SCIENCE 1206

Unit 3

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

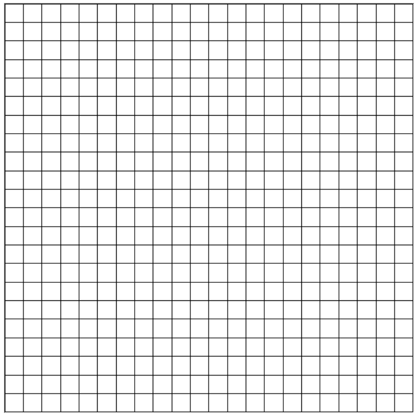
Physical Science – Motion

Required items for Physics

1) You will need a ruler

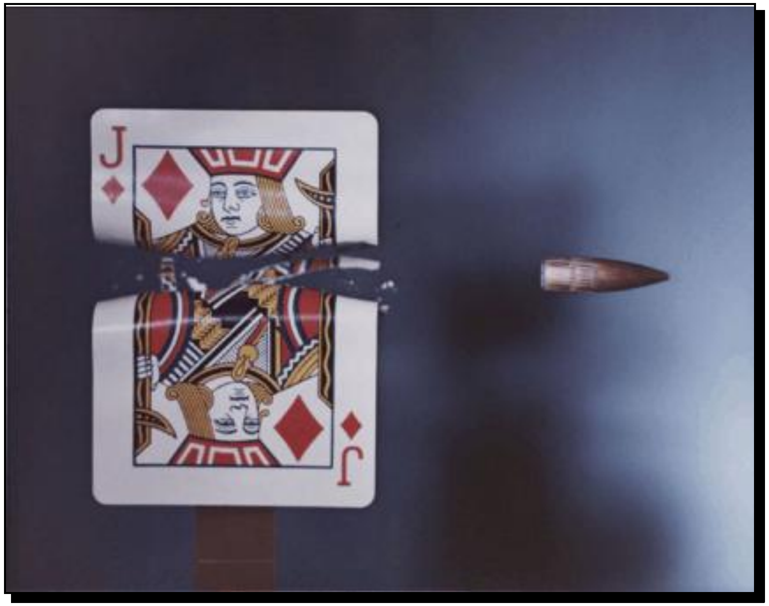
2) Bring a calculator to every Class

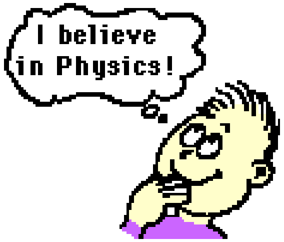
3) Graphing paper



What is Physics?

- <u>Physics</u> ***is the study of motion, matter, energy, and force.***

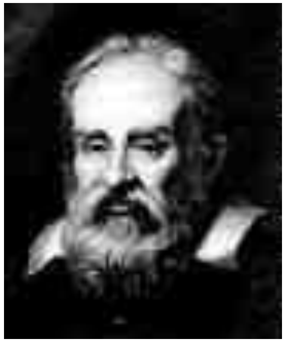




Called the Fundamental Science

Famous Physicist

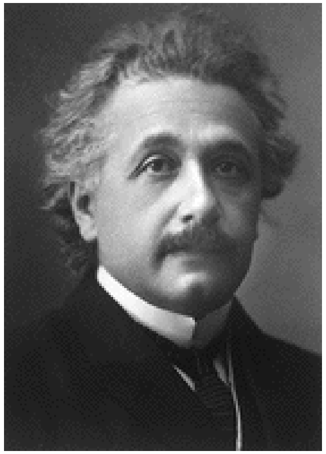
- Galileo Galilei



Sir Isaac Newton

- Stephen Hawkings

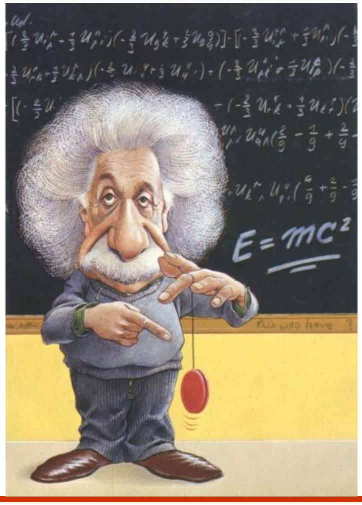
- Albert Einstein



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

Why Study Physics?

- Most modern technology came from physics (blackberry, internet).
- Most branches of sciences contain principles obtained from physics. It is hard to find a branch of science which does not contain some physics-related aspect such as electricity, magnetism, mechanics, heat, light, sound, optics.
- Physics classes hone thinