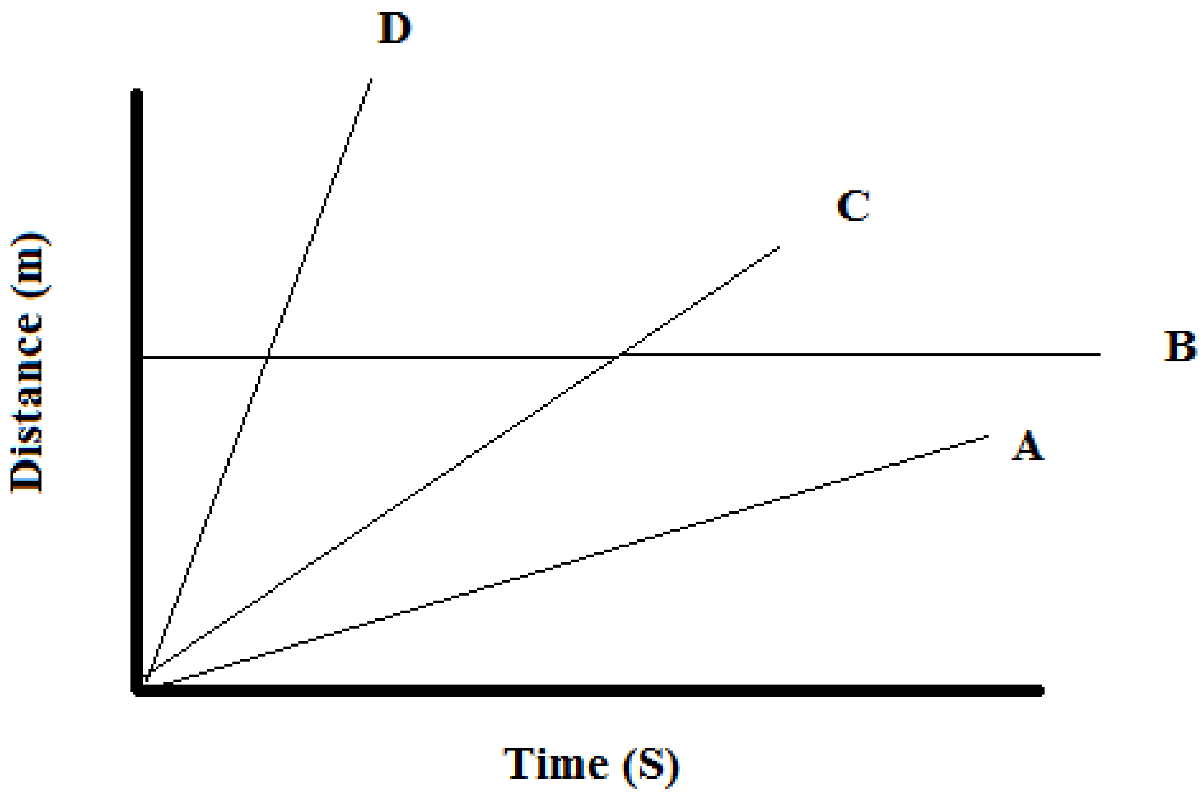
Slope of the d-t graph represents **speed (v)**

Since the slope is the same no matter what points are chosen, the object is moving at a CONSTANT speed, thus the instantaneous speed remains the same at all points.

Slopes and Speeds



Which Object Is Moving The Fastest?



SPEED

$$\text{SPEED (v)} = \frac{\text{Distance}}{\text{Time}}$$

or

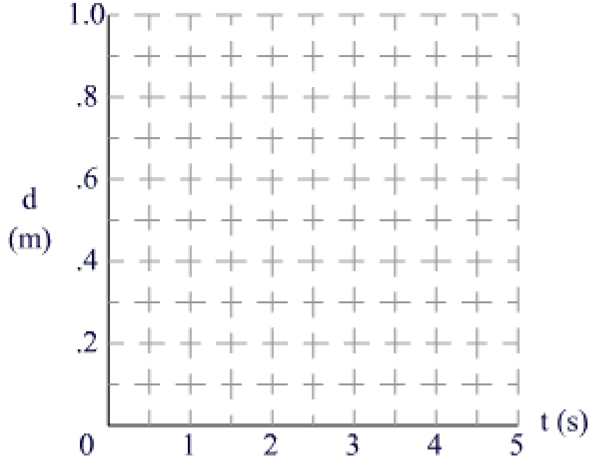
$$v = \frac{d}{t}$$

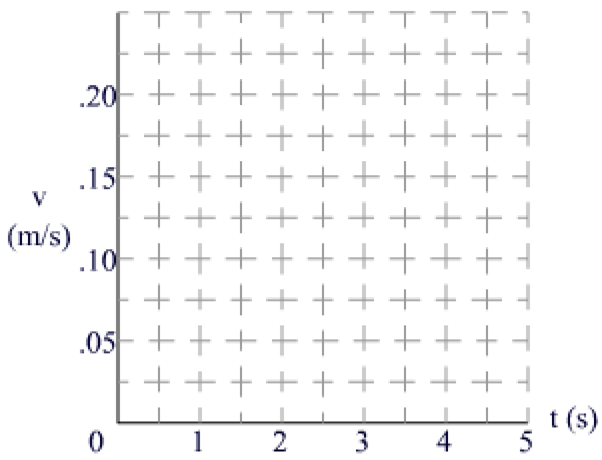
WE WILL NOT BE USING A TRIANGLE IN PHYSICS!!!

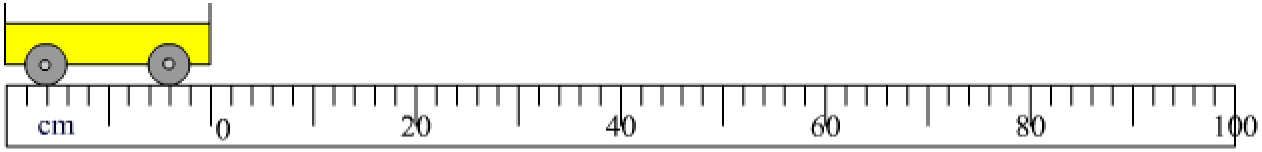
Distance(d) measure in meters or kilometer
Time (t) measured in seconds or hours
Speed (v) measured in m/s or km/hr

Uniform Motion in Two Parts

1 0 - 3 s 2 3 - 5 s 3 0 - 5 s







Example 1:

Suppose that during your trip to school, you traveled a distance of 1002 m and the trip lasted 300 seconds. What was the speed of your car

Example 2:

A bicyclist travels 60.0 kilometers in 3.5 hours. What is the cyclist’s speed?

Example 3:

If you drive at 100 km/hr for 6 hours, how far will you go?

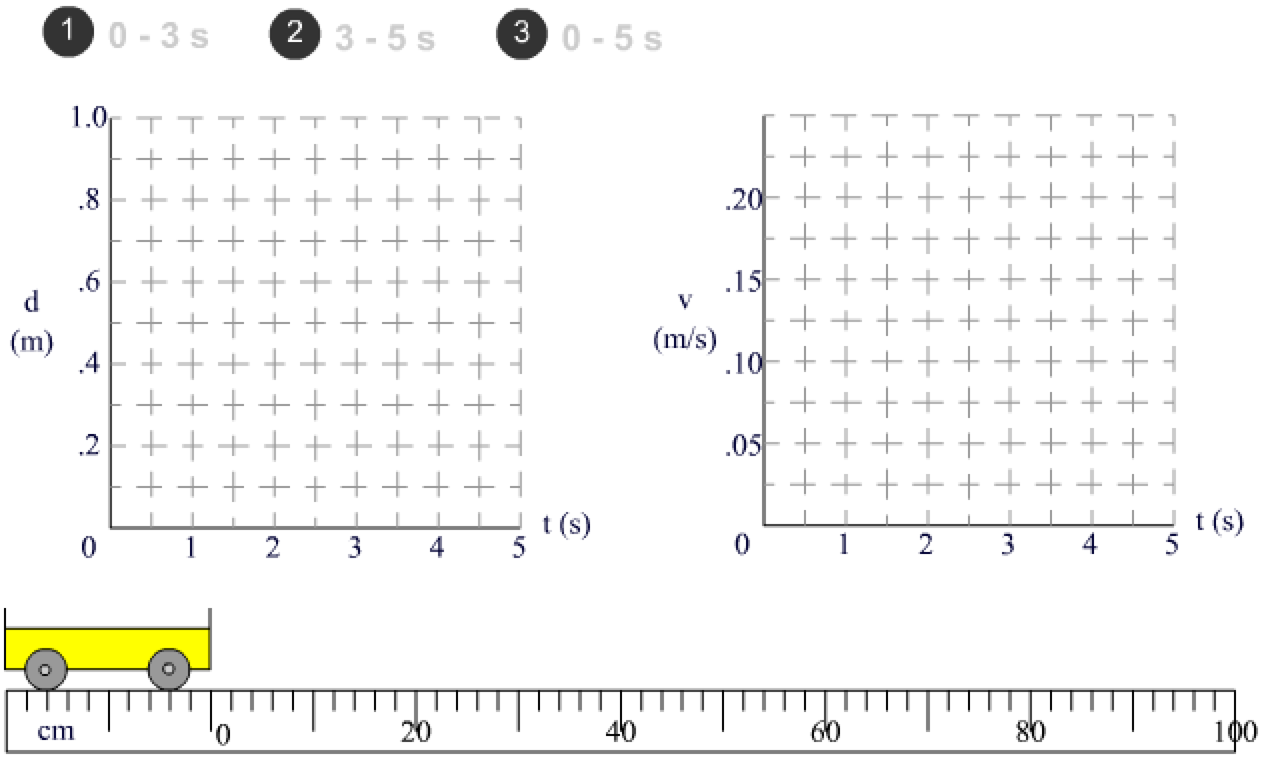
Example 4:

If you run a t 12 m/s for 15 minutes, how far will you go?

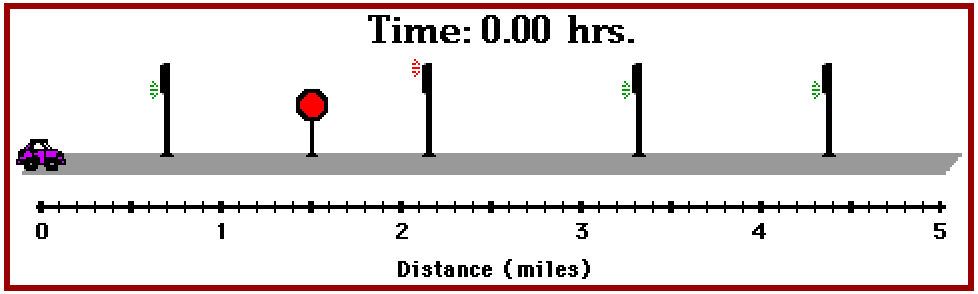
Example 5:

A bullet travels at 850 m/s. How long will it take a bullet to go 1 km?

Uniform Motion in Two Parts



Average Speed



During a trip your speed can fluctuate, stop, speed up or slow down over some distance. So, you need to determine the average.

- **Average speed** distance per time ratio. is a measure of the distance traveled in a given period of time;

Δ **Change In**

Δd **Change in distance**

Δt **Change in time**

$$V_{ave} = \frac{\Delta d}{\Delta t}$$

WHEN WE ARE DEALING WITH UNIFORM MOTION THAT HAS DIFFERENT SPEEDS AT DIFFERENT TIMES, YOU CANNOT DETERMINE THE OVERALL AVERAGE SPEED BY AVERAGING THE SPEEDS OF THE DIFFERENT PARTS

Example 6:

You go out for some exercise in which you run 12.0 km in 2.0 hours, and then bicycle another 20.0 km in 1.0 hour. What was your average speed for the entire marathon?

Example 7:

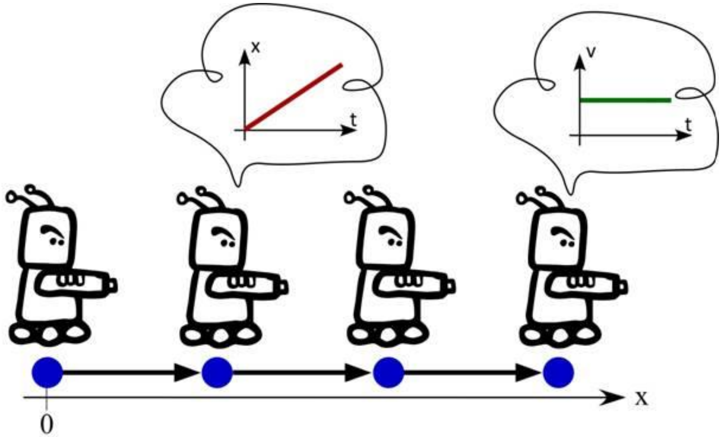
A traveler journeys by plane at 400.0 km/hr for 5.0 hours, then drives by car for 180 km in 2.0 hours and finally takes a 45 minute ferry ride the last 12 km to his home. What is her average speed for the entire trip?

SUMMARY FOR UNIFORM MOTION

- Two conditions for uniform motion

  1) Constant Speed

  2) Moving one Direction



- Slope of Distance – Time graph is Speed

- Instantaneous Speed refers to the speed at which an object is moving at a particular moment in time.

- Formula for speed is $\text{Speed} = \dfrac{\text{Distance}}{\text{Time}}$

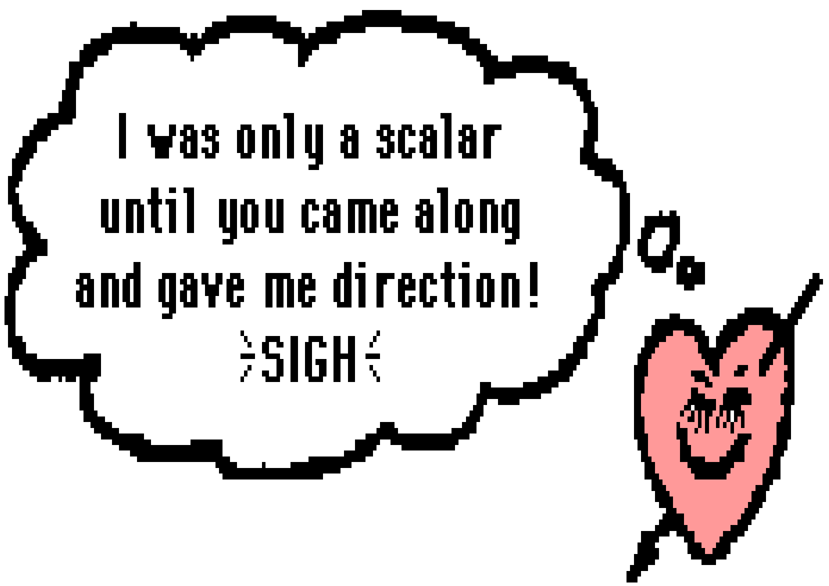
  - Formula for average speed is $\textit{Average Speed} = \dfrac{\textit{Total Distance}}{\textit{Total Time}}$

PHYSICS LABORATORY

- STUDY OF UNIFORM MOTION

- ## Section 6:

SCALARS AND VECTORS

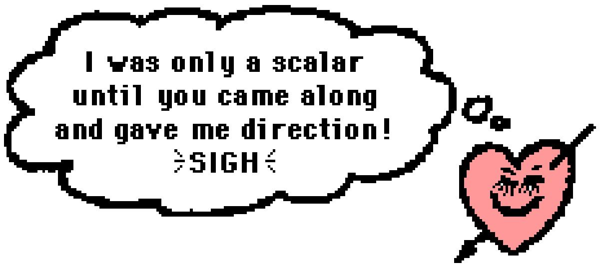


Scalar Quantity

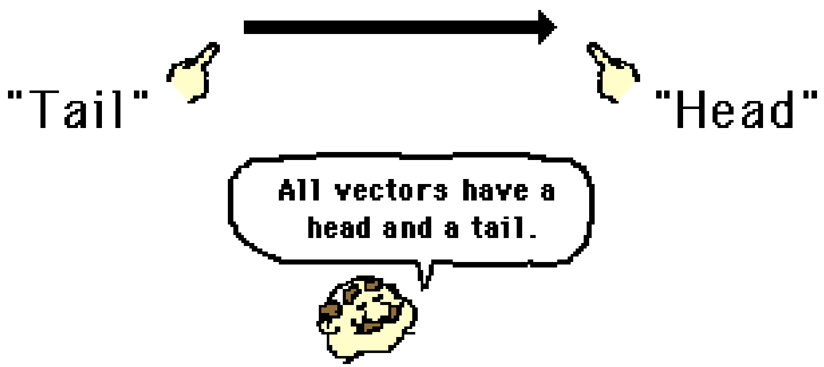
- **a quantity that involves size, but not direction ie. has a magnitude and units.**

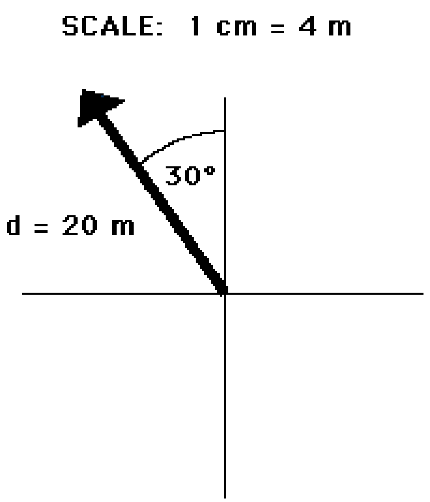
Scalar Example	Magnitude
Speed	20 m/s
Distance	10 m
Time	15 hours
Mass	95 kg

Vector Quantity



- A quantity that involves direction and has a magnitude
- Ex. displacement, velocity





Head of the arrow indicates direction

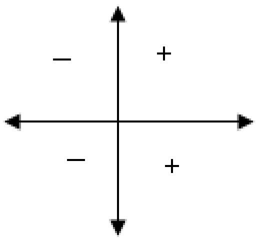
Length of arrow indicates magnitude

Direction

- Stated relative to a reference point (usually the origin or starting point).

- Can be indicated by:

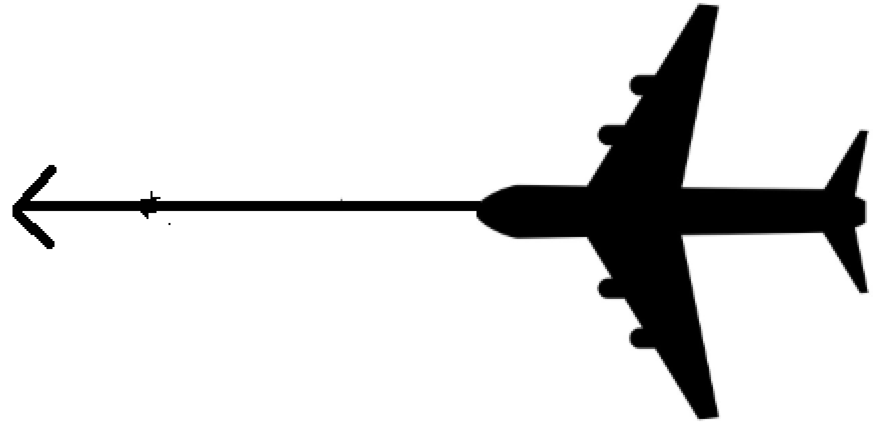
Geography	Space	Vector	Sign (+ / -)
North	Up	↑	+
South	Down	↓	-
West	Left	←	-
East	Right	→	+



Vector Diagrams

Plane flying 500 km North

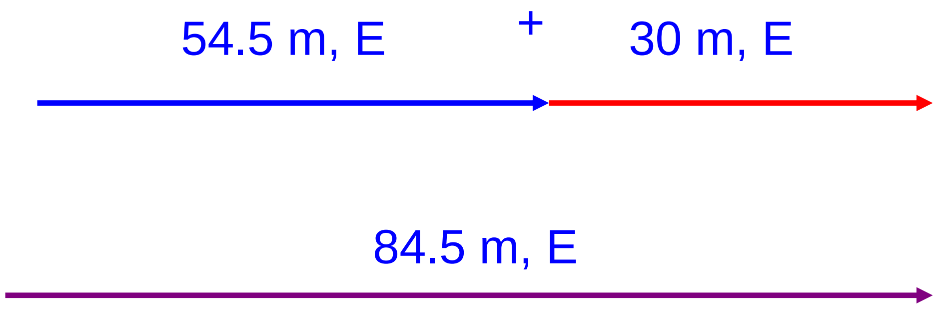
Plane flying 1000 km West



Vector Addition

VECTOR ADDITION – If 2 similar vectors point in the SAME direction, add them.

- **Example: A man walks 54.5 meters east, then another 30 meters east. Calculate his displacement relative to where he started?**

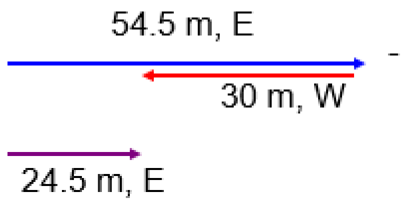


Notice that the SIZE of the arrow conveys MAGNITUDE and the way it was drawn conveys DIRECTION.

Vector Subtraction

VECTOR SUBTRACTION - If 2 vectors are going in opposite directions, you **SUBTRACT.**

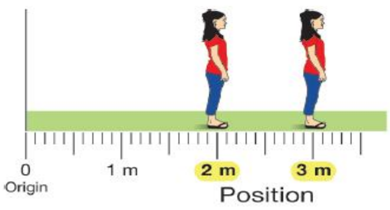
Example: A man walks 54.5 meters east, then 30 meters west. Calculate his displacement relative to where he started?



Distance –Position- Displacement

Distance (d) is a scalar quantity which refers to "how much ground an object has covered" during its motion.

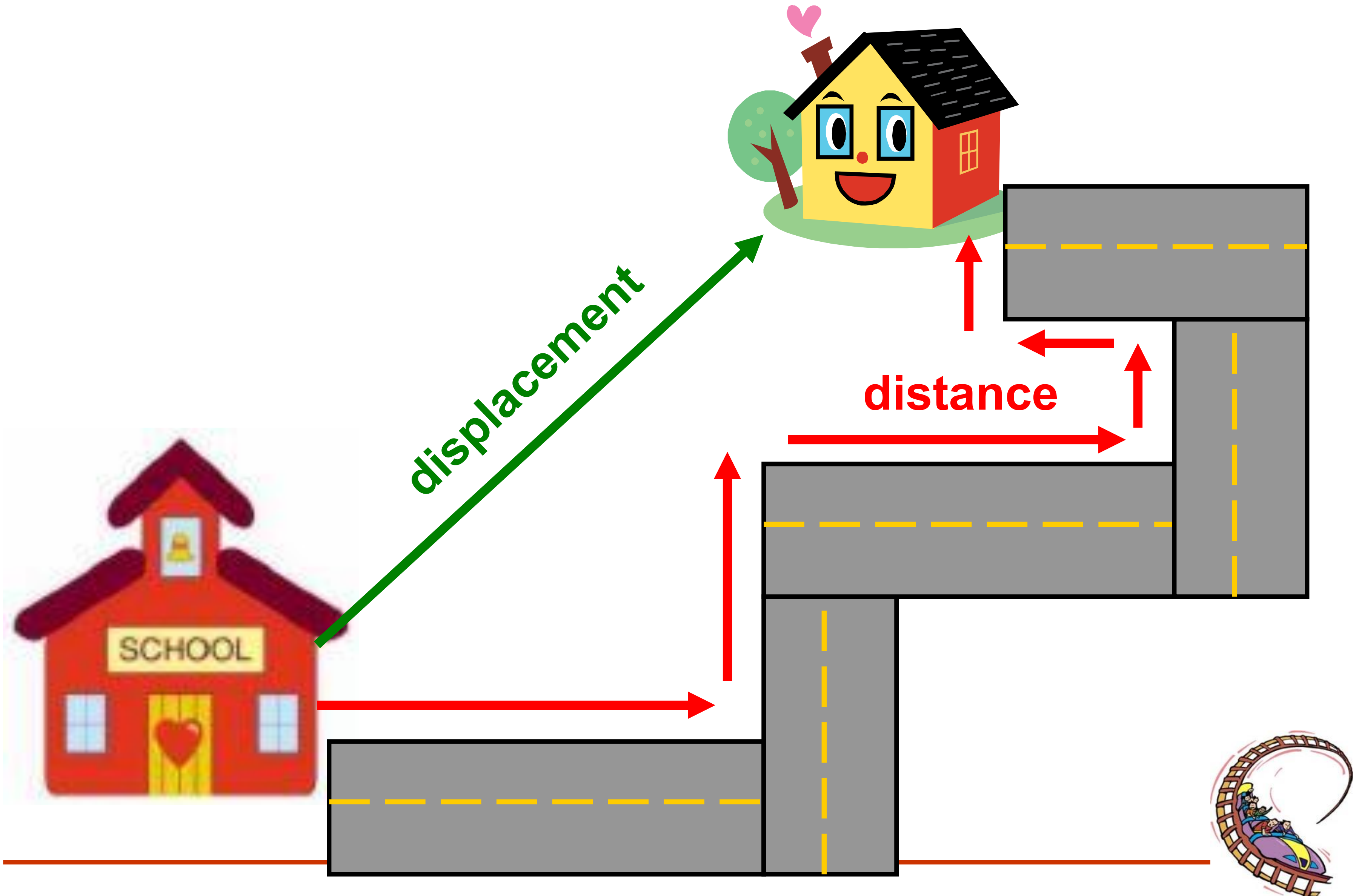
Position $(\vec{d})$ is a vector quantity which refers to the straight line distance and direction from a reference point. Location of an object at one instant



Displacement $(\Delta \vec{d})$ is a vector quantity which refers to "how far out of place an object is"; it is the object's change in position. Only concerned about the beginning and the end of the trip

$$\overrightarrow{\Delta d} = \vec{d_2} - \vec{d_1}$$

Displacement Vs Distance



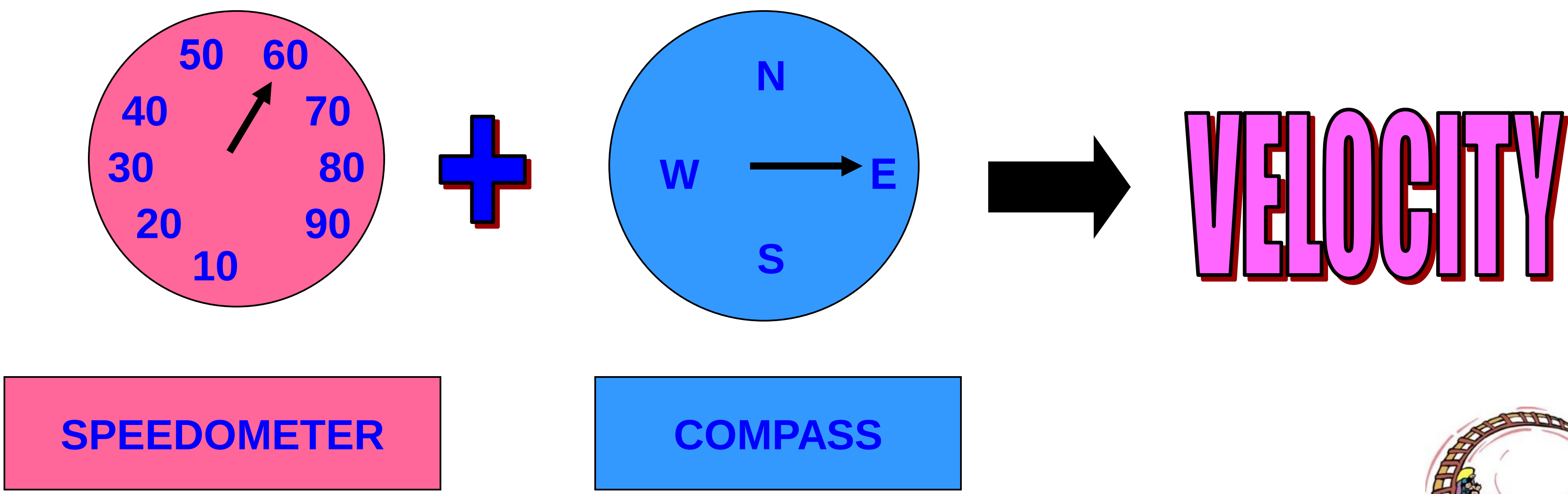
Speed & Velocity

Speed and velocity are not the same.

Velocity requires a directional component and is therefore a vector quantity.

Speed tells us how fast we are going but not which way.

Speed is a scalar (direction doesn't count!)



Speed and Velocity

Speed and Distance

Distance is a **scalar** quantity. The change in an object's distance with time is called **speed**:

$$\text{Speed (m/s)} = \frac{\text{Distance (m)}}{\text{Time (s)}}$$

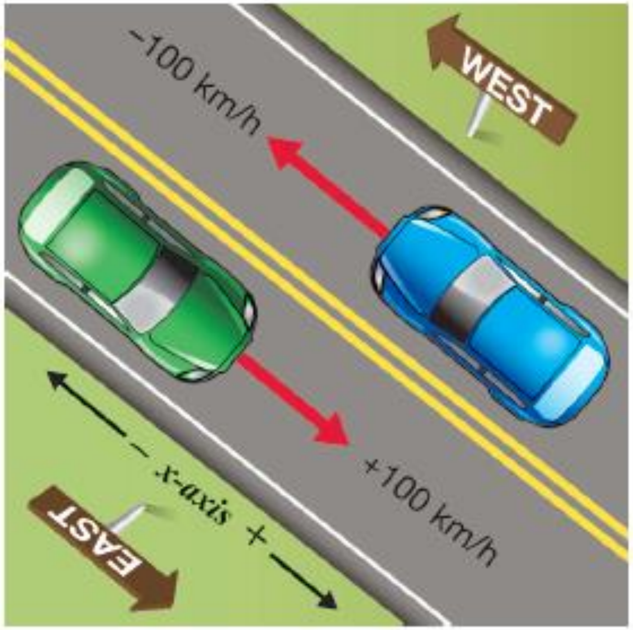
Displacement is a **vector** quantity that describes a distance moved, in a particular direction. The change in an object's displacement with time called **velocity**:

$$\text{Velocity (m/s)} = \frac{\text{Displacement (m)}}{\text{Time (s)}}$$

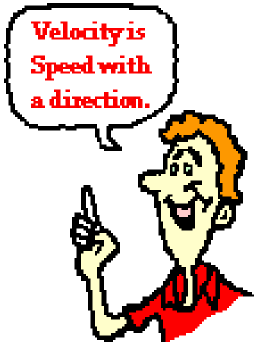
- The *velocity* of an object tells you both its speed and its direction of motion.

- A velocity can be positive or negative.

- The positive or negative sign for velocity is based on the calculation of a change in position.



Two cars going opposite directions have the same speed, but their velocities are different—one is positive and the other is negative.

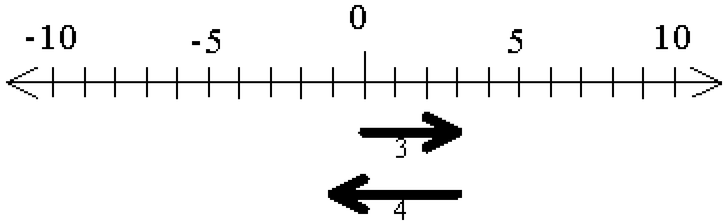


Example 1: One Dimension =>Adding Vectors

A person started from the zero position, moved 3.0 *km* East (or to the right), then moved backward 4.0 *km* West (or to the left) in a time of 0.25 hr.

A) What is the distance

3.0 km + 4.0 km = 7.0 km



B) What is the displacement

3.0 *km* East + *4.0km* West = +*3km* + -*4.0* km = -1.0 *km*

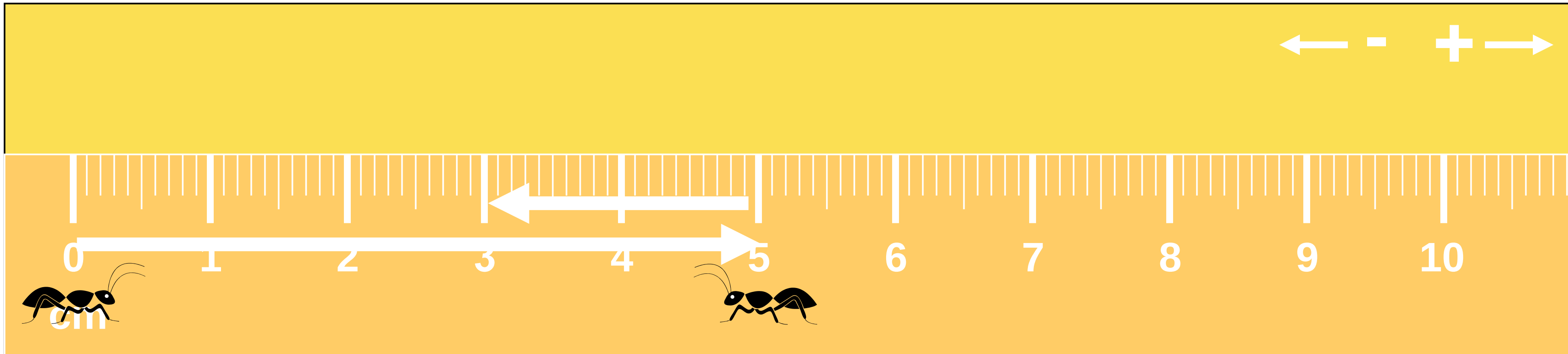
C) What is the speed?

D) What is the velocity?

Notice that the plus symbol is used for a displacement to the right, and a negative symbol is used for displacement to the left.

Example 2: Subtracting Vector

An ant walks 5.0 m [right] and turns to walk 2.0 m [Left] in 5.2 sec.



(A) What is the distance?

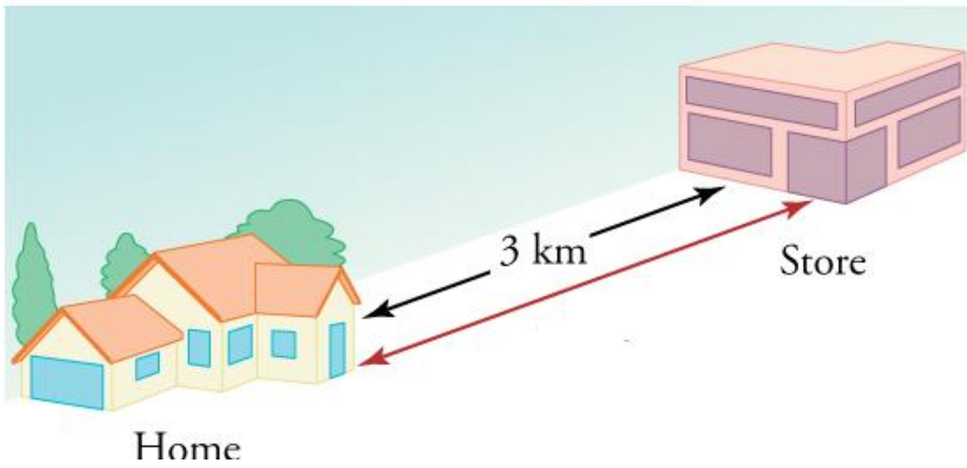
(B) What is the displacement?

(C) What is the speed?

(D) What is the velocity?

Example 3: Return Trip

It takes 30 minute for a round trip to the store which is 6 km away.



(A) What is the distance?

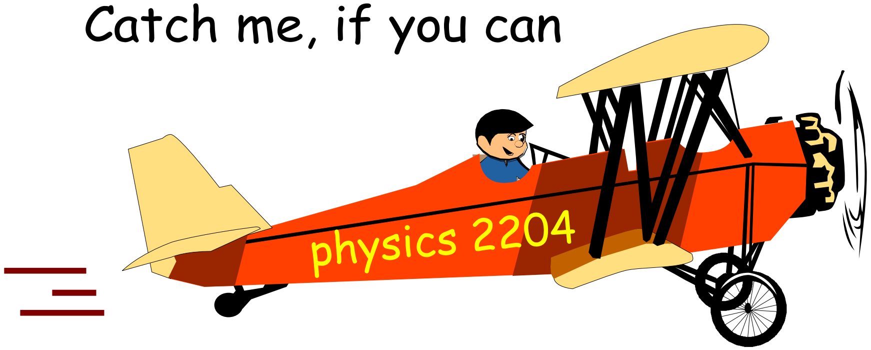
(B) What is the displacement?

(C) What is the speed?

(D) What is the velocity?

- **Section 7:**

Graphical Analysis of Non- Uniform Motion **(ACCELERATING**



ACCELERATION

- Acceleration is a vector quantity which is defined as "the rate at which an object changes its velocity." An object is accelerating if it is changing its velocity.

UNIFORM ACCELERATION

Accelerating Objects are Changing Their Velocity ...

... by a constant amount each second ...

Time (s)	Velocity (m/s)
0	0
1	4
2	8
3	12
4	16

...in which case, it is referred to as a constant acceleration.

... or by a changing amount each second ...

Time (s)	Velocity (m/s)
0	0
1	1
2	4
3	5
4	7

...in which case, it is referred to as a non-constant acceleration.

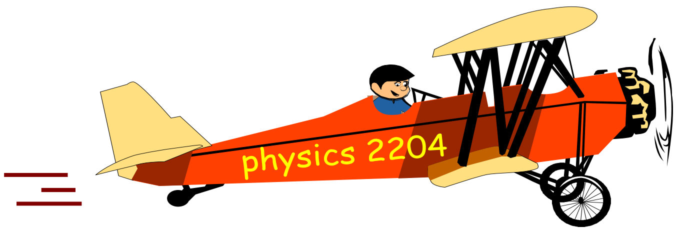
Uniformly acceleratedobject will change its velocity by the same amount each second. This is known as a uniform acceleration

Uniform acceleration should not be confused with an object with a **uniform velocity.**

Graphical Analysis of Uniformly Accelerated Motion

Data is collected as a plane travels down a runway for take-off and is summarized below:

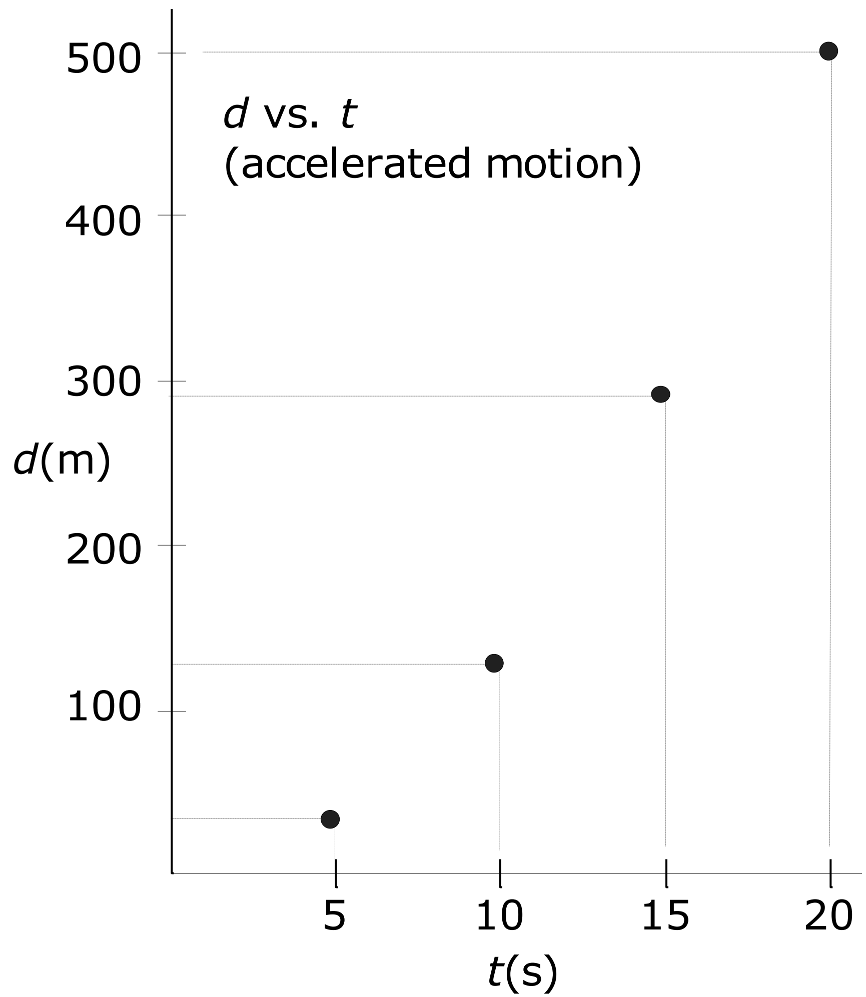
t(s)	*d*(m)
5	30
10	125
15	290
20	500



We will use the data to plot a *d*-*t* graph that shows how far down the runway the plane travels as the clock runs.

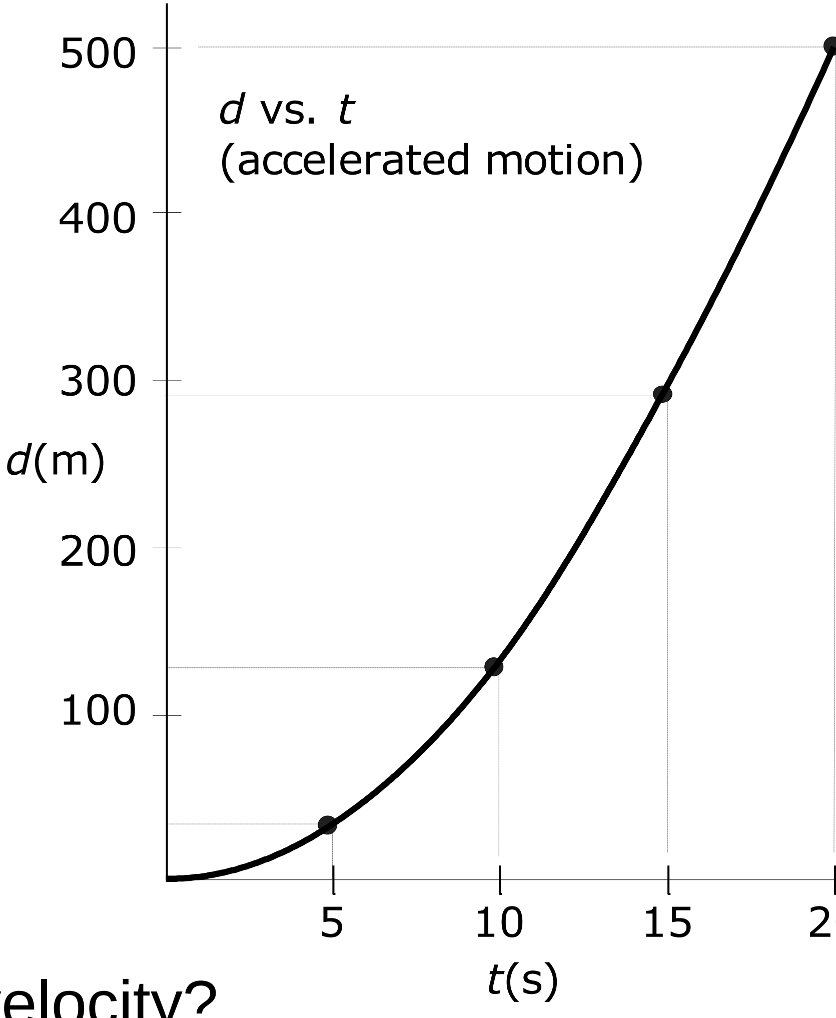
Graphical Analysis of Uniformly Accelerated Motion

t(s)	*d*(m)
5	30
10	125
15	290
20	500



Drawing a smooth line through the dots depicts the following graph.

The *d-t* graph for uniformly A**ccelerated** motion is definitely not the same as a d-t graph for **uniform** motion.



The d-t graph for uniformly accelerated motion is a curve known as a **parabola.**

Question:

How do we find the instantaneous velocity?

Answer:

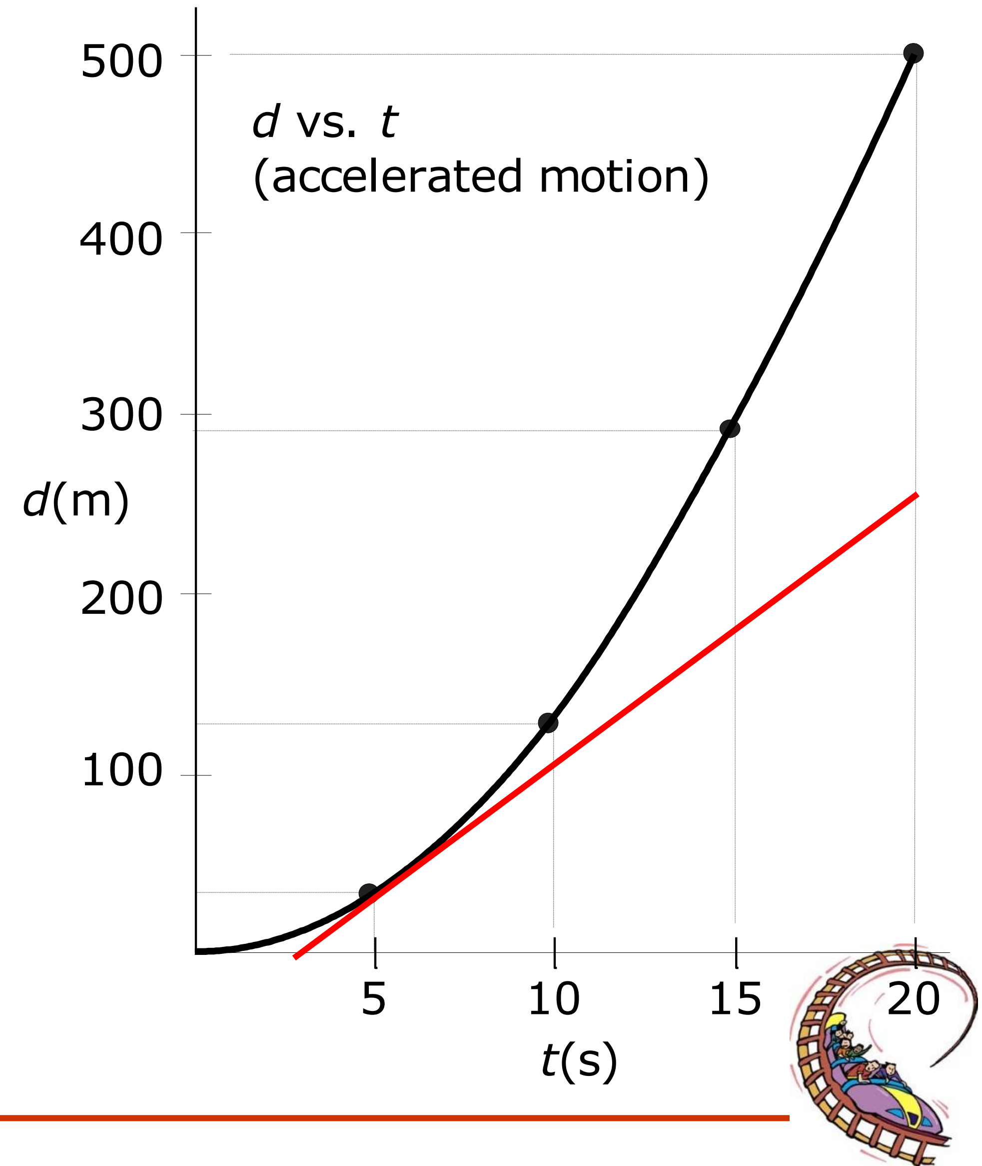
We use Tangents!

What is a Tangent?

Tangent is a straight line that touches a curve at only one point.

Each tangent on a curve has a unique slope, which represents the velocity at that instant.

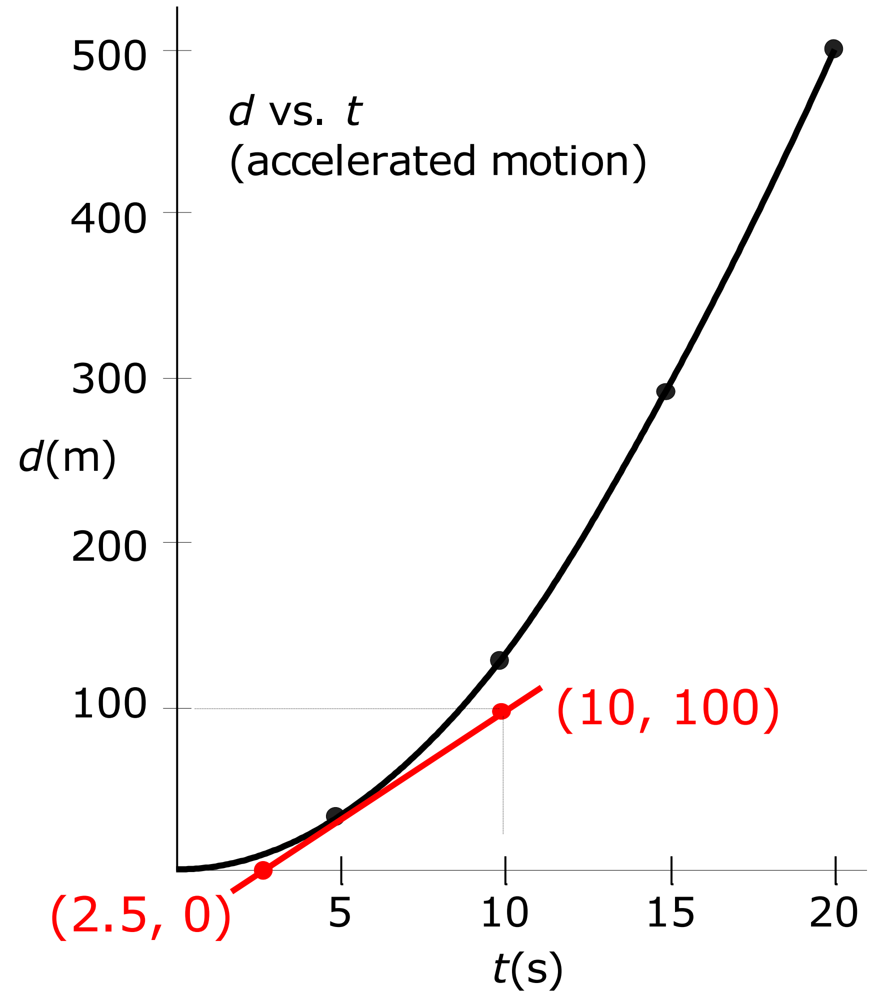
In order for the object to be at that position, at that time, it must have an *instantaneous velocity equal to the slope of the tangent* at that point



Choose two points on the tangent and find the slope of the **tangent.**

The two points shown here are (10,100) and (2.5, 0).

$$v_5 = \text{slope}$$
$$= \frac{100\,\text{m} - 0\,\text{m}}{10\,\text{s} - 2.5\,\text{s}}$$
$$= \frac{100\,\text{m}}{7.5\,\text{s}} = 13\,\text{m/s}$$



The speed at 5 s is 13 m/s

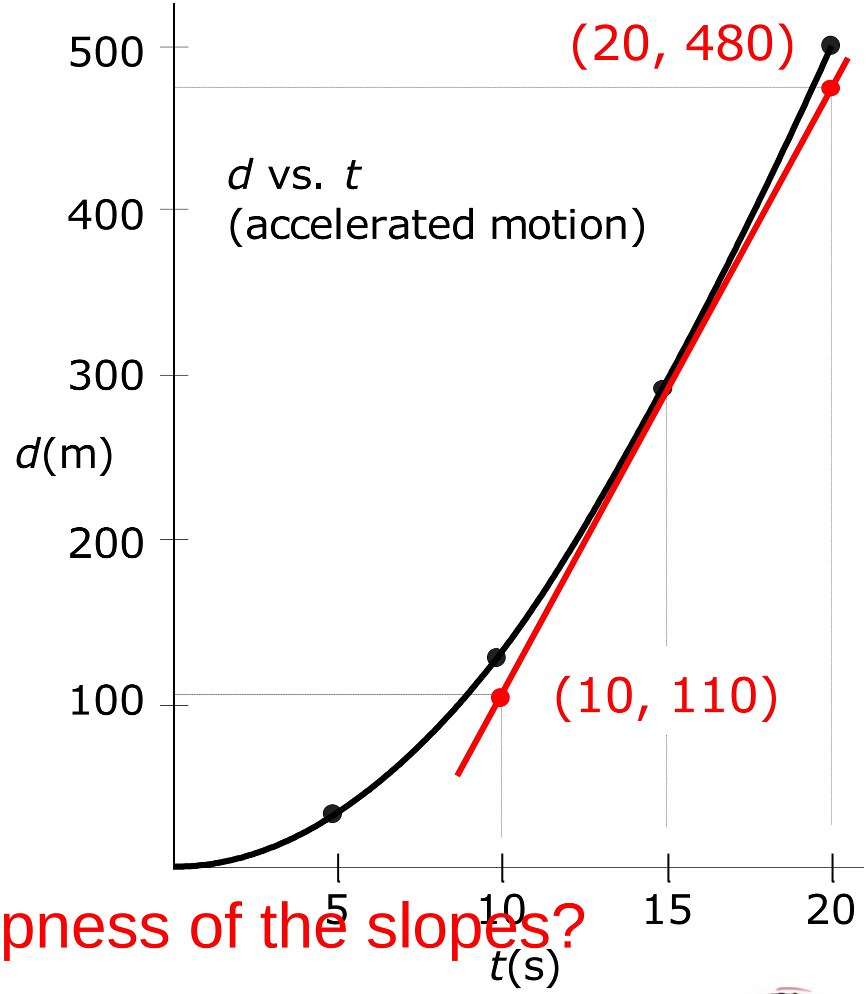
Choose two points on the tangent and find the slope of the tangent.

The two points shown here are (20, 480) and (10, 110).

$$v_{15} = \text{slope}$$

$$= \frac{480\,\text{m} - 110\,\text{m}}{20\,\text{s} - 10\,\text{s}}$$

$$= \frac{370\,\text{m}}{10\,\text{s}} = 37\,\text{m/s}$$



The speed at 15 s is 37 m/s

Question:

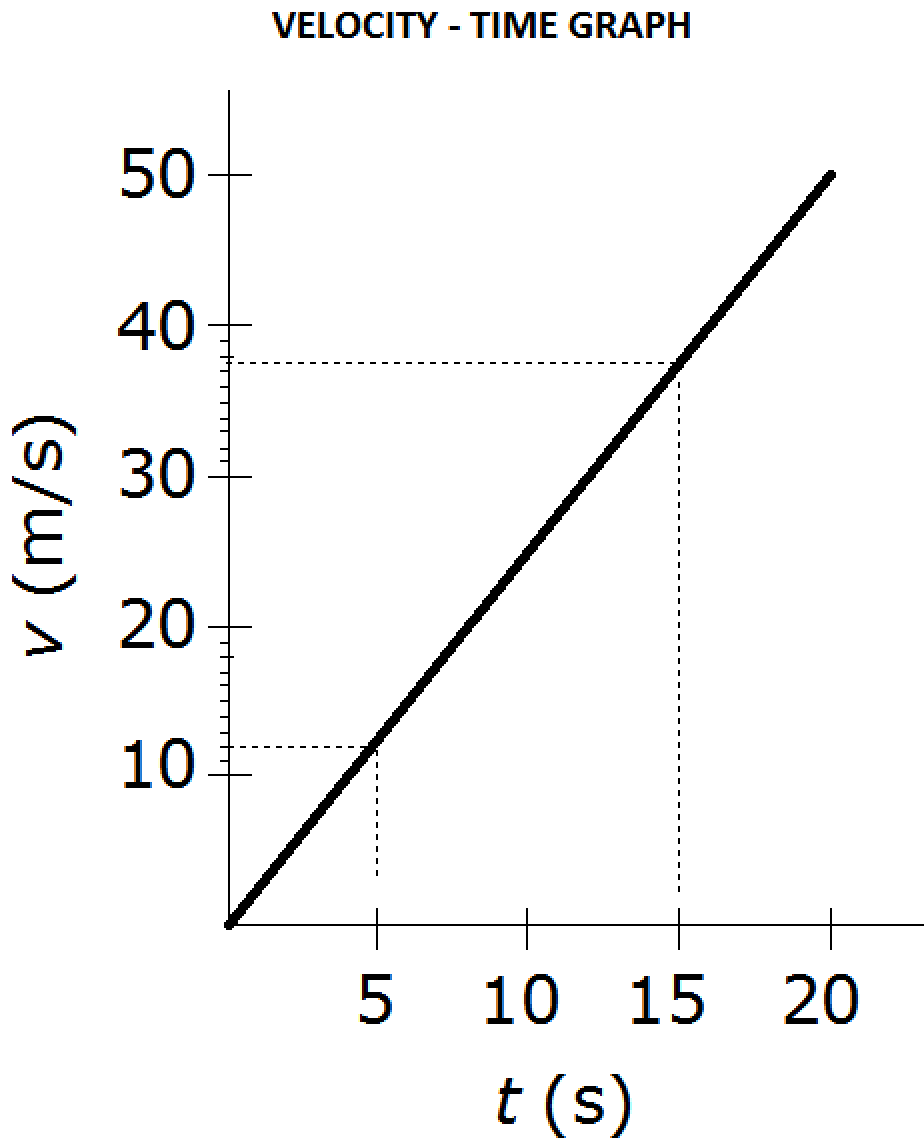
What do you notice about the steepness of the slopes?

Answer:

The tangents are getting steeper because the plane is going faster.

Finally we can use these tangential speeds to plot a v-t graph.

The tangential speeds were 13 m/s at 5 sec, and 37 m/s at 15 sec.

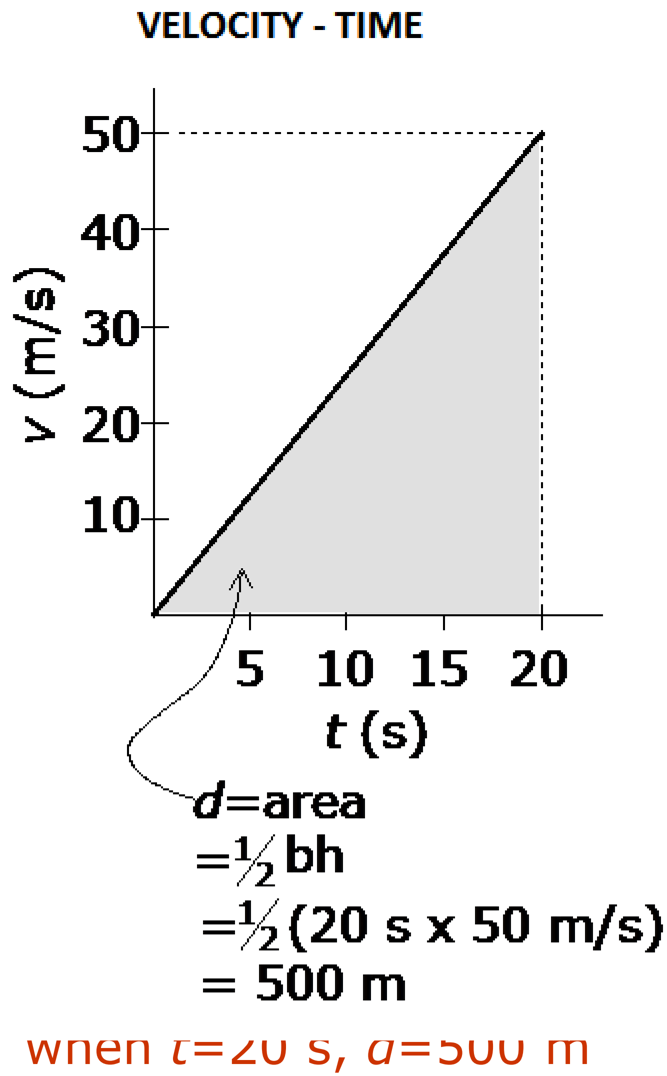


Question:

What information can we get from a Velocity – time ?

Area under a Velocity Time Graph

The **area** under a velocity-time graph is the **displacement**.



Slope of a Velocity –Time Graph

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

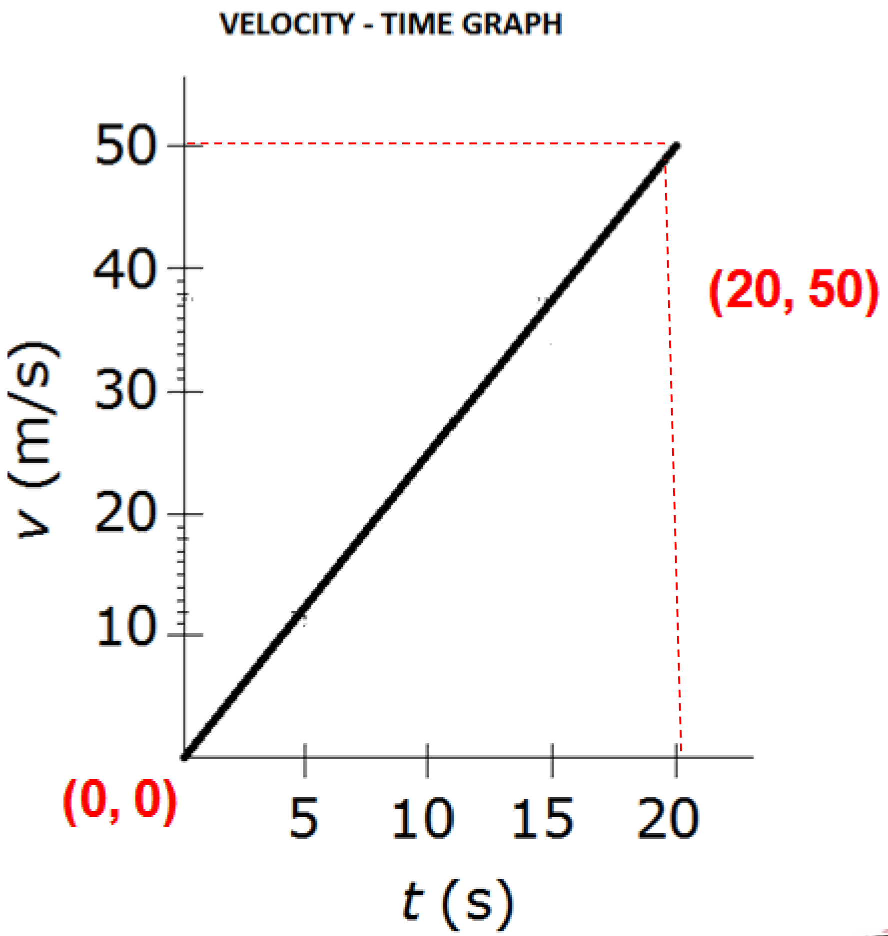
$$Slope = \frac{y_2 - y_1}{x_2 - x_1}$$

$$= \frac{(50m/s) - (0m/s)}{(20s) - (0s)}$$

$$= \frac{(50m/s)}{20s}$$

$$= 2.5m/s$$

$$= 2.5m/s^2$$

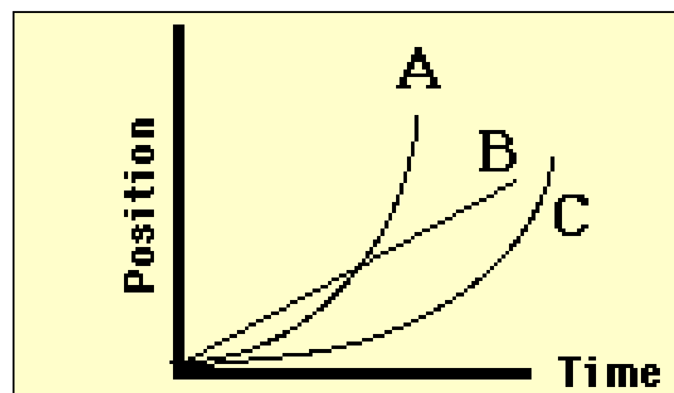


Check your Understanding…

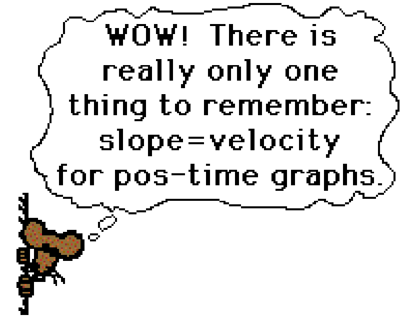
- Observe the animation of the three cars below. Which car or cars (red, green, and/or blue) are undergoing an acceleration?

Which car (red, green, or blue) experiences the greatest acceleration?

Consider the position-time graph at the right. Match the appropriate line to the particular color of car.



Summary



1. Displacement-time graph of uniform acceleration parabola.

2. Slope of tangent on a displacement-time graph is instantaneous velocities

3. Greater the slope of the tangent on a displacement-time graph the greater the instantaneous velocities

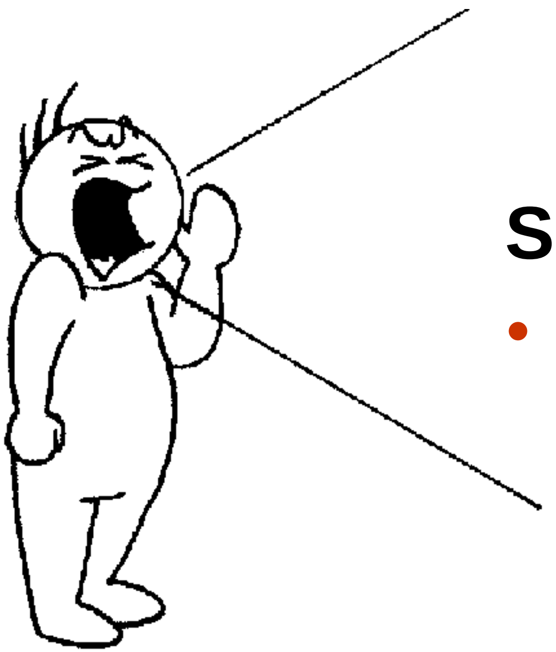
4. Velocity-time graph of uniform acceleration is a linear line.

5. Area under a velocity-time graph is the displacement of the object.

6. Slope of a velocity-time graph is the acceleration of the object.

CORE LAB 2

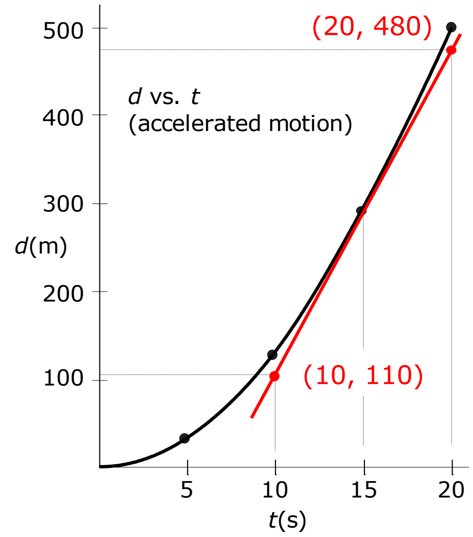
- *Acceleration due to Gravity*



Section 8

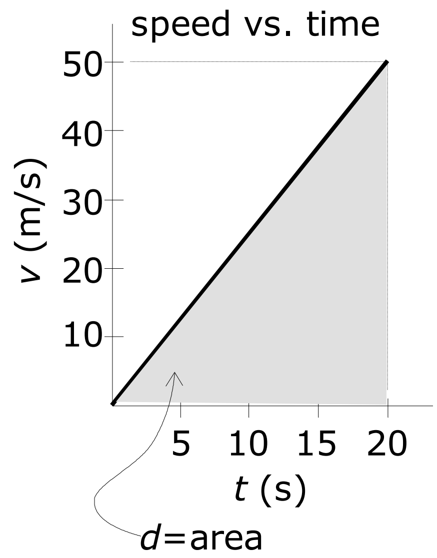
- ANALYZING MOTION GRAPHS

Review



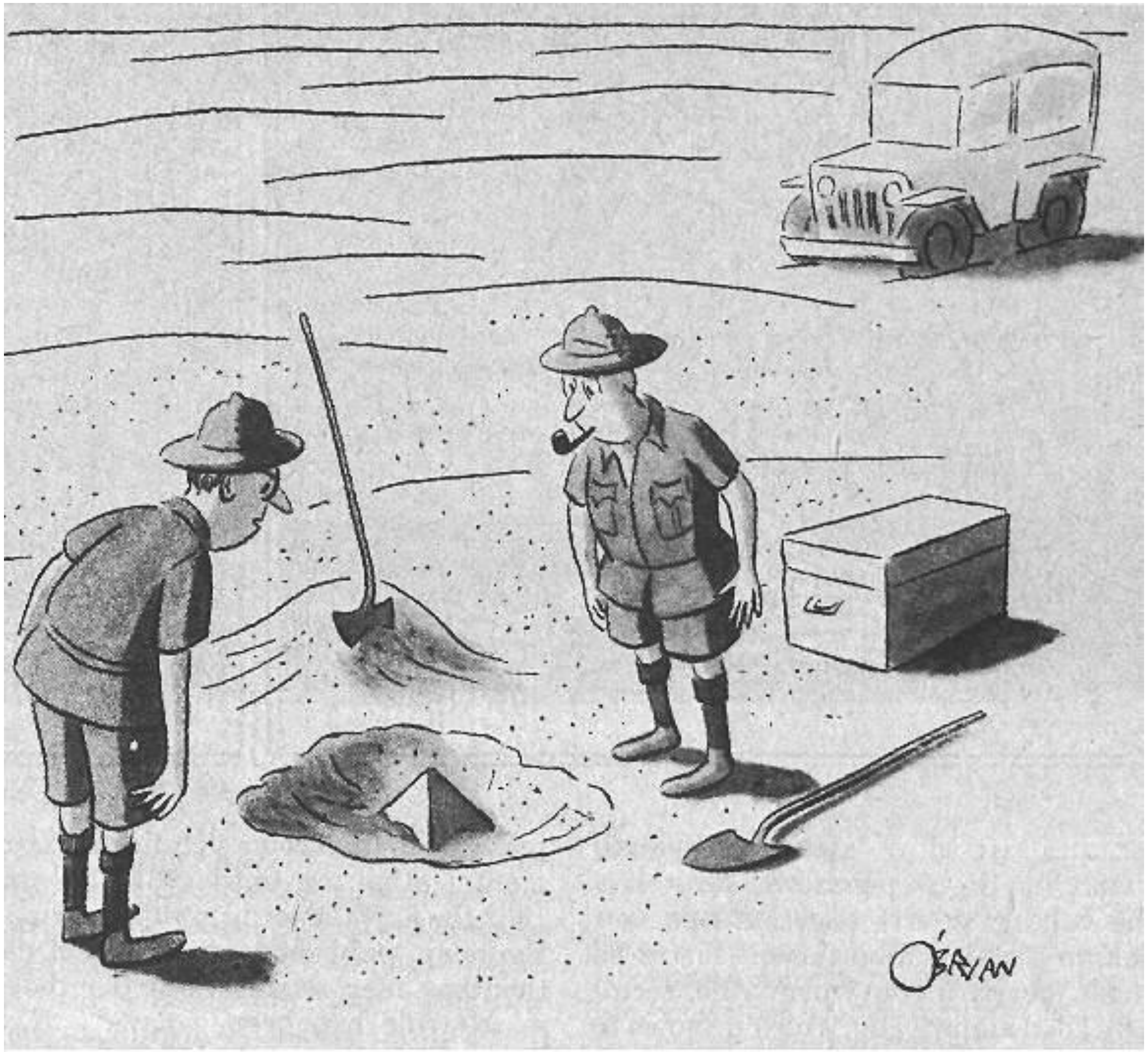
For graphs of Displacement vs. time

- the slope represents the velocity.
- the slope of a tangent drawn at any point represents the instantaneous velocity



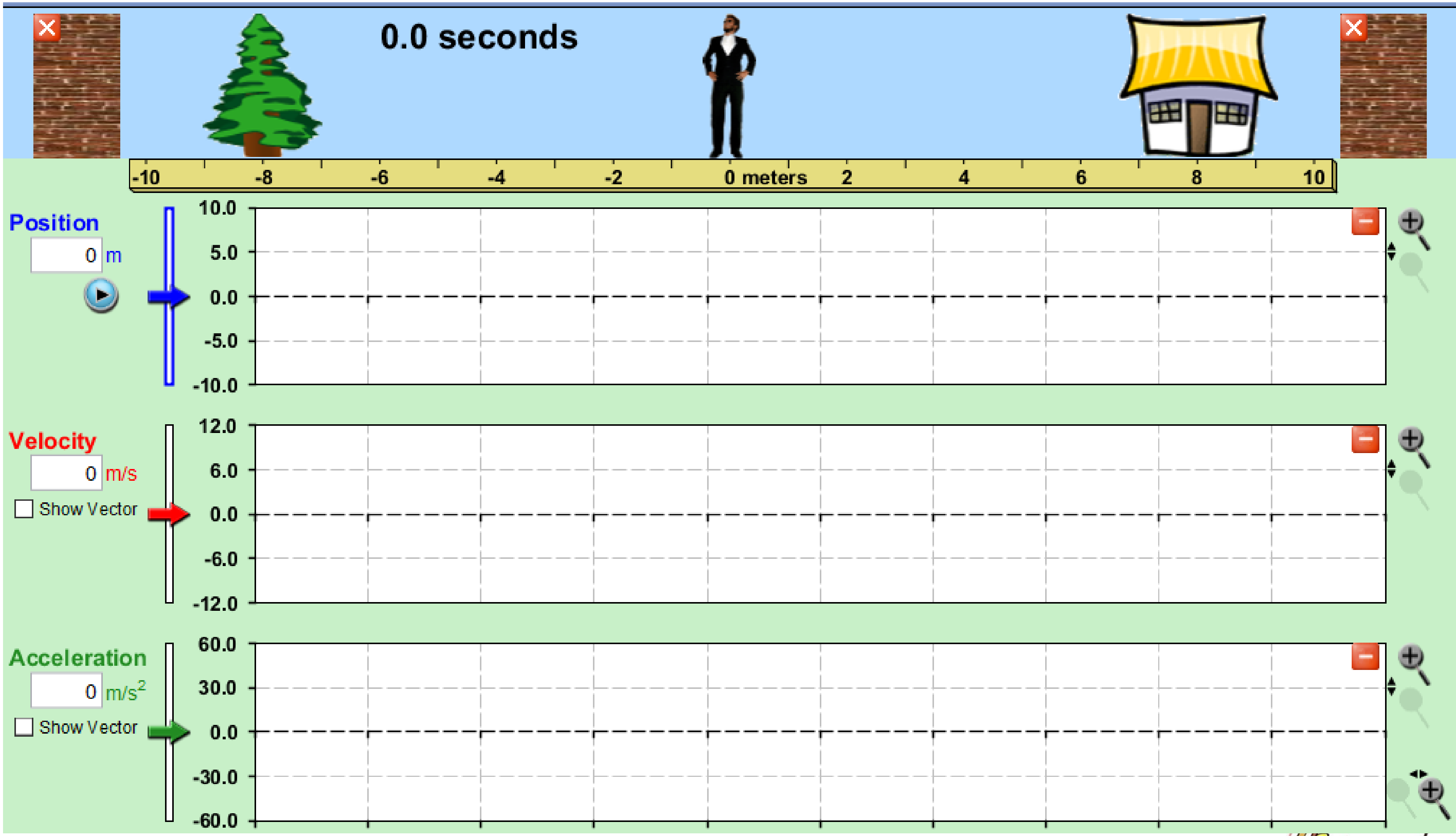
For graphs of Velocity vs. time

- the slope represents the acceleration.
- the area under any portion of the graph represents the net displacement.

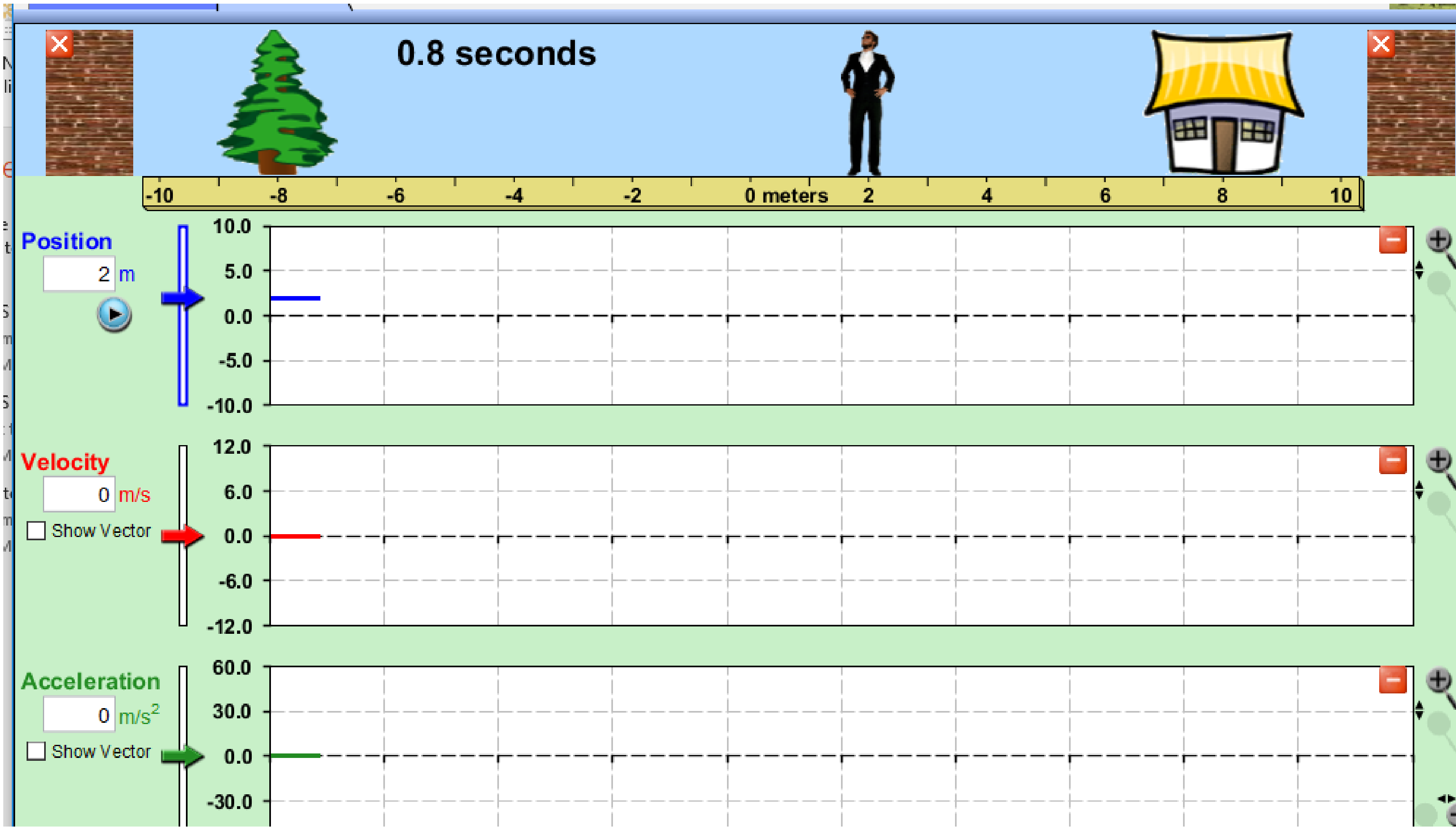


"This could be the discovery of the century. Depending, of course, on how far down it goes."

In this section we will be interpreting a graphs for a variety of motion using Phets “Moving Man”

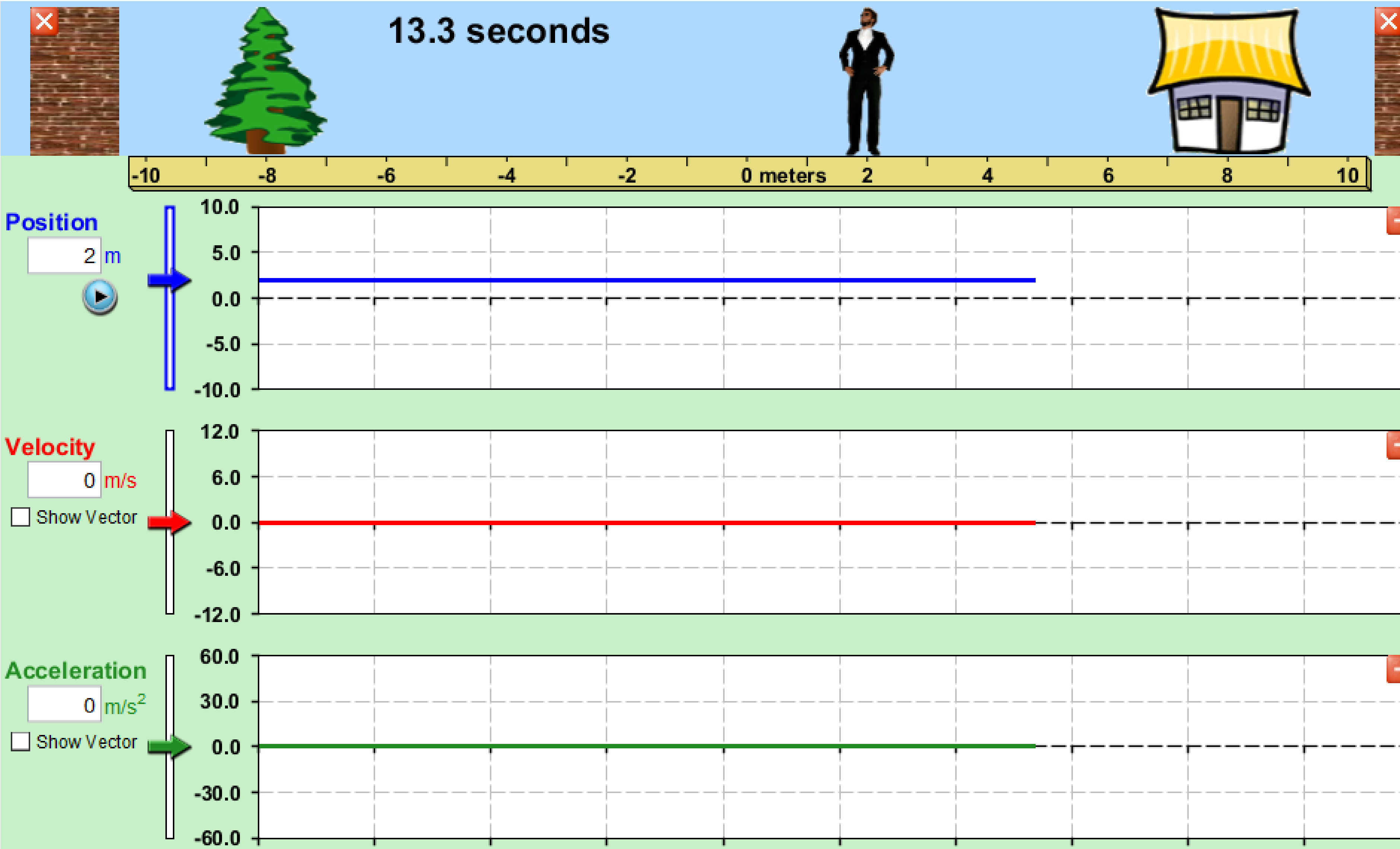


Row 1



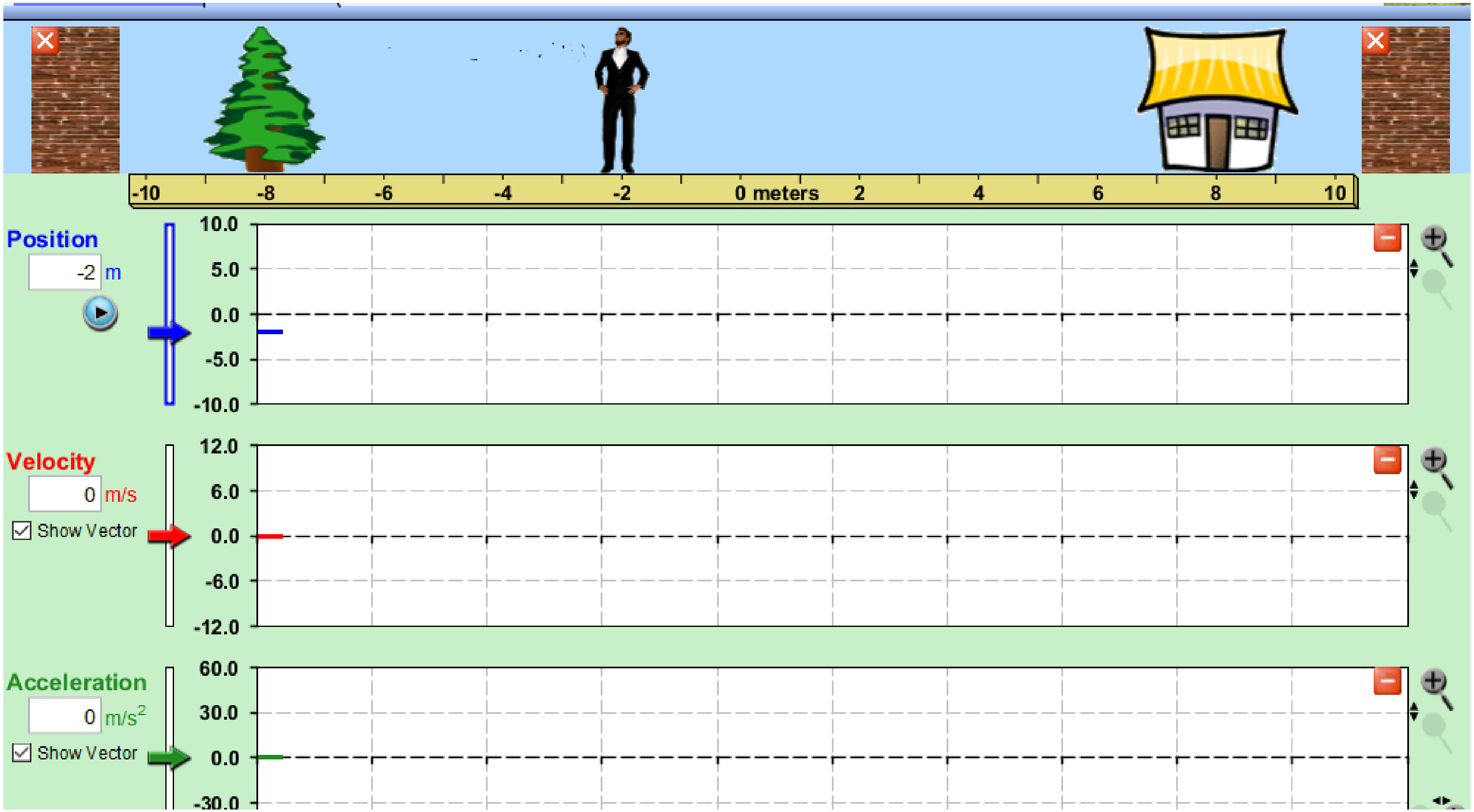
Place the person at 2m right and hit play

Fill in the first column of your table



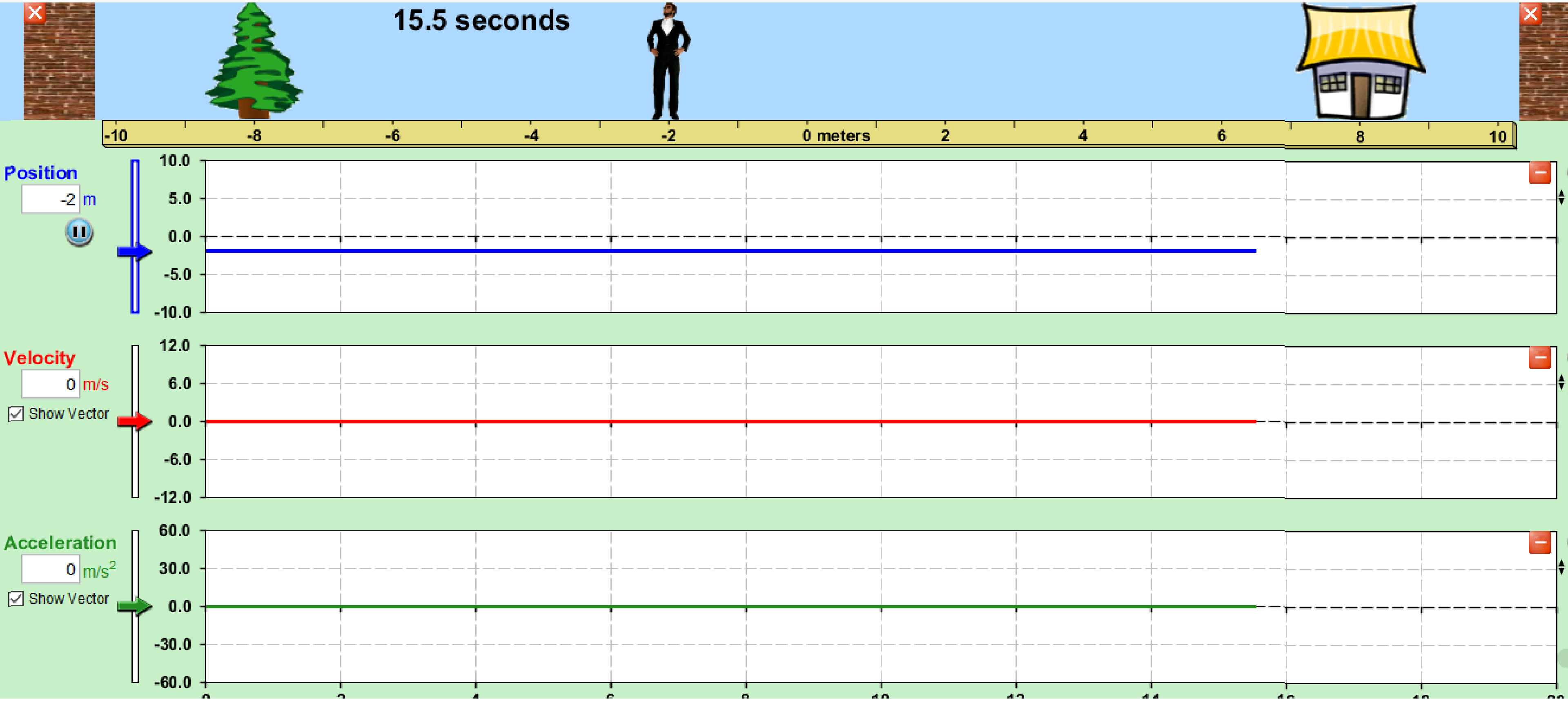
Try difference positive positions but keep velocity and acceleration set to zero

Row 2



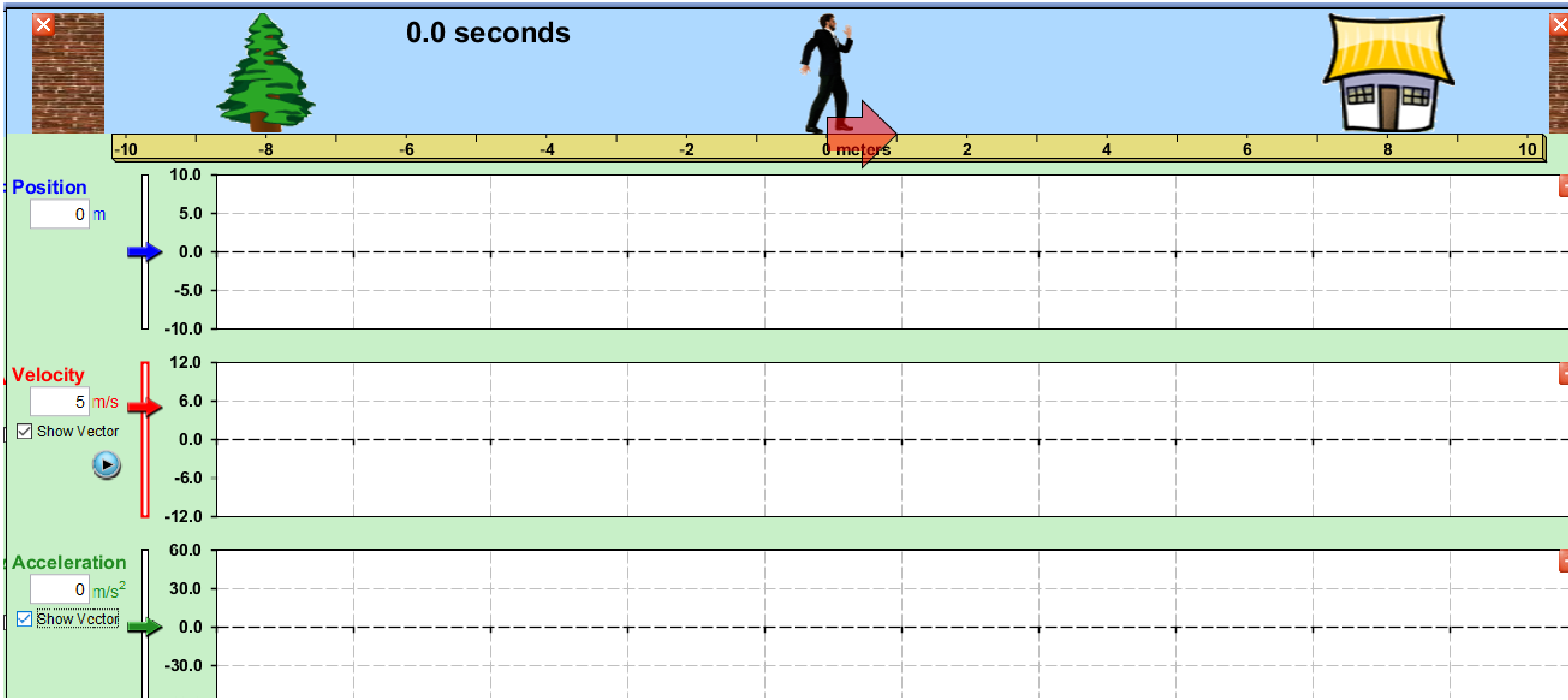
Place the person at -2m right and hit play

Fill in the second column of your table



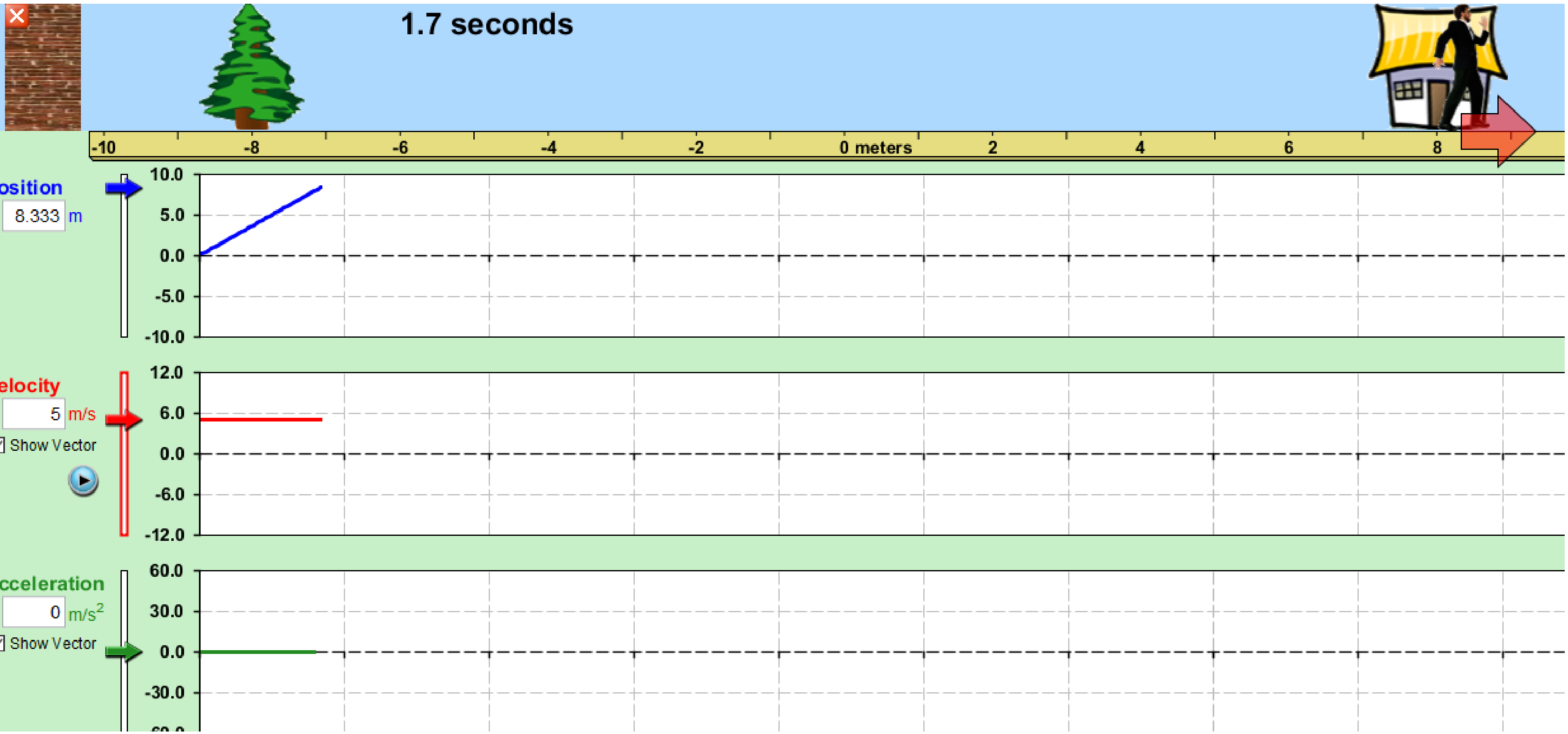
Try different negative positions but keep velocity and acceleration set to zero

Row 3



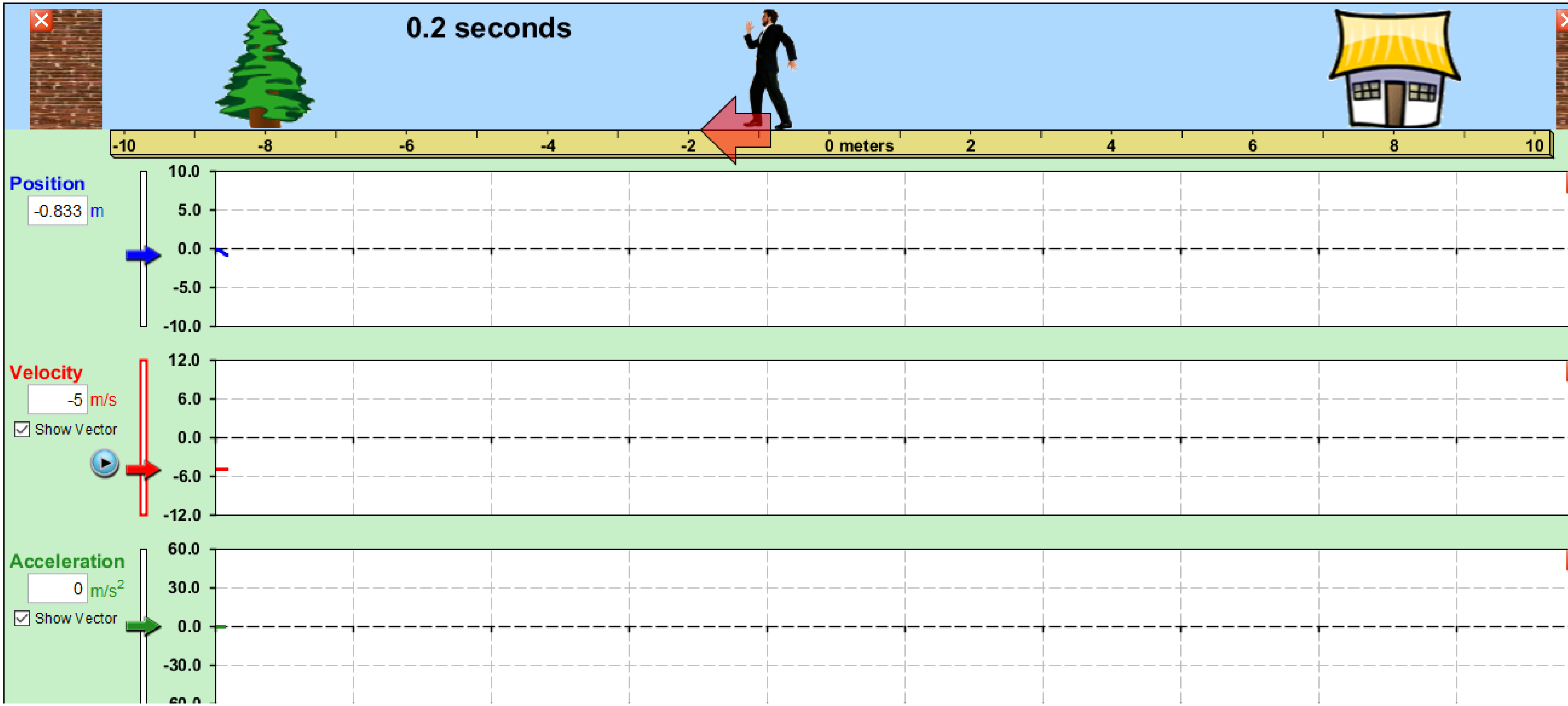
0.0 seconds
-10
-8
-6
-4
-2
0 meters
2
4
6
8
10
Position
0 m
10.0
5.0
0.0
-5.0
-10.0
Velocity
5 m/s
Show Vector
12.0
6.0
0.0
-6.0
-12.0
Acceleration
0 m/s2
Show Vector
60.0
30.0
0.0
-30.0

Fill in the third column of your table

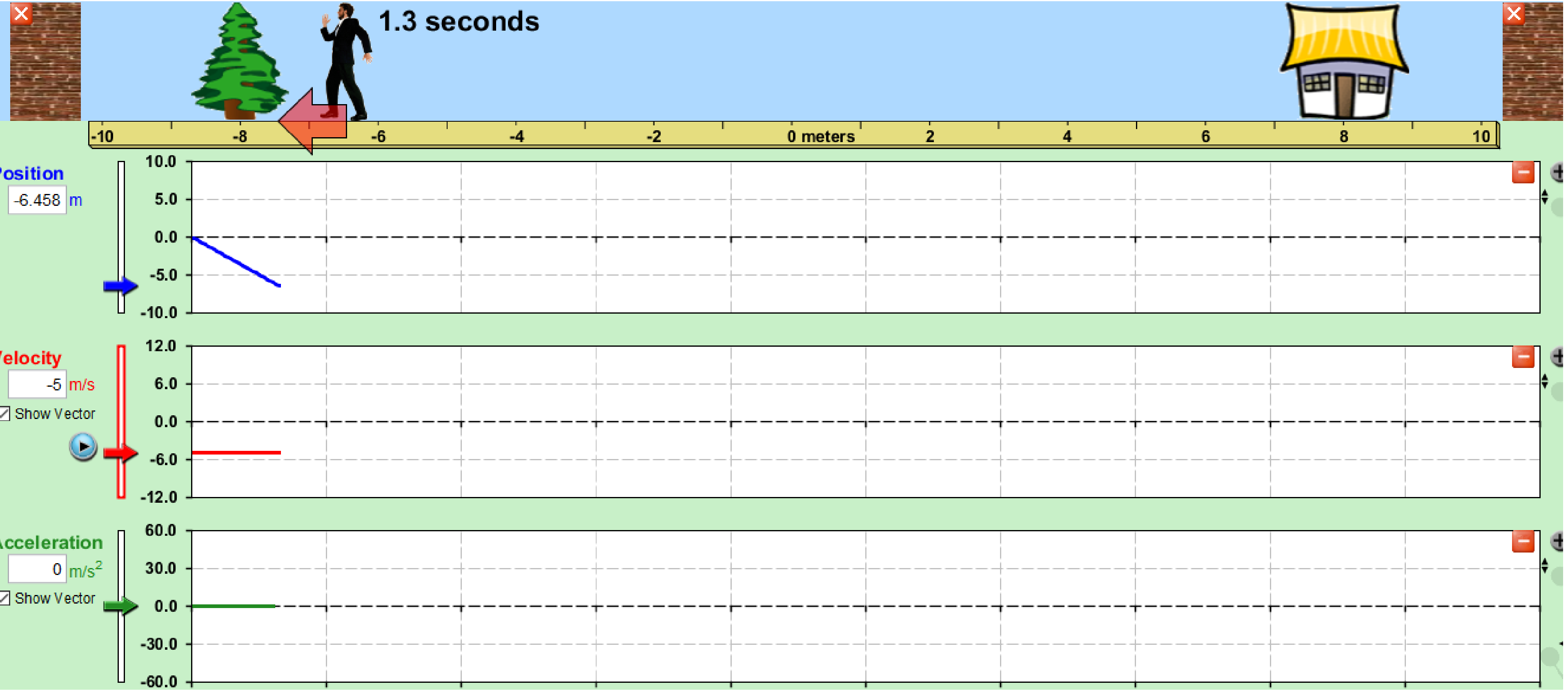


Try different positions, both positive and negative but always keep your velocity positive and your acceleration equal to zero

Row 4

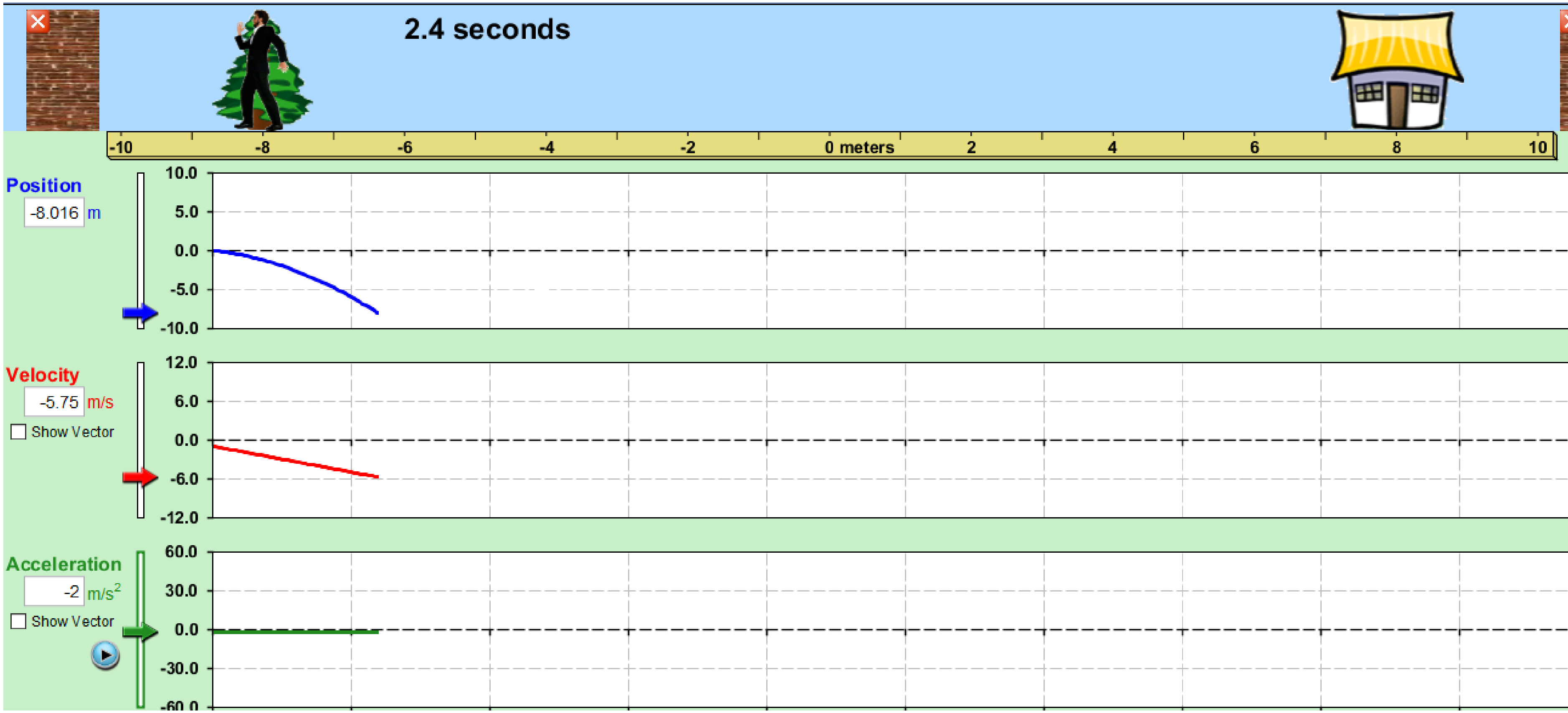

0.2 seconds
-10
-8
-6
-4
-2
0 meters
2
4
6
8
10
Position
-0.833 m
10.0
5.0
0.0
-5.0
-10.0
Velocity
-5 m/s
Show Vector
12.0
6.0
0.0
-6.0
-12.0
Acceleration
0 m/s2
Show Vector
60.0
30.0
0.0
-30.0

Fill in the fourth row of the table



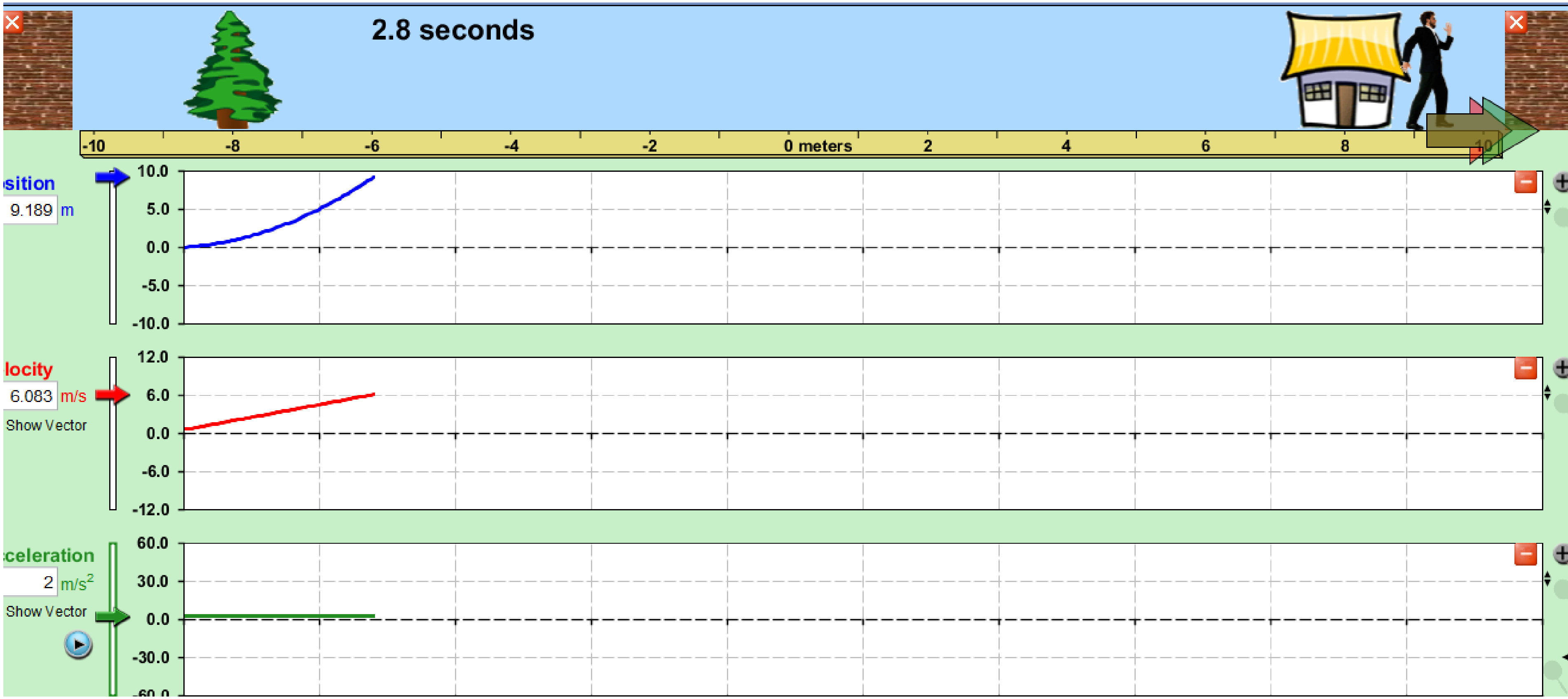
Try different positions, both positive and negative but always keep your velocity negative and your acceleration equal to zero

Row 5



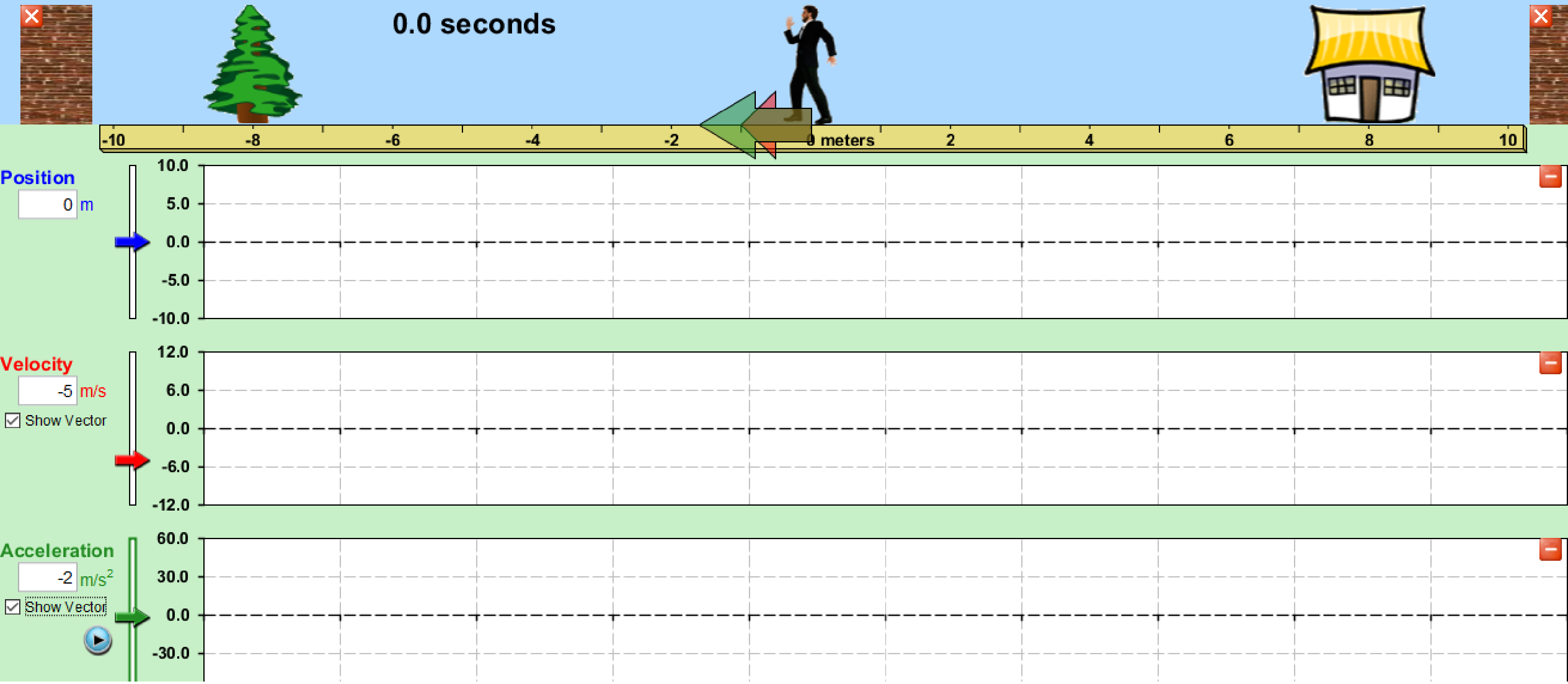
2.4 seconds
-10
-8
-6
-4
-2
0 meters
2
4
6
8
10
Position
-8.016 m
10.0
5.0
0.0
-5.0
-10.0
Velocity
-5.75 m/s
Show Vector
12.0
6.0
0.0
-6.0
-12.0
Acceleration
-2 m/s2
Show Vector
60.0
30.0
0.0
-30.0
-60.0

Fill in the fifth row of your table

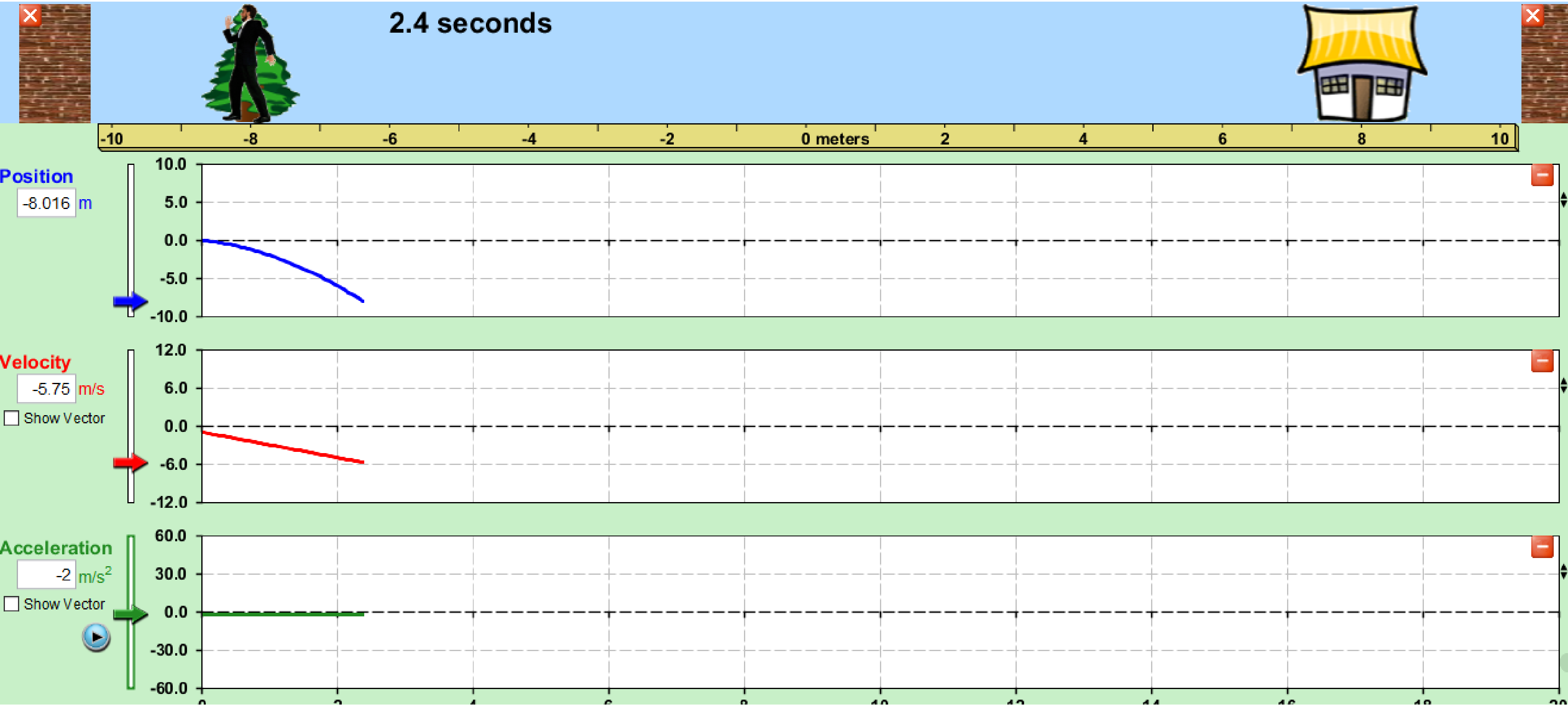


Try different positions, both positive and negative but always keep your velocity positive and acceleration positive

Row 6

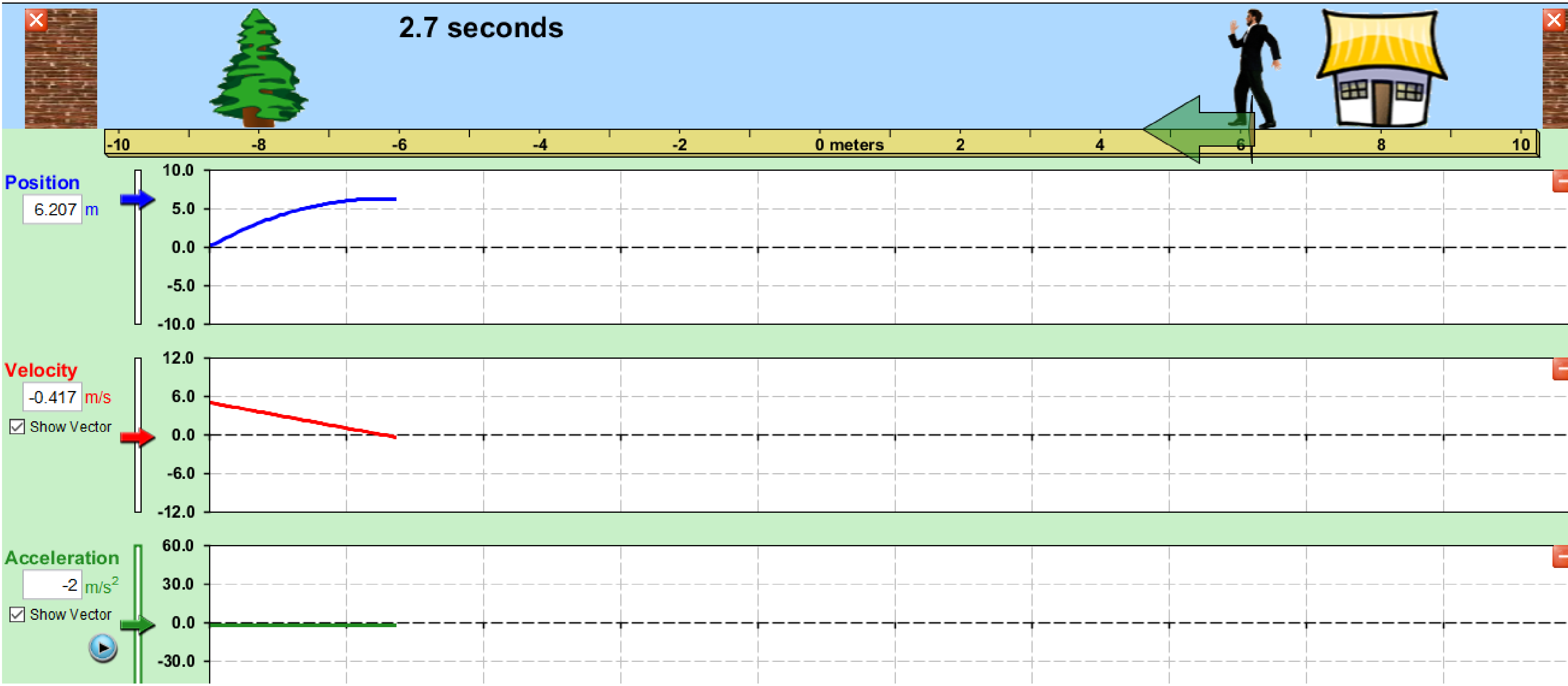

0.0 seconds
-10
-8
-6
-4
-2
0 meters
2
4
6
8
10
Position
0 m
10.0
5.0
0.0
-5.0
-10.0
Velocity
-5 m/s
Show Vector
12.0
6.0
0.0
-6.0
-12.0
Acceleration
-2 m/s2
Show Vector
60.0
30.0
0.0
-30.0

Fill in the sixth row of your table



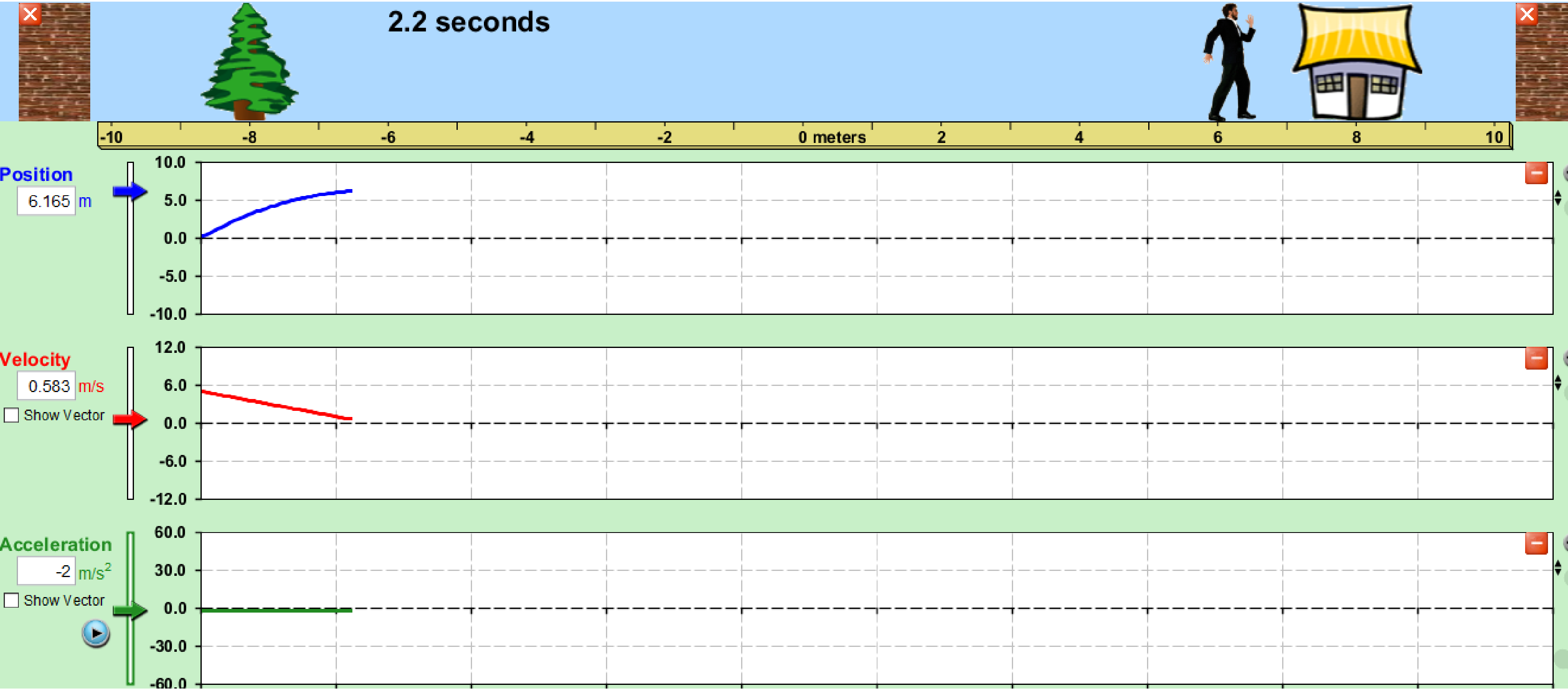
Try different positions, both positive and negative. However, always keep your velocity negative and acceleration negative

Row 7



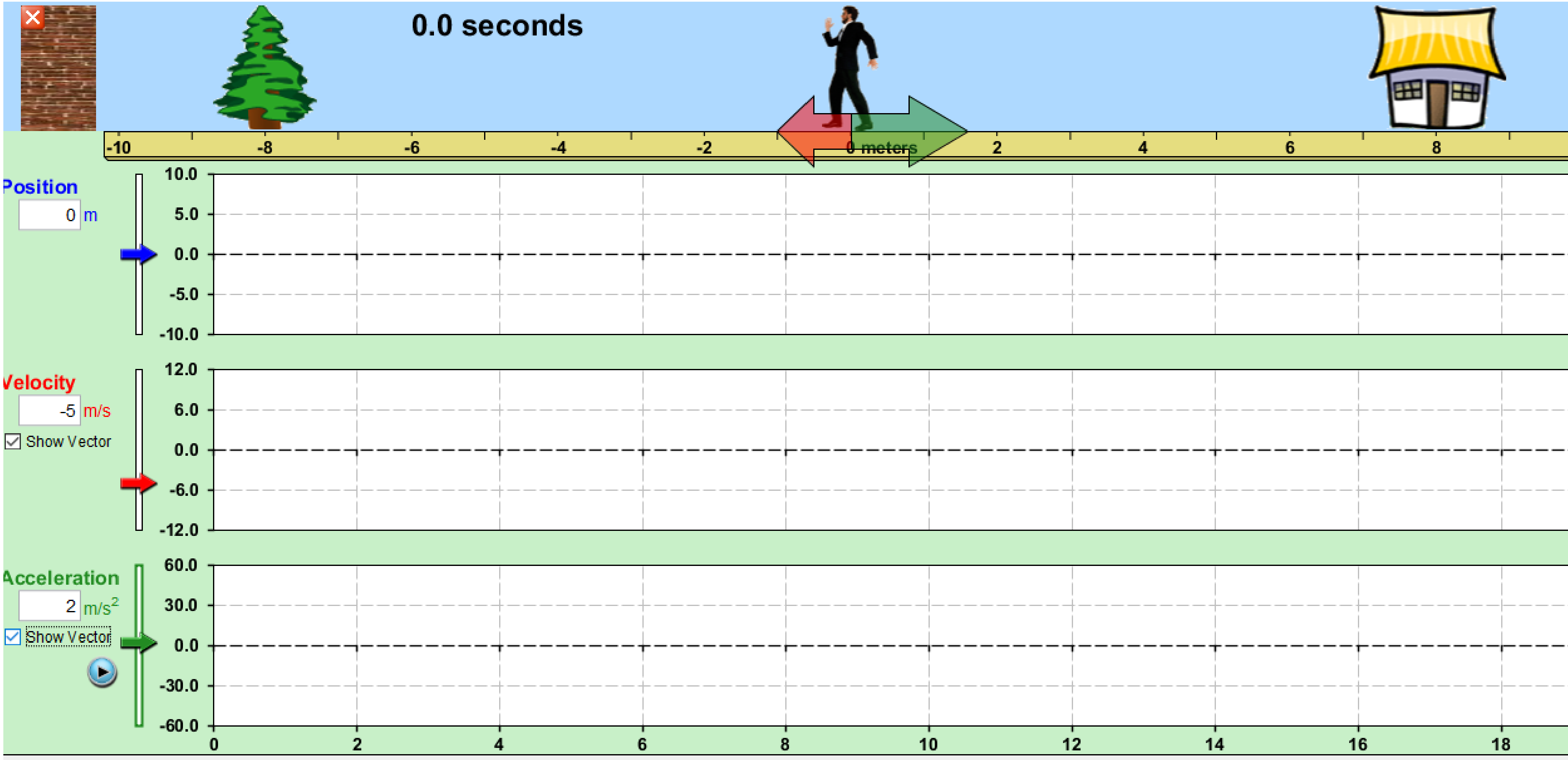
2.7 seconds
-10 -8 -6 -4 -2 0 meters 2 4 6 8 10
Position
6.207 m
10.0
5.0
0.0
-5.0
-10.0
Velocity
-0.417 m/s
Show Vector
12.0
6.0
0.0
-6.0
-12.0
Acceleration
-2 m/s2
Show Vector
60.0
30.0
0.0
-30.0

Fill in the seventh row of your table



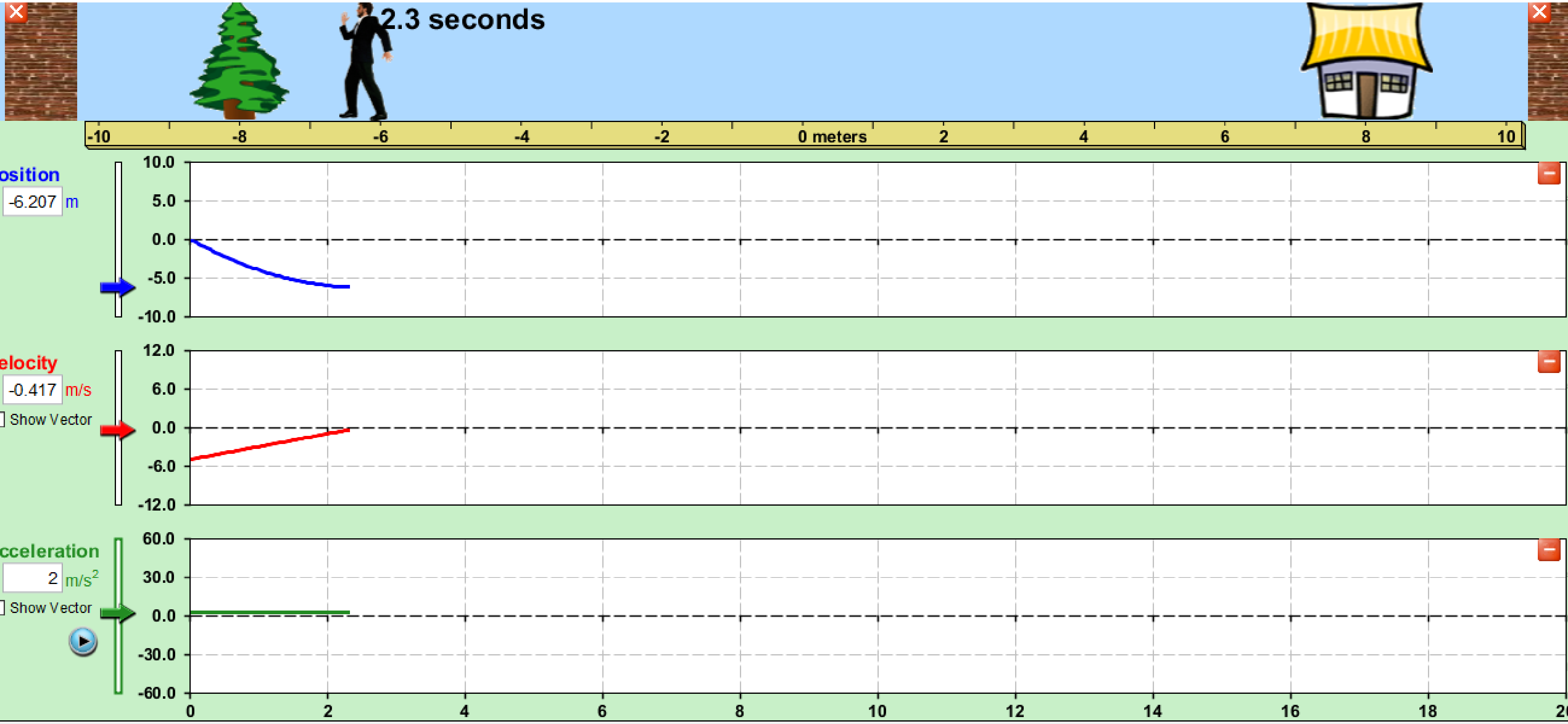
Try different positions, both positive and negative. However, always keep your velocity positive and acceleration negative

Row 8



0.0 seconds
-10
-8
-6
-4
-2
0 meters
2
4
6
8
Position
0 m
10.0
5.0
0.0
-5.0
-10.0
Velocity
-5 m/s
Show Vector
12.0
6.0
0.0
-6.0
-12.0
Acceleration
2 m/s2
Show Vector
60.0
30.0
0.0
-30.0
-60.0
0
2
4
6
8
10
12
14
16
18

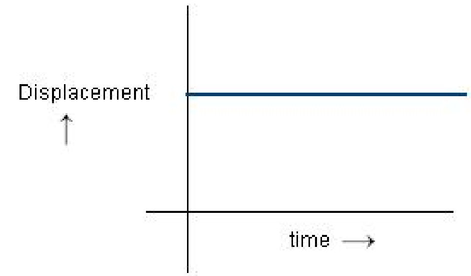
Fill in the eight row of your table



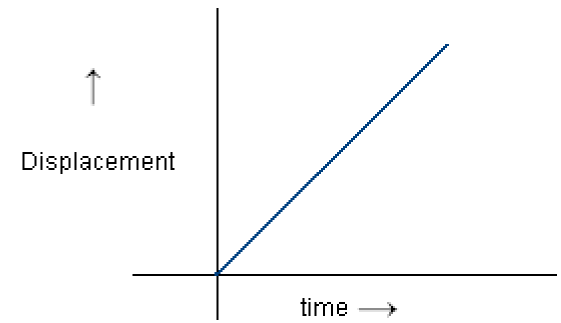
Try different positions, both positive and negative. However, always keep your velocity negative and acceleration positive

What did you learn about displacement time graphs?

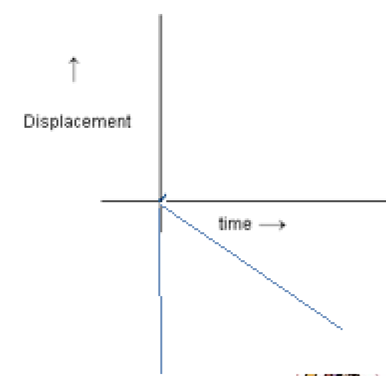
- For a stationary body, slope of the line is zero that indicates the velocity of the body is zero.



- For a body moving with constant velocity, the displacement time graph is a straight line inclined at any angle from the time axis.

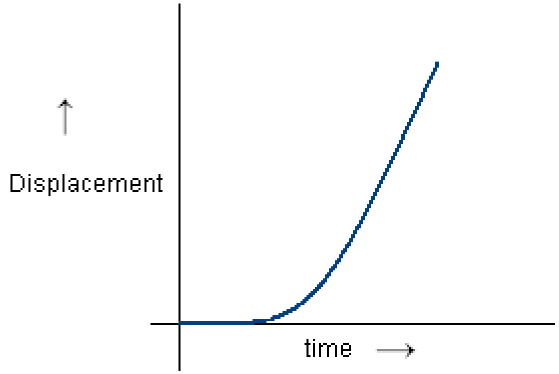


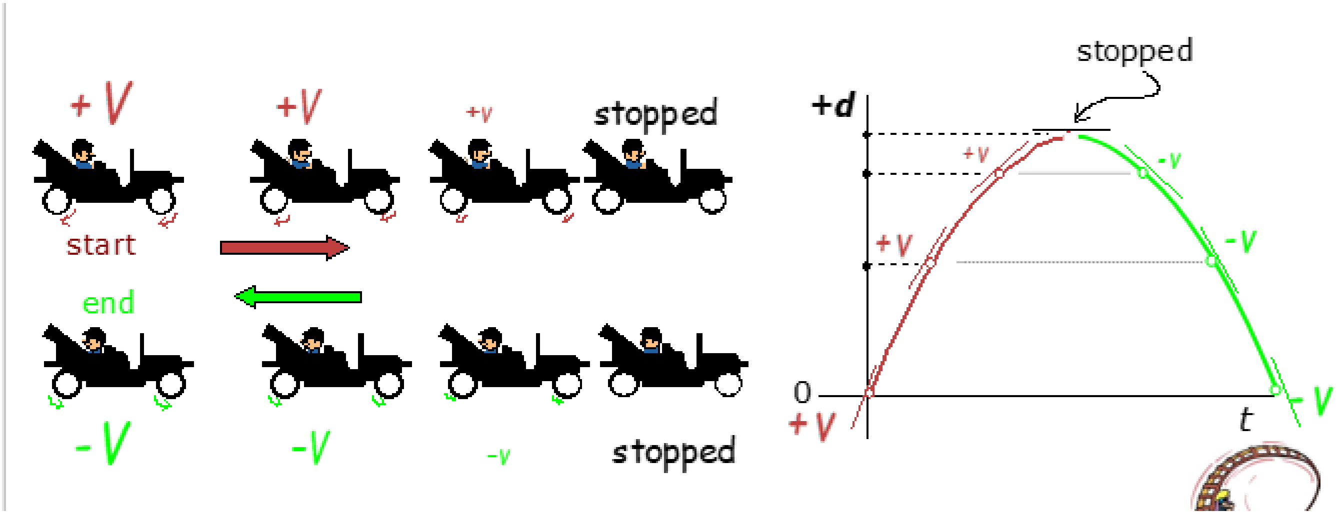
- The positive or negative indicates the direction



- Y intercept tell you how far you started from the reference point

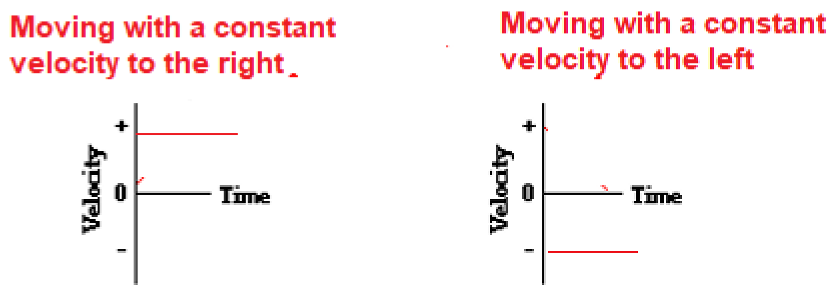
- For a body moving with non-uniform velocity the displacement time graph is a curved line tells that the velocity is increasing or decreasing . Imagining tangents on the line will help determine the motion



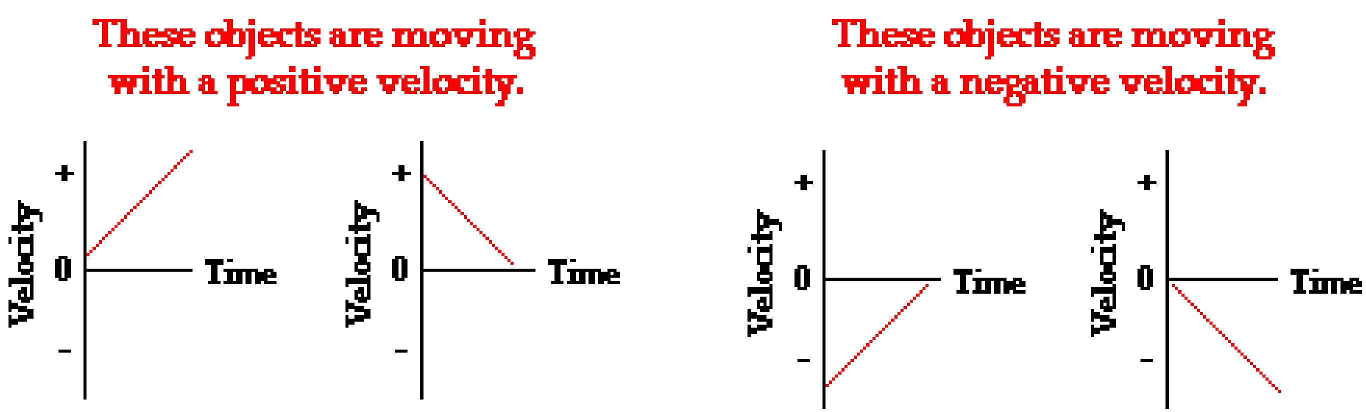


What did you learn about a velocity time Graph?

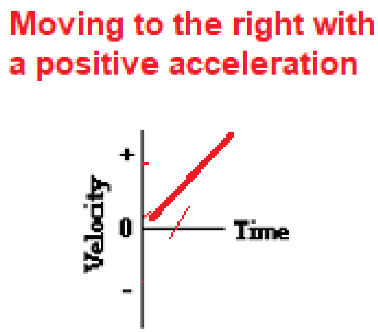
A slope of zero represents an object moving with a constant velocity.

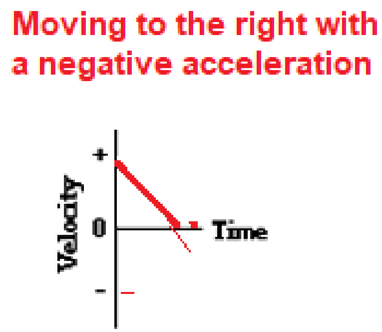


A positive velocity means the object is moving in the positive direction; and a negative velocity means the object is moving in the negative direction.

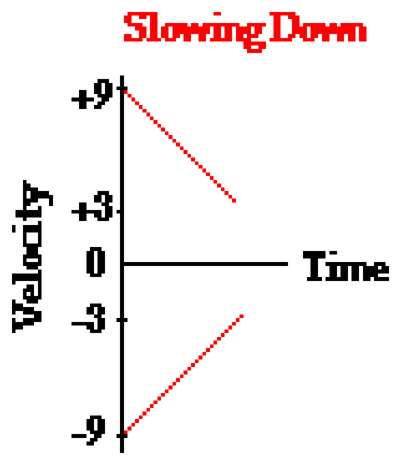


- Slope of a velocity- time graph represents acceleration



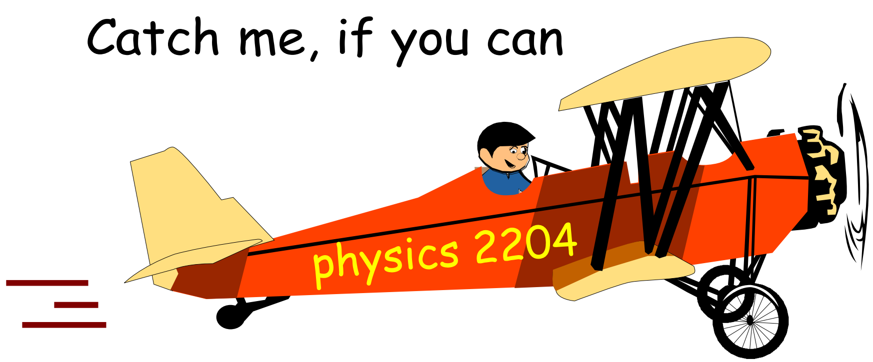


- When objects are slowing down, the velocity and acceleration are always always opposites in sign



- **Section 9:**

Part 1: Problem Solving Involving Acceleration



Calculating Acceleration

Remember Science 1206:

- **Acceleration can be found using the following formula:**

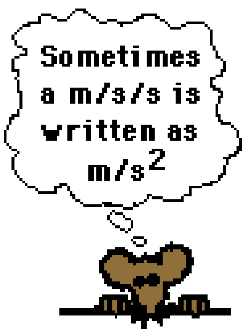
$$\text{Ave. acceleration} = \frac{\Delta \text{velocity}}{\text{time}} = \frac{v_f - v_i}{t}$$

a = acceleration

V_1 = initial velocity

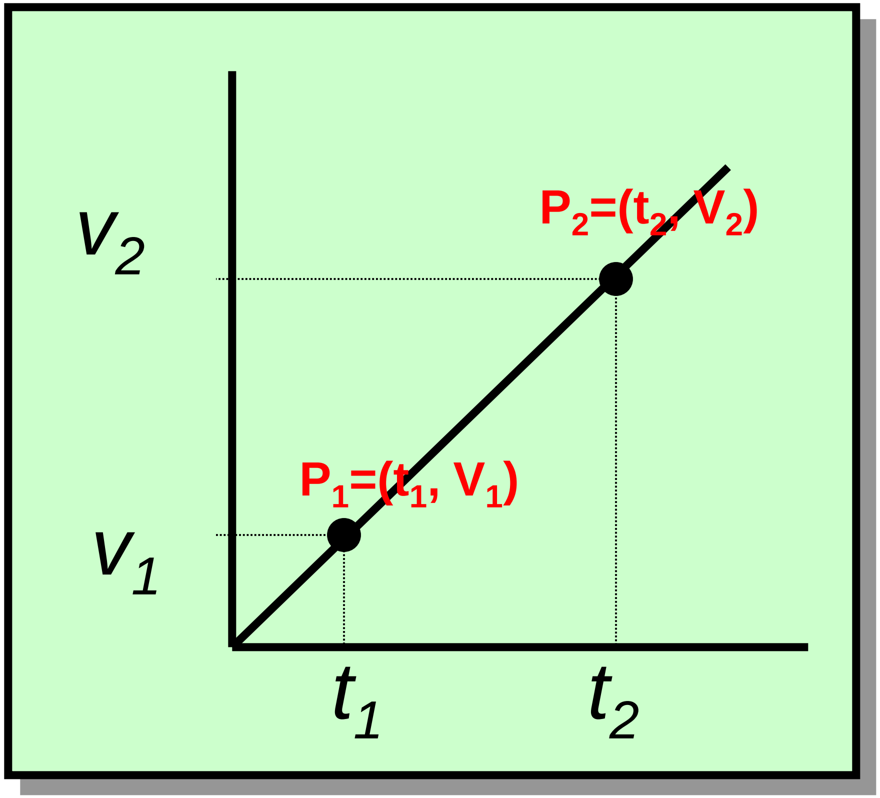
V_2 = final velocity

t= change in time



Note: The units for acceleration is m/s/s or m/s^2

Where did this formula come from?



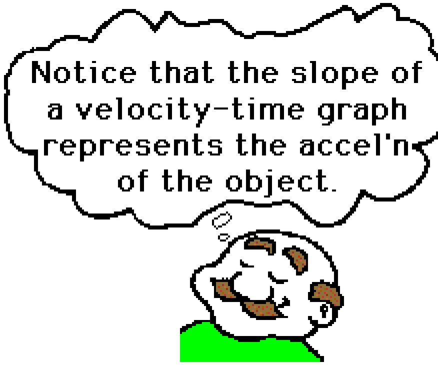
The **slope** of a line on a V-T graph provides the **acceleration** of the object

Therefore, pick any two point on the graph and calculate the slope.

$$Slope = \frac{y_2 - y_1}{x_2 - x_1}$$

$$Slope = \frac{v_2 - v_1}{t_2 - t_1}$$

$$\vec{a} = \frac{v_2 - v_1}{t_2 - t_1}$$



How can you determine if your acceleration is to high?

Example 1: A skier is moving at 1.8 m/s (down) near the top of a hill. 4.2 s later she is travelling at 8.3 m/s (down). What is her average acceleration?

Example 2: A rabbit, eating in a field, scents a fox nearby and races off. It takes only 1.8 s to reach a top velocity of 7.5 m/s [N]. What is the rabbit's acceleration during this time?

Solution:

Example 3: A person accelerates at an average of 2.5 m/s^2 (E) for 1.5 s, what is the change in velocity at the end of 1.5 s?

Solution:

Example 4: An air puck on an air table is attached to a spring. The puck is fired across the table at an initial velocity of 0.45 m/s right and the spring accelerates the air puck at an average acceleration of 1.0 m/s^2 left. What is the velocity of the air puck after 0.60s?

Solution:

Note: The direction of velocity and acceleration will determine the size of the velocity (ie. If an object is speeding up or slowing down)

If they are in the same direction (both are positive or both are negative) then the object is *speeding up*

If they are in opposite directions (one is positive and the other is negative), the object is *slowing down*

THE DIRECTION OF THE ACCELERATION VECTOR

Since acceleration is a vector quantity, it will always have a direction associated with it. The direction of the acceleration vector depends on two things

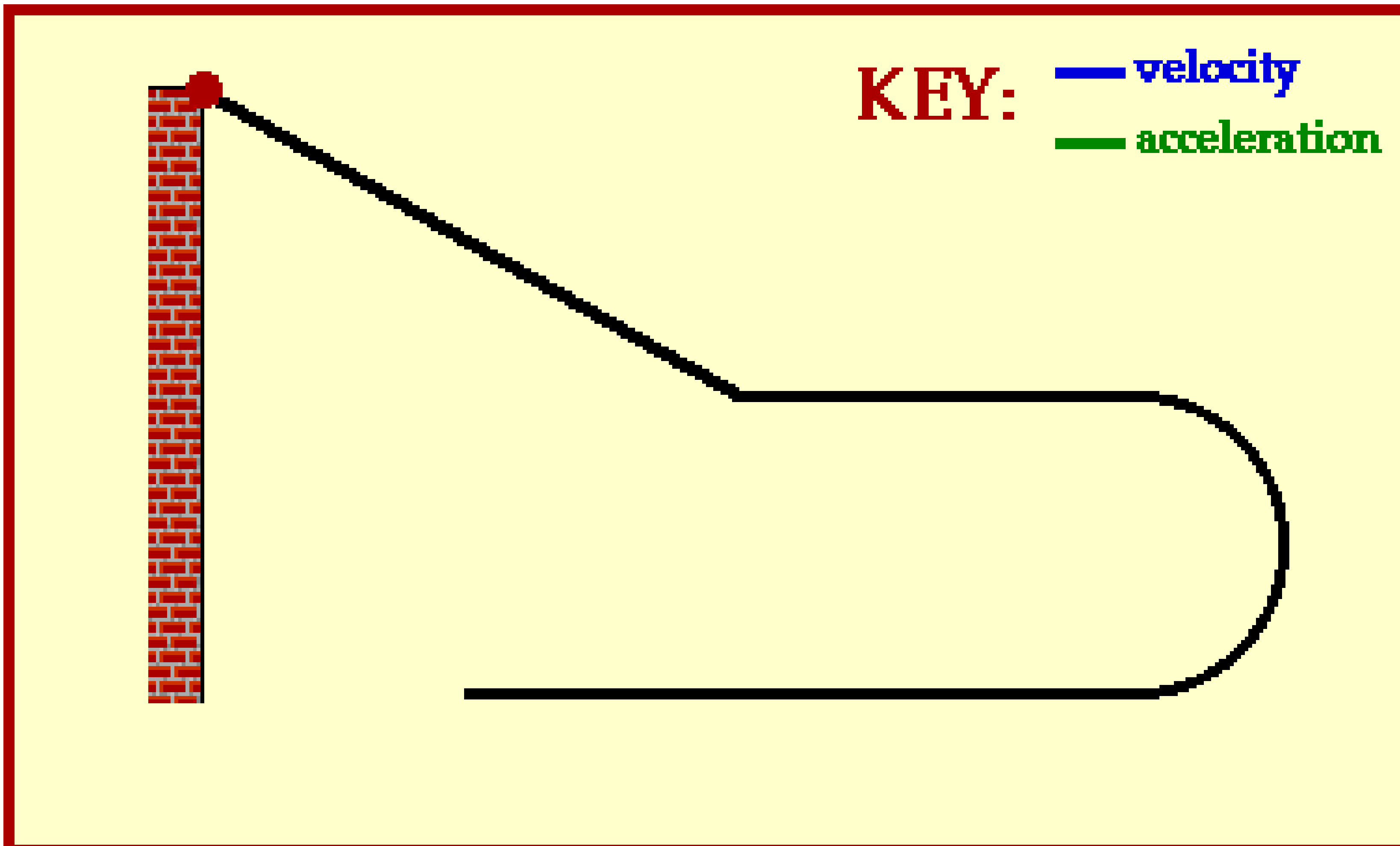
-whether the object is moving in the + or - direction

-whether the object is speeding up or slowing down

The general RULE OF THUMB is:

If an object is slowing down, then its acceleration is in the opposite direction of its motion.

Comparing velocity and acceleration

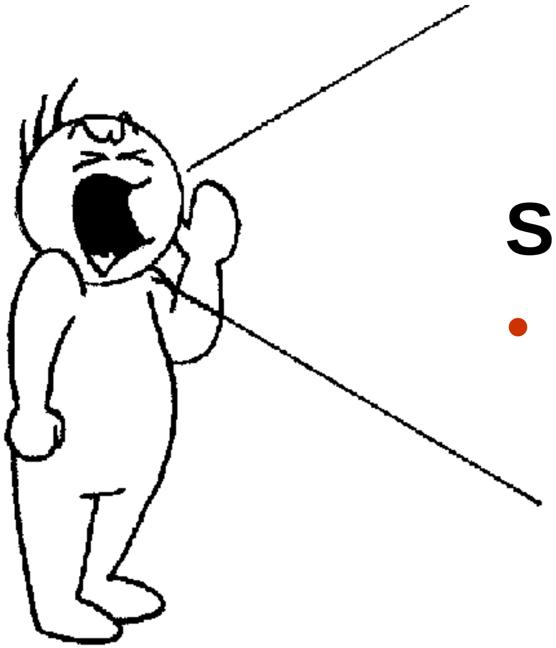


Velocity & Acceleration Sign Chart

		VELOCITY	
ACCELERATION		+	-
	+	Moving forward; Speeding up	Moving backward; Slowing down
	-	Moving forward; Slowing down	Moving backward; Speeding up

Activity

- *Practice:*
- *p. 388-399, # 1-15; p. 465 # 2, 3, 5-8*



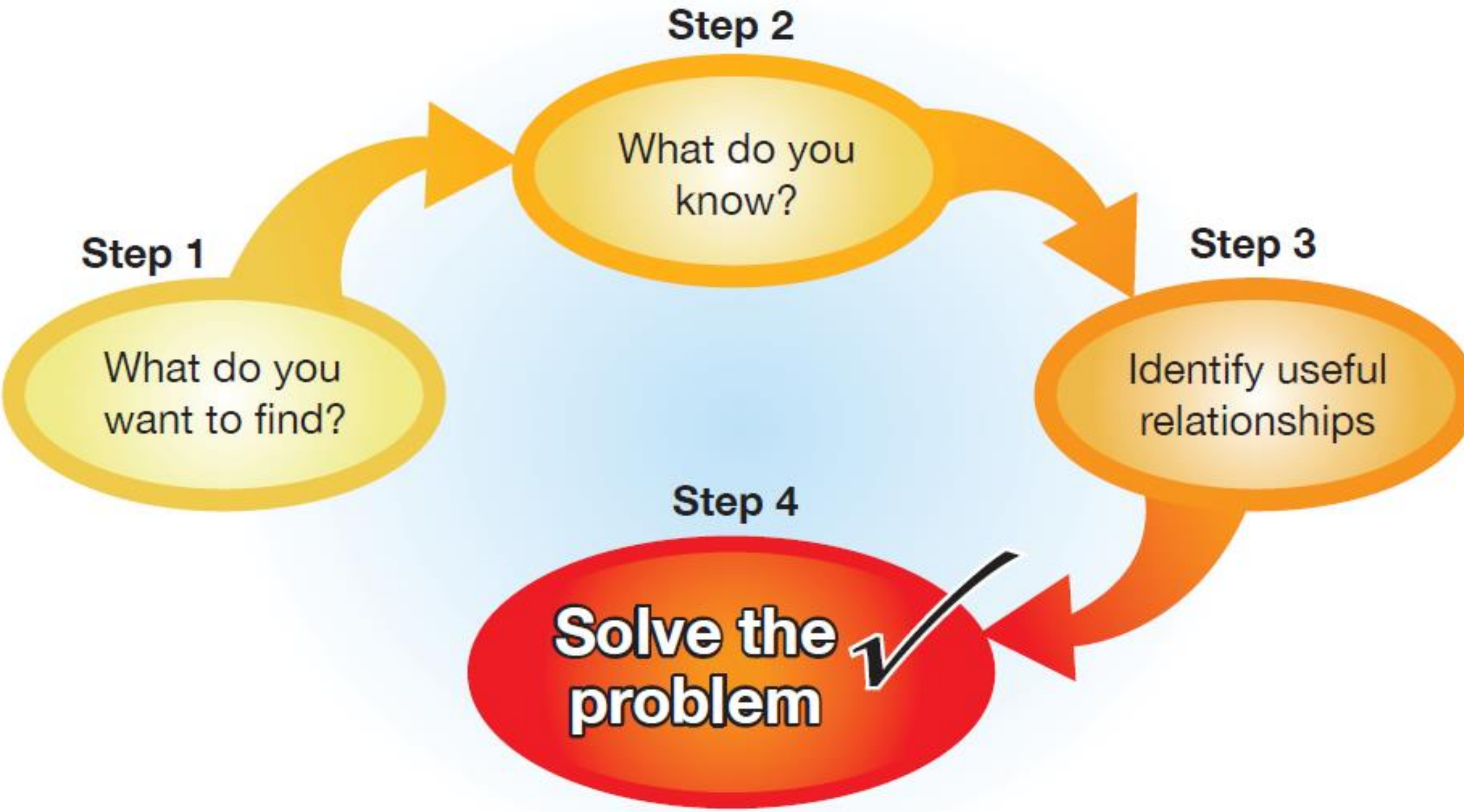
Section 10

- Problem Solving Part 2

Kinematics Formulae

Sec 2.3 2.4

Problem Solving Steps



The best way to understand the formula's is through examples and practice. The following examples below demonstrates a basic application of the formulas.

- Some good steps to follow:
  - Read the question
  - Write the givens what you know (look for units) and what you want to know
  - Sketch a diagram if needed
  - Choose a formula(s)
  - Find the answer.
    - Don't forget to use the correct units
    - Is the answer reasonable

Basically, there are 5 kinematics equation:

Equation 1: $v_1 = v_2 + at$

Equation 2: $v_2^2 = v_1^2 + 2ad$

Equation 3: $d = v_1 t + \frac{1}{2}at^2$

Equation 4: $d = v_2 t - \frac{1}{2}at^2$

Equation 5: $d = \frac{(v_2 + v_1)t}{2}$

These formulas are for uniform acceleration in 1 dimension

Review of Symbols and Units

- Displacement *(d); meters (m)*
- Velocity *(v,); meters per second (m/s)*
- Acceleration *(a); meters per* s^2 *(*m/s^2*)*
- Time *(t); seconds (s)*

Review sign convention for each symbol

	Variables				
Equation	**Δd**	**a**	**v_f**	**v_i**	**t**
$v_1 = v_2 + at$	–	√	√	√	√
$v_2^2 = v_1^2 + 2ad$	√	√	√	√	–
$d = v_1 t + ½at^2$	√	√	–	√	√
$d = v_2 t - ½at^2$	√	√	√	–	√
$d = ½(v_2 + v_1)t$	√	–	√	√	√

Each kinematic equations contains 4 variables, therefore,you must have three of the unknowns in order to use that equantion. However, you can use more than one equation to solve a problem. Good LUCK!

Example 1:

A boat moving at 2.0 m/s to the right accelerates to the right at 0.80 m/s^2 for 4.0s.

A) Calculate the final velocity of the boat.

B) Calculate the displacement for the 4.0 s interval

Example 2:

A car is coasting at 17 m/s (about 60 km/hr) when the driver accelerates at 5.3 m/s^2 for a distance of 25 m in a passing lane. What will be the speed after traveling the 25 m?

Solution:

Example 3:

A bicycle crests the top of a hill moving at 3.0 m/s. While rolling down the hill the bike experiences an acceleration of 0.50 m/s^2. How long is the hill if the bike is moving at 5.0 m/s at the bottom?

Solution:

Example 4:

A car travelling at 24 m/s can slow down at a rate of 8.0 m/s^2. If while driving this car you notice a child in the street 41 m in front of the car, can the car stop without hitting the child. Give mathematical evidence.

Solution:

Example 5:

Assuming that in question 4 your reaction time is 0.25 seconds, can the car still stop without hitting the child? Give mathematical evidence.

Solution:

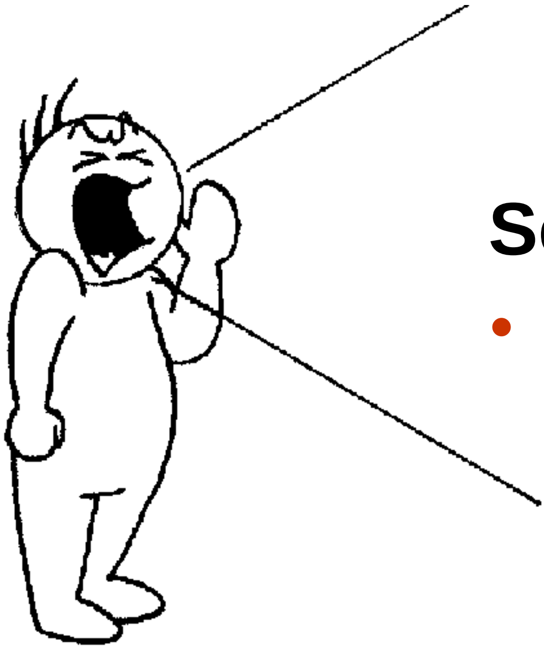
Example 6:

A car traveling at 22 m/s pulls into a passing lane and accelerates at 4.8 m/s^2 to pass a slow vehicle. If the lane is 610 m long, how many seconds elapse before the car must pull back into the regular lane?

Solution:

Activity

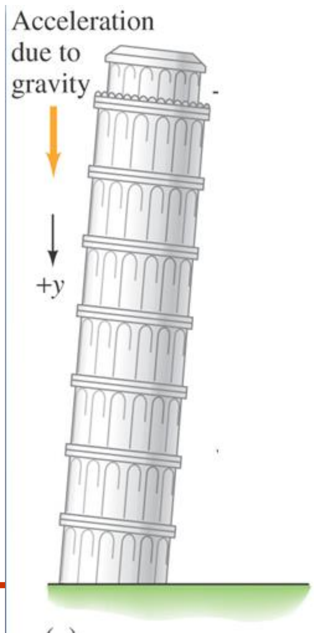
- Complete STSE on “The Physics of Tailgating”



Section 11

- Algebraic Problem Solving

FREE FALLING OBJECTS



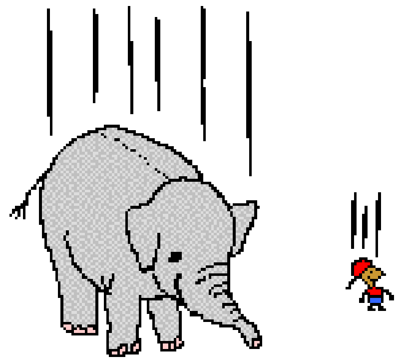
ACCELERATION DUE TO GRAVITY

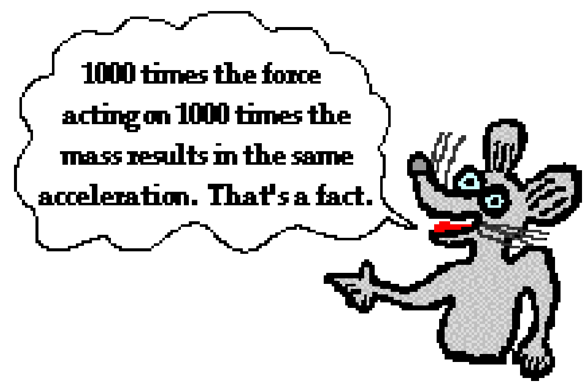
The Big Misconception

- The acceleration of gravity, g, is the same for all free-falling objects regardless of how long they have been falling, or whether they were initially dropped from rest or thrown up into the air.
- BUT "Wouldn't an elephant free-fall faster than a mouse?"

→ NO!!

WHY?





$$\frac{F}{m} = \frac{F}{m}$$

All objects free fall at the same rate of acceleration, regardless of their mass.

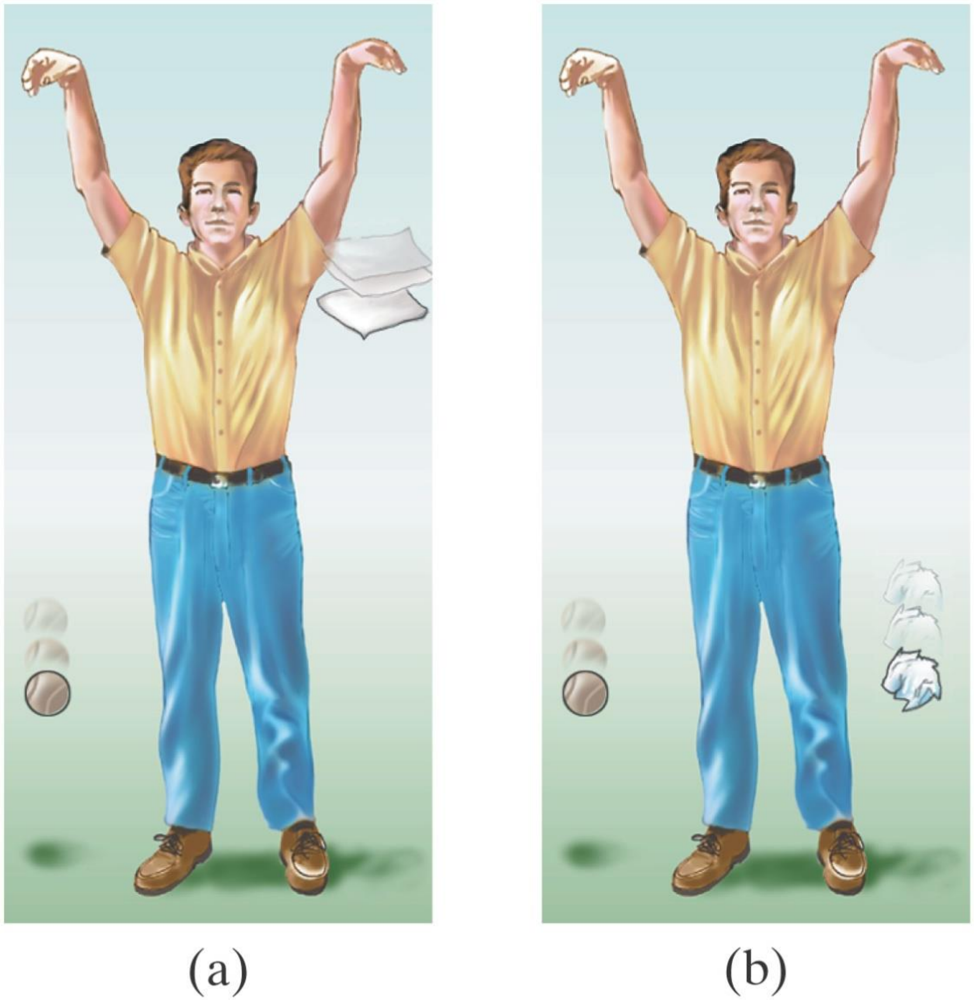
Galileo

Galileo dropped two cannon balls

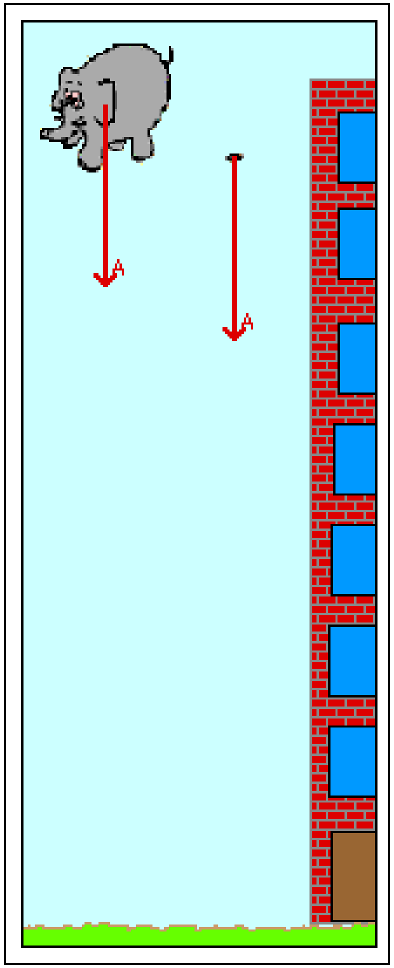
of different weights from the top of

Leaning Tower of Piza. The two cannon balls reached the ground at the same time. He proved that when objects of different weights are dropped at the same height and time, they take the same amount of time to fall to the ground (ignoring air resistance).

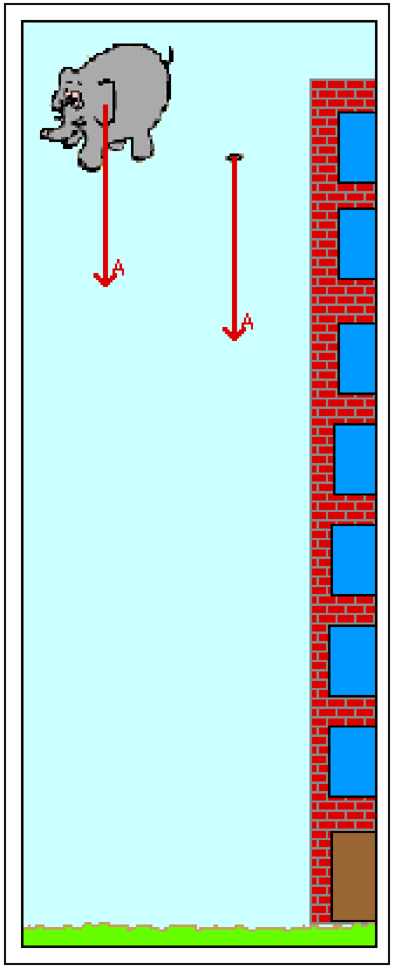
Falling Objects



In the absence of air resistance, all objects fall with the same acceleration, although this may be hard to tell by testing in an environment where there is air resistance.



No Air Resistance



With Air Resistance

1971 - on the Apollo 15 mission, NASA astronauts drop a feather and a hammer on the moon, where there is NO atmosphere!

This is the BIG Idea

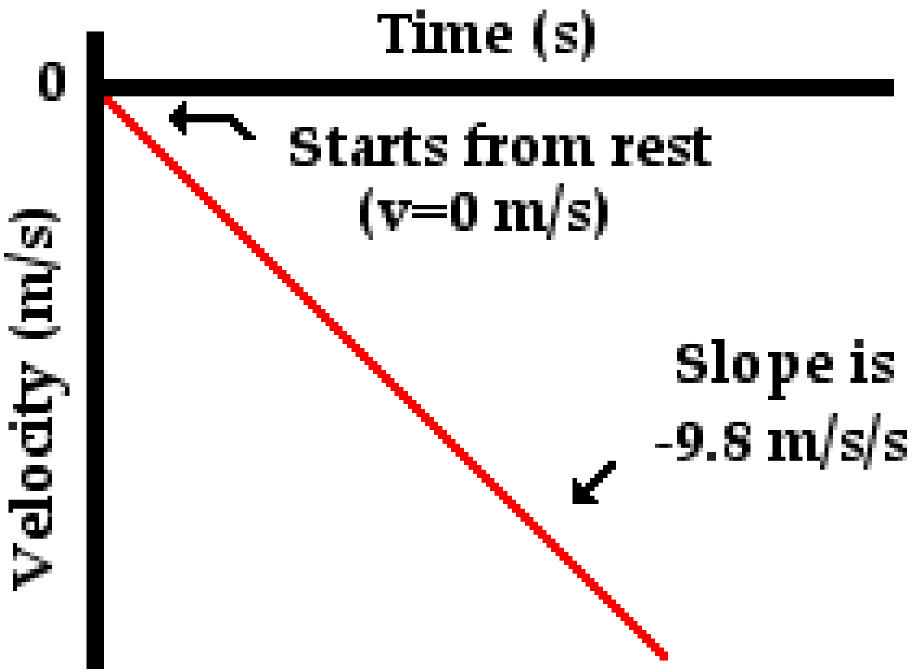
Objects that are dropped close to the earth accelerate downward at 9.80 m/s^2 (-9.80 m/s^2). The value 9.80 m/s^2 is acceleration due to gravity

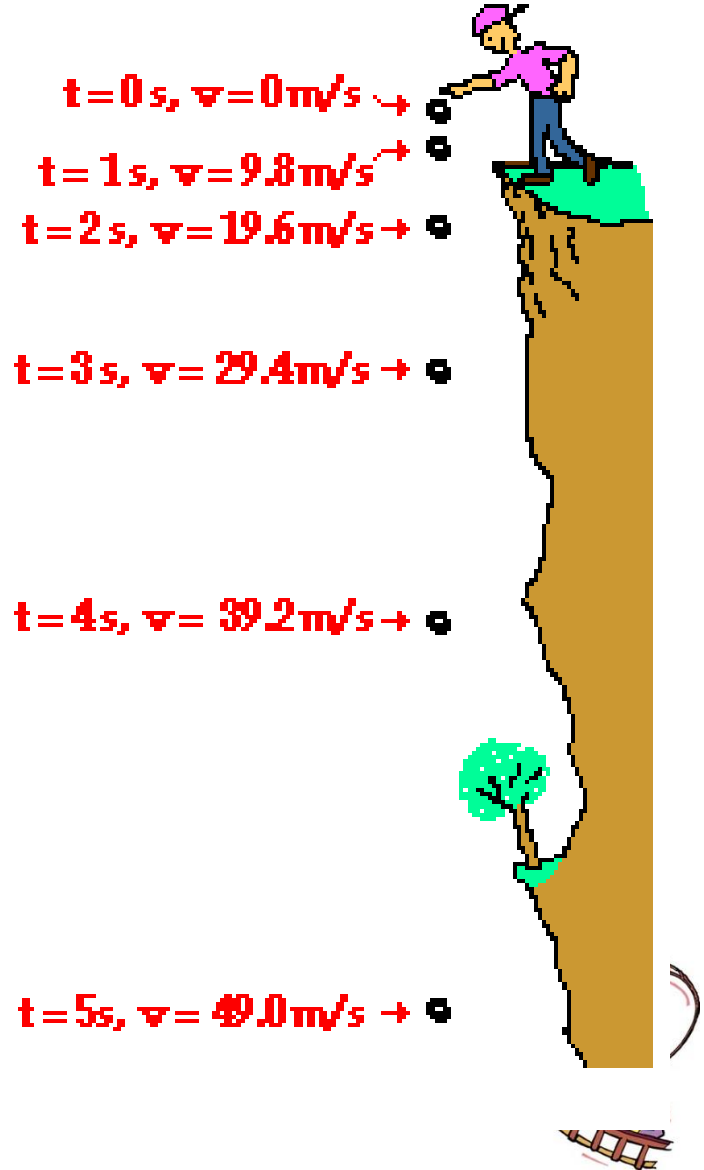
$$accleration = \frac{velovity}{time} = \frac{m/s}{s} = m/s^2$$

Note: It does not depend on the objects mass

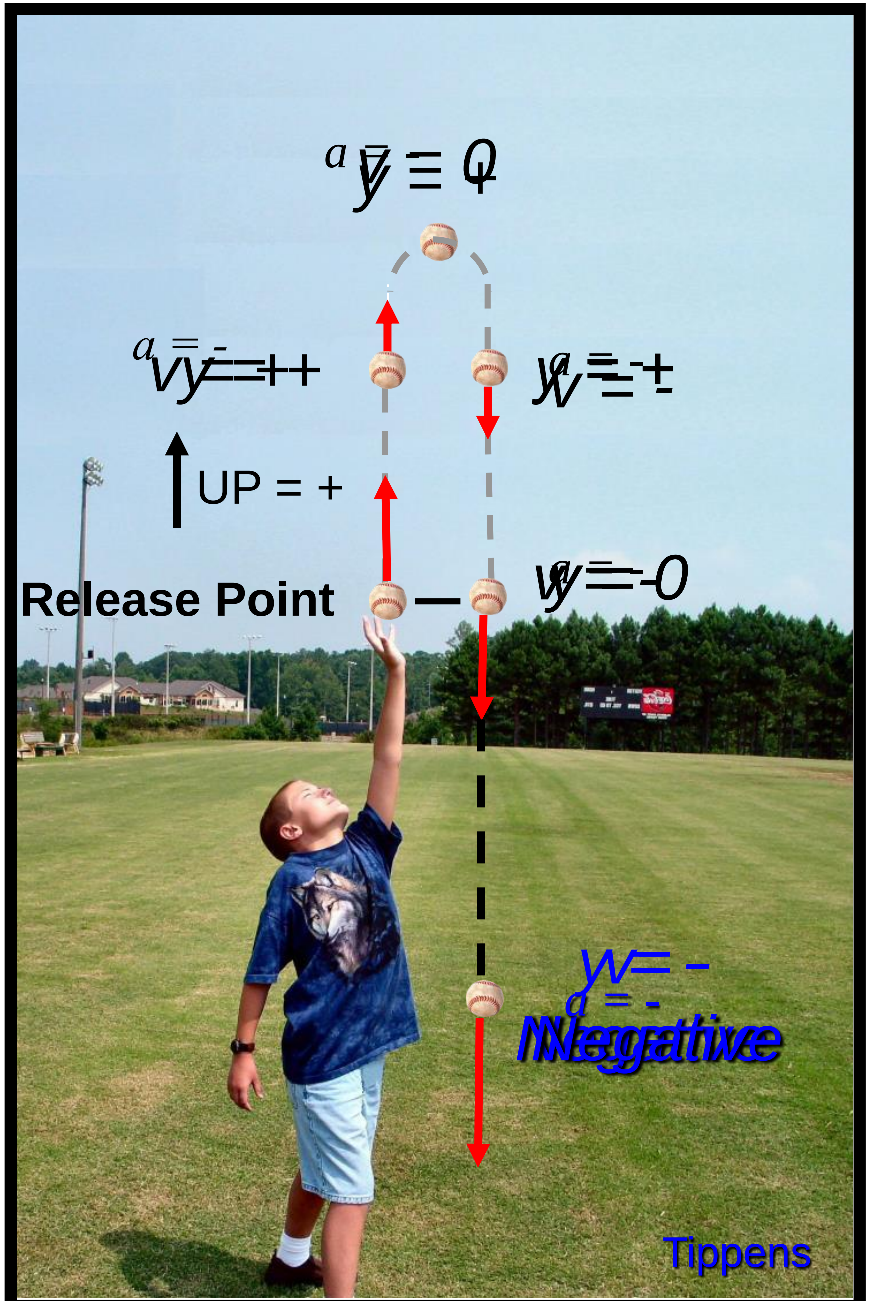
We assume that air resistance is negligible (not considered) and the earth is a perfect sphere

How Fast





Graphics from Minds On Physics



Sign Convention: A Ball Thrown Vertically Upward

- Displacement is positive (+) or negative (-) based on LOCATION.

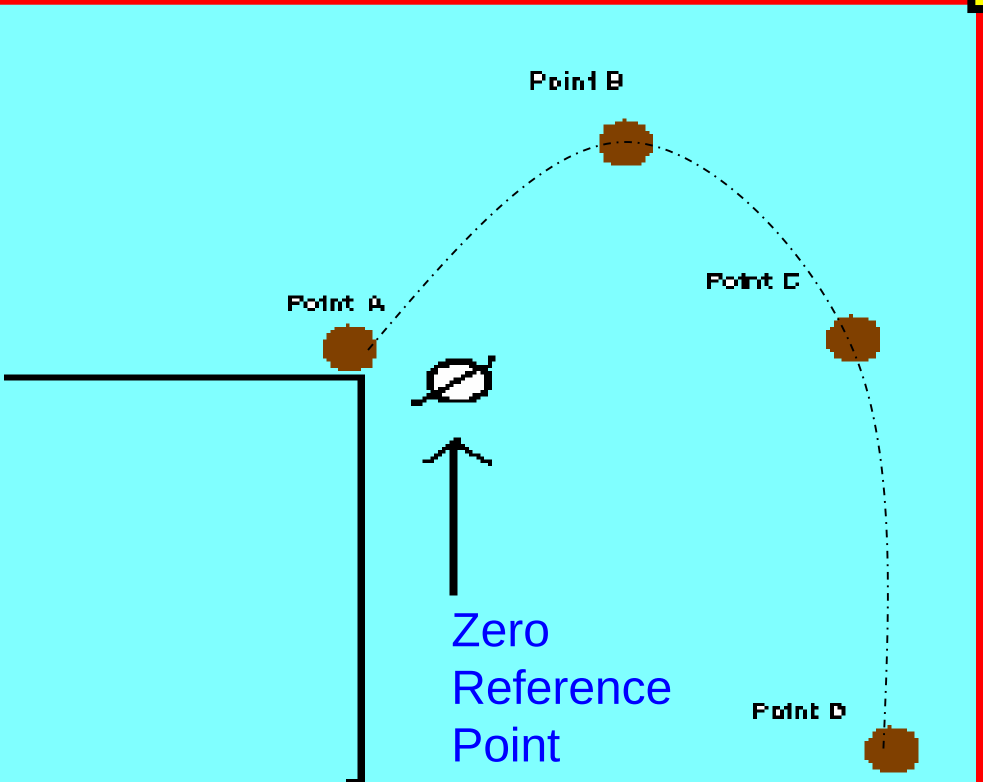
- Velocity is positive (+) or negative (-) based on direction of motion.

- Acceleration is (+) or (-) based on direction of force (weight).

Sign Conventions for Free-Fall

	A	B	C	D
d	0	+	0	-
v	+	0	-	-
a	-9.8	-9.8	-9.8	-9.8

Up "+" Down "-"



- At point A the change in y is 0, the velocity is positive.
- At point B the change in y is positive, the velocity is zero.
- At point C the change in y is 0, the velocity is negative.
- At point D, the change in y is negative, the velocity is negative.
- The acceleration for all the points is $-9.8\ m/s^2$

Example 1

A cell phone is dropped from the edge of a building that is 441 m high. How long does it take for the object to hit the ground ?

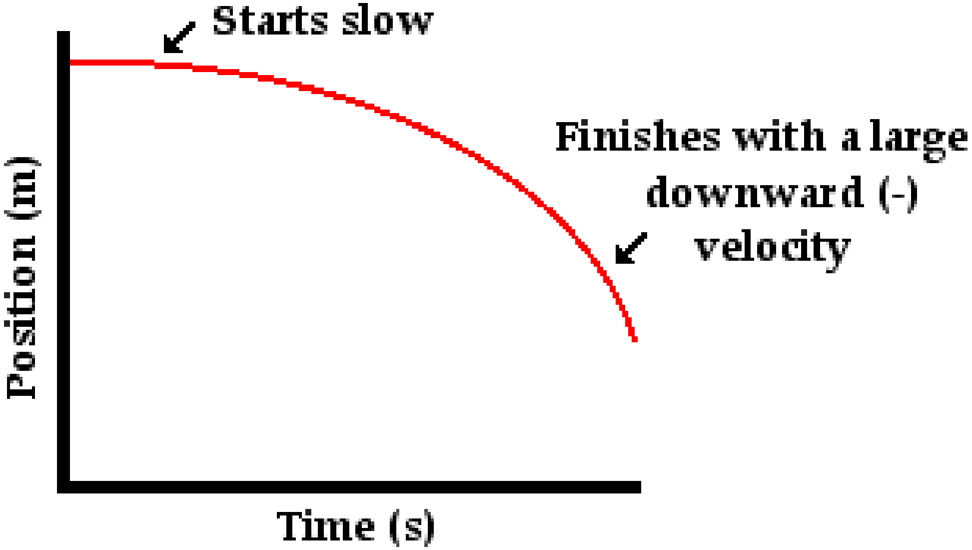
Solution:

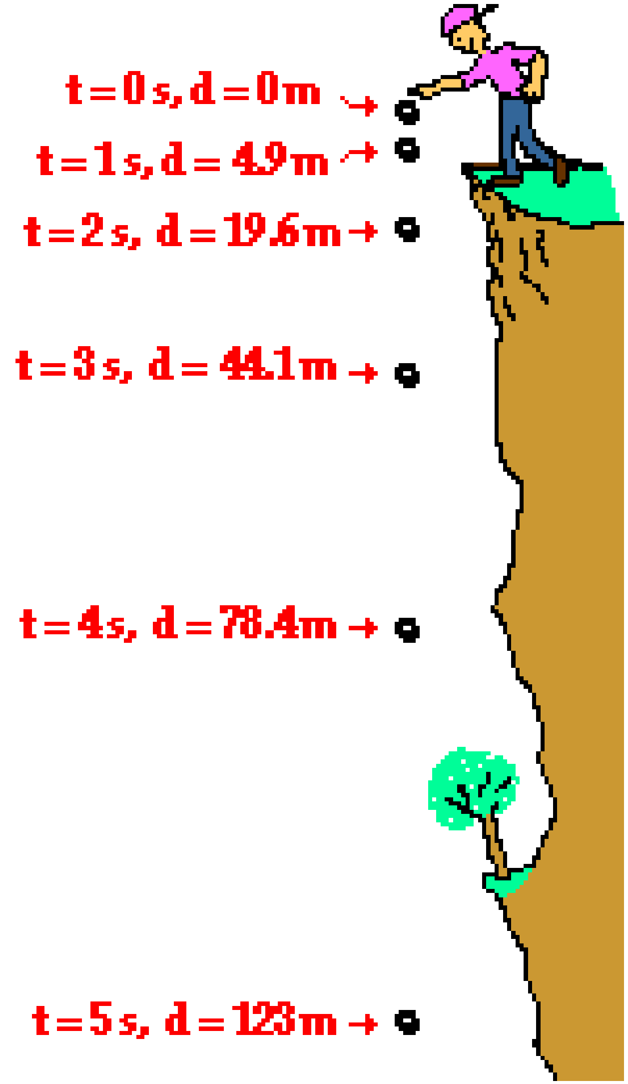
How Far

What did you notice from example 1? You can calculated the distance of an object dropped (v_1= 0 m/s) by simplifying kinematic equation 3 to:

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

$$d = \frac{1}{2}at^2$$





Example 2:

A person throws a ball straight up from the ground. The ball leaves the person’s hand at an initial velocity of 10.0 m/s up. The acceleration of the ball is $9.81 m/s^2$ down. What is the velocity of the ball after 1.5s?

Solution:

Example 3:

While standing on the edge of a 40 m cliff, Mr. Bishop throws a rock a rock vertically up at 31 m/s . How fast was it be moving when it hits the water?

Solution:

Example 4:

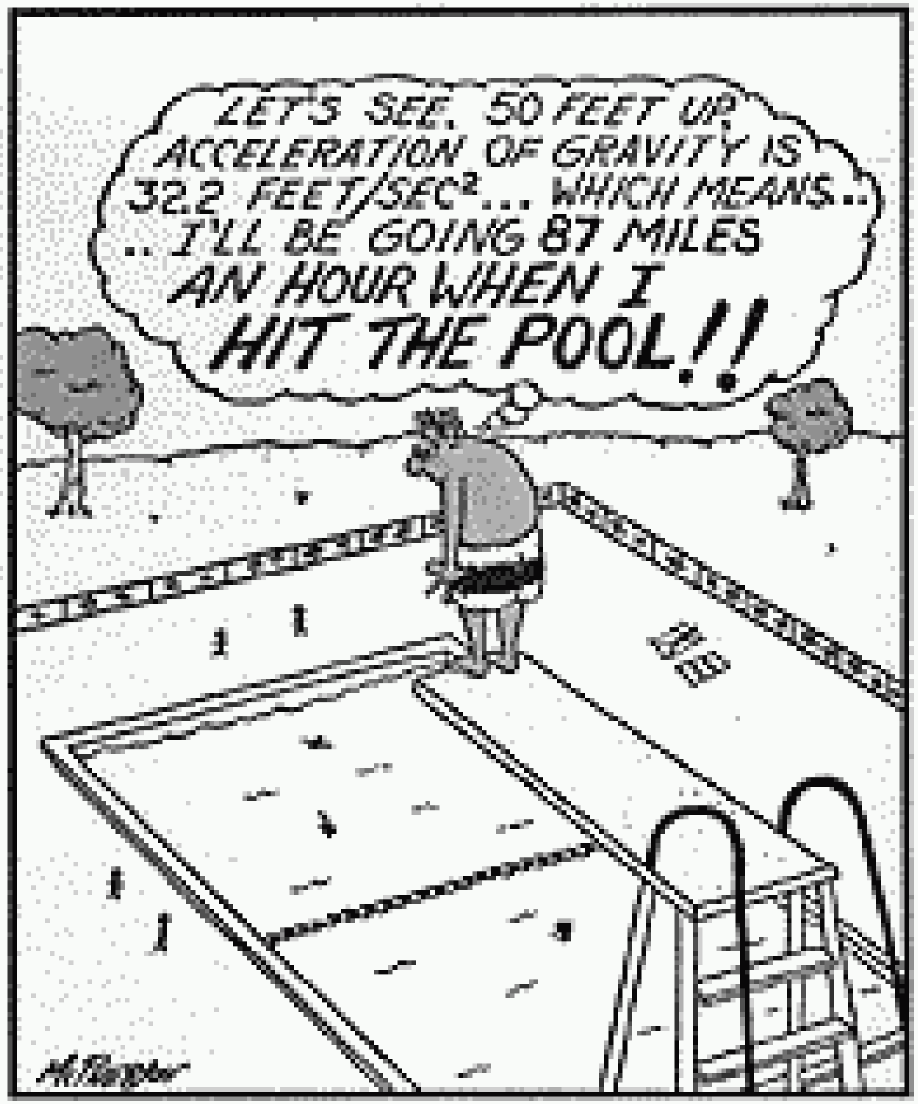
A soccer ball is kicked vertically upward at 15 m/s from the ground.

A) How long does it to reach the maximum height?

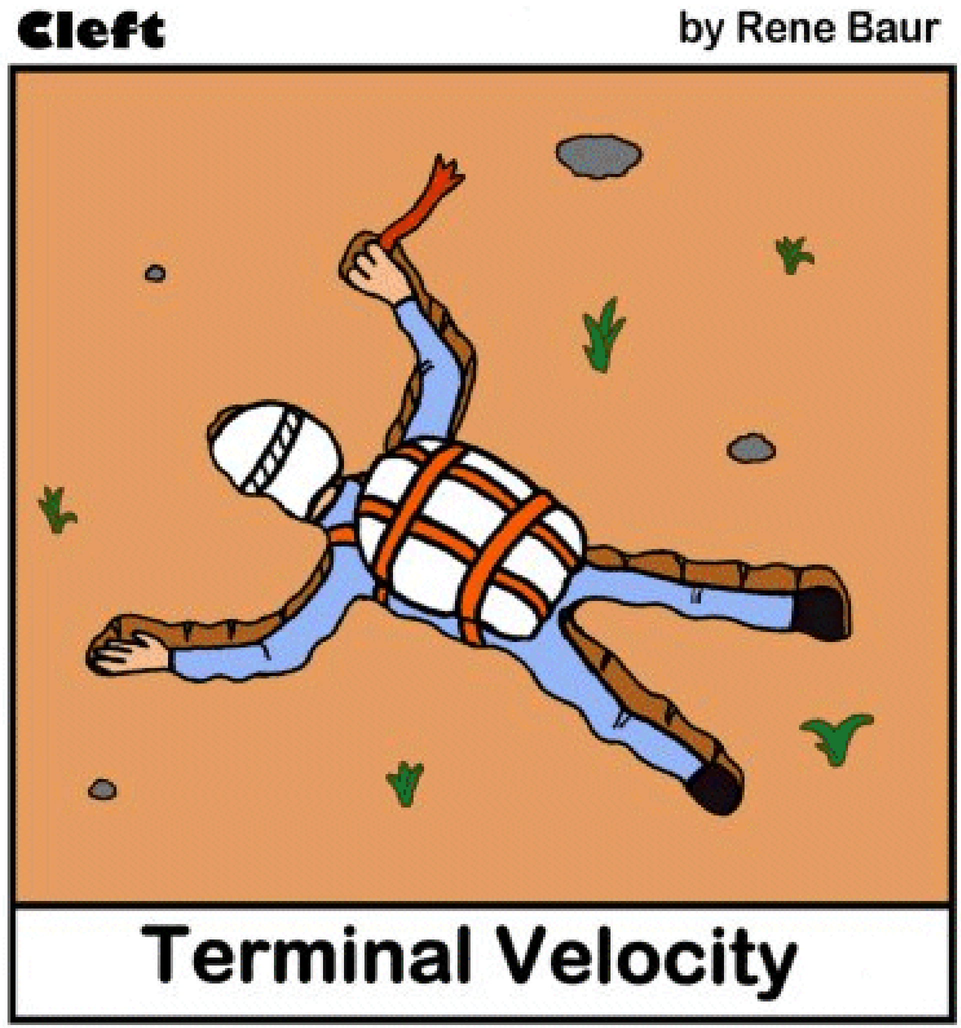
B) How long is the dart in the air(time of flight)?

Example 5:

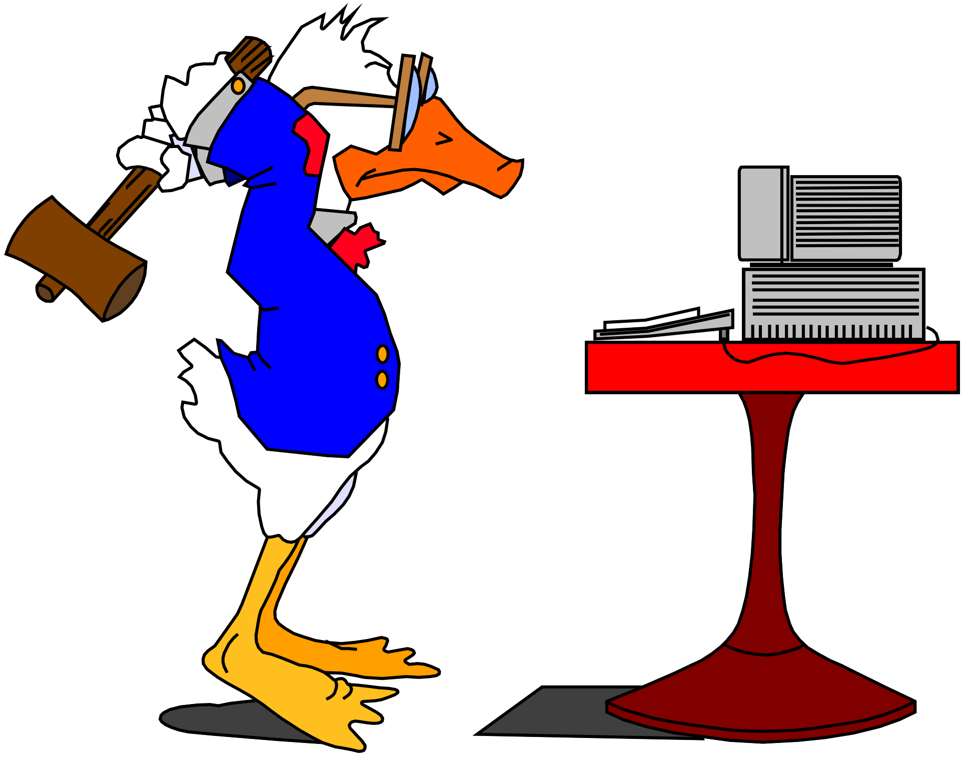
A bottle is thrown straight upwards at 9.39 m/s. What is the maximum height reached by the bottle?

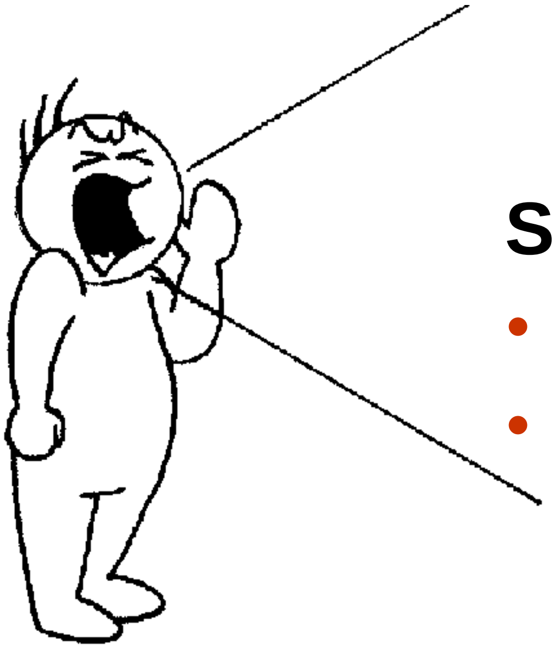


There are times when being a whiz at physics can be a definite drawback.


Cleft
by Rene Baur
Terminal Velocity

CONCLUSION OF Acceleration





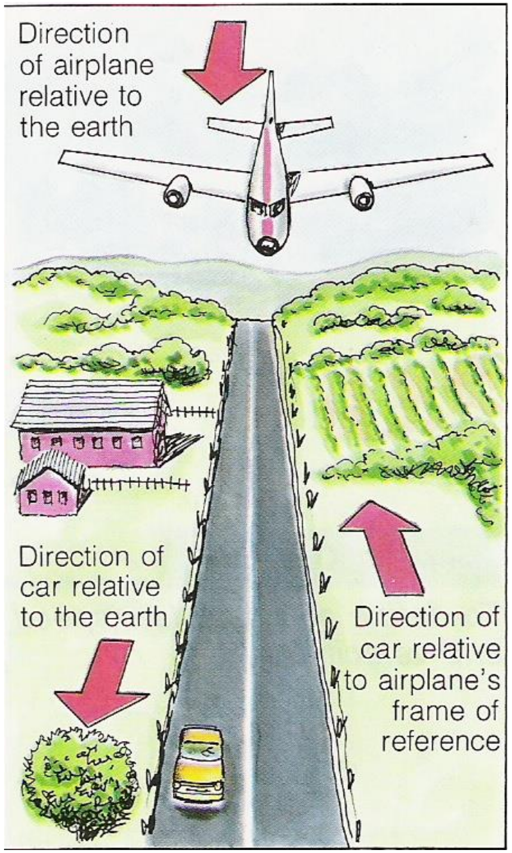
Section 11

- RELATIVE MOTION
- (One dimension)

Text Sec. 2.2

Frame Of Reference

Frame of reference : A coordinate system from which all measurements are made. A frame of reference does not always have to be stationary.

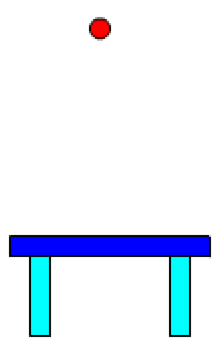


Example 1

Pretend you are traveling on a train watching a ping pong ball bounce on a table.

- Does it go straight up and down in a vertical line?
  Answer: YES

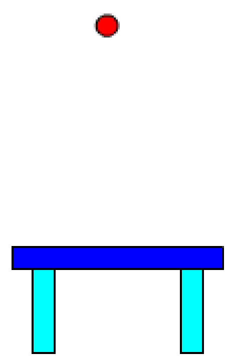
- From the **frame of reference** of the train you see the ball going straight up and down.



Suppose now you have a friend outside the train, some distance into the field on one side of the road and watching the action.

What does your friend see?

Answer: from your friend's **frame of reference** the ball is moving in an arc or trajectory.

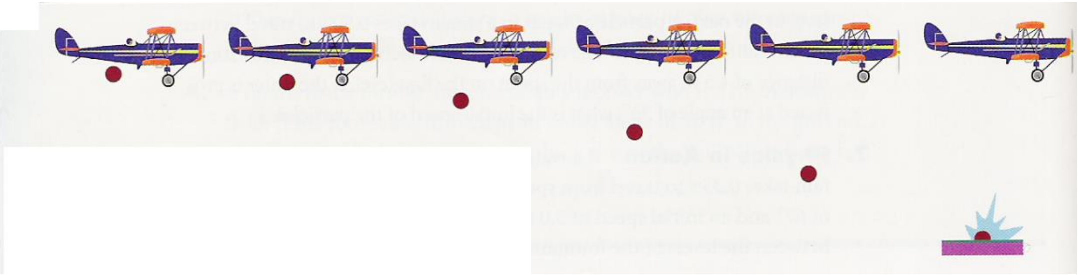


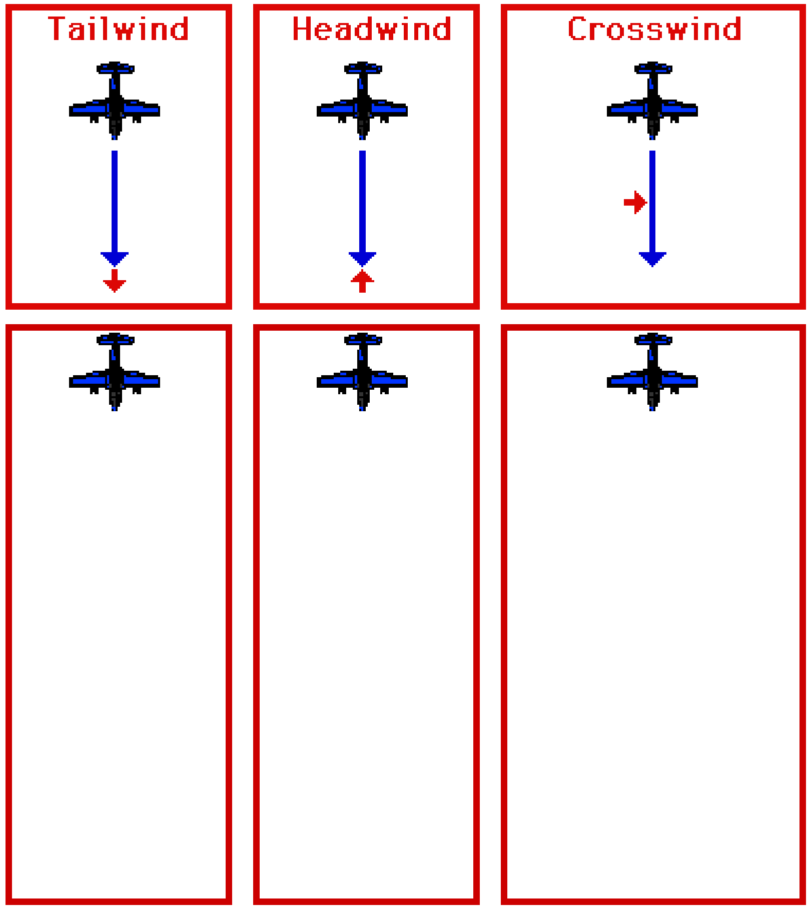
Falling Object

Comparing Frames of Reference

What the pilot sees…

What an outside observer sees…




Tailwind
Headwind
Crosswind

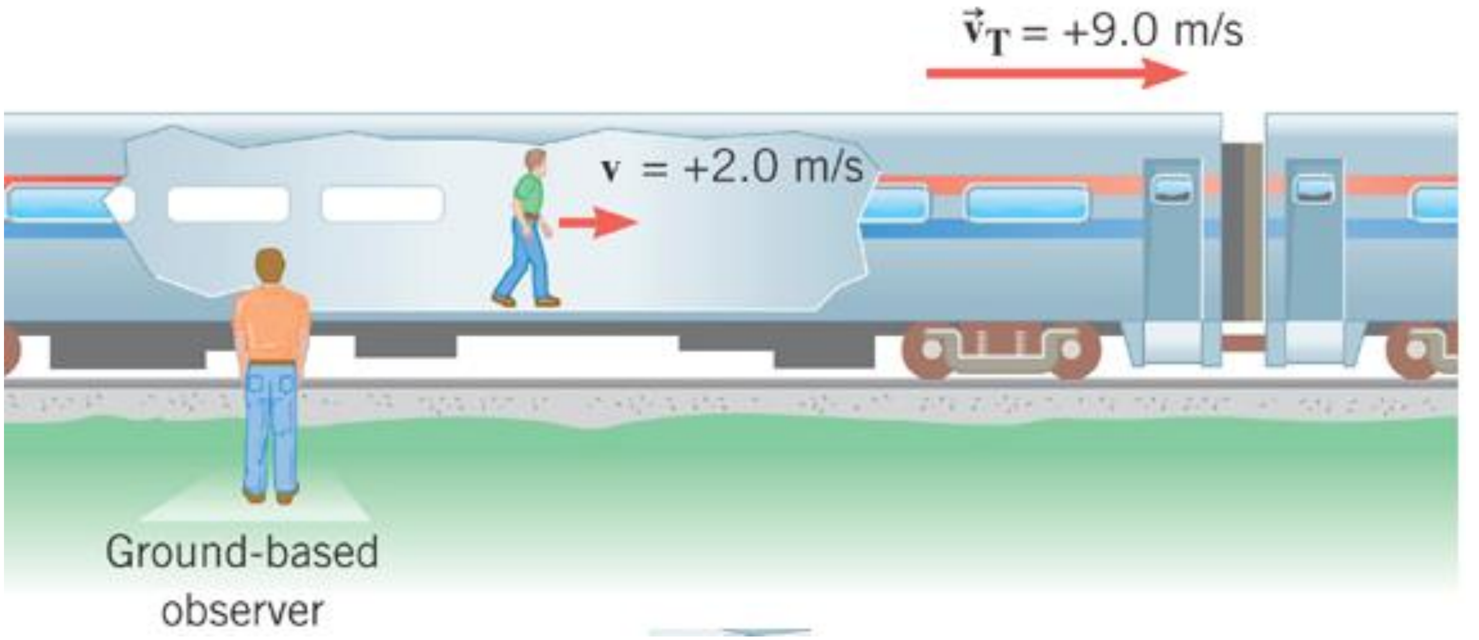
What is this guy’s velocity?

He travels 4 meters in 2 seconds going east.

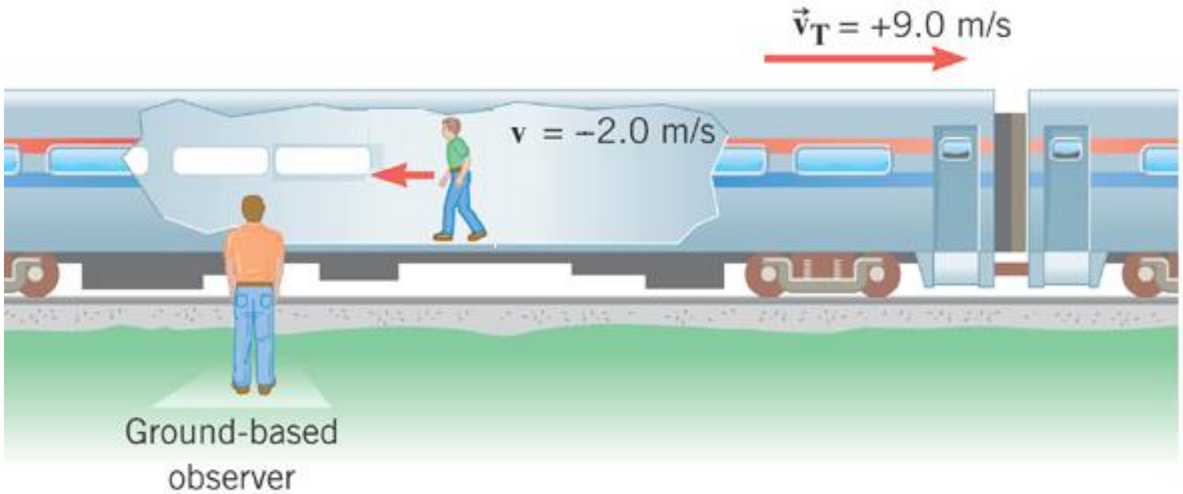
What is this guys velocity?

So what is his frame of reference?

What about now?



What about now?



Example 1

An ant travels 10 cm to the right on a plate relative to the plate as a disgusted picnicker pushes the plate a distance of 40 cm to the right relative to the earth. What is the displacement of the ant with respect to the earth?

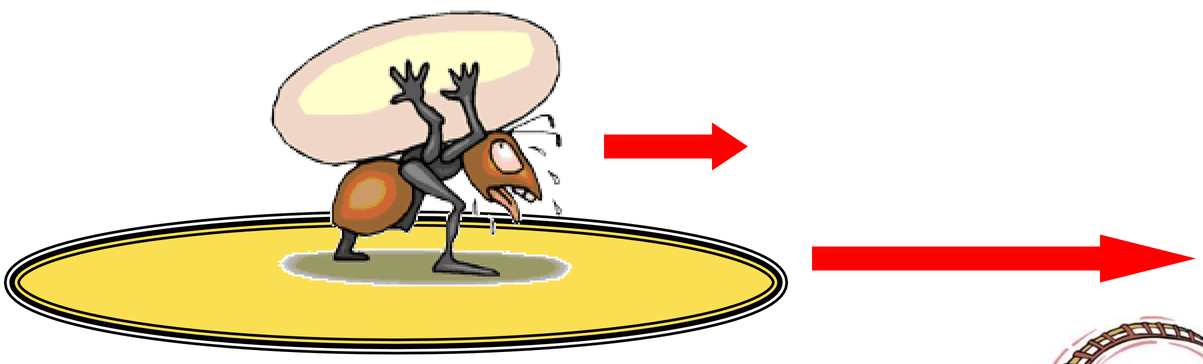
The Symbols:

_a**d**p_	the displacement of the ant with respect to the plate
_p**d**e_	the displacement of the plate with respect to the earth
_a**d**e_	the displacement of the ant with respect to the earth.

Method I: The doing it in your head method

You can reason like this: if the ant crawls 10 cm to the right on the plate, and then if the plate is pushed an additional 40 cm to the right, the ant will altogether move 50 cm to the right. (relative to the earth).

*a**d**e = 50cm [right]*

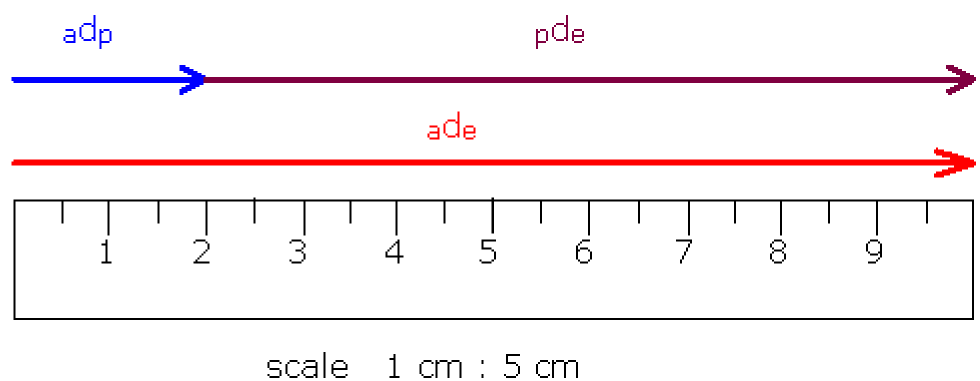


Method II: The vector diagram method

1. We will use a scale for the vectors, 1 cm : 5 cm.
2. Add the two vectors: make sure that the tail of the second falls on the tip of the first.
3. Determine **the Resultant vector**: draw the **RESULTANT** vector (in this case ${}_{a}d_{e}$) from the tail of the first to the tip of the second.

As with Method I, once again we have the displacement of the ant with respect to the earth to be 50 cm to the right.

${}_{a}\boldsymbol{d}_{e}$ = 50cm [right]



Method III: Vector Algebra Method

In this method we use the “symbols" to create a mnemonic aid.

The displacement of the ant with respect to the earth EQUALS the displacement of the ant with respect to the plate PLUS the displacement of the plate with respect to the earth.

$$ {}_a d_e = {}_a d_p + {}_p d_e $$

Notice the arrangement of the symbols.

$$ {}_a d_e = {}_a d_p + {}_p d_e $$

$$ = {}^{+}10\,\text{cm} + {}^{+}40\,\text{cm} $$

Substituting the correct values gives

$$ = {}^{+}50\,\text{cm} $$

YOU TRY THIS ONE!

Practice the trick of writing vector algebra equations. Write the following three terms in an equation:

${}_{h}\mathbf{P}_{w}$ ${}_{s}\mathbf{P}_{w}$ ${}_{s}\mathbf{P}_{h}$

Example 2:

You are watching a frog on a log drifting downstream. You see the log go 12.0 m down-stream, but the frog only travels 10.5 m downstream. What must be the displacement of the frog with respect to the log? (Downstream positive.)

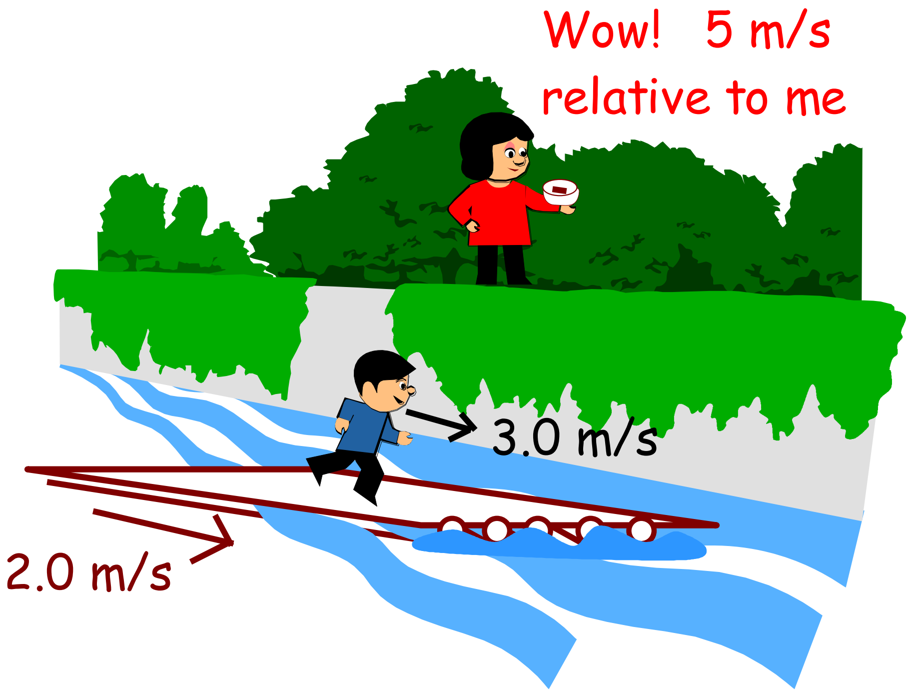
Given

${}_{l}\boldsymbol{d}_{y} = {}^{+}12.0 \text{ m}$

${}_{f}\boldsymbol{d}_{y} = {}^{+}10.5 \text{ m}$

${}_{f}\boldsymbol{d}_{l} = ?$

The same methods use for solving relative motion problems and displacement can also be used for Velocity



Relative Motion and Velocity

Example 3:

You walk in an **up-stream** direction at 1.4 m/s relative to a raft which is traveling downstream at 3.2 m/s. What is your velocity relative to your friend who is standing on the bank? (Downstream is positive.)

Example 4

You are driving Mr. Fifield’s souped-up Beast at 195 km/hr north (relative to the earth) when your on-board radar tells you that your Friend in a south-bound snowmobile is traveling at 210 km/hr relative to your snowmobile. What is the reading on the speedometer of your friends machine? (North is positive)

Movie

scie_ref

Movie

phy03_vid_sprelativity_56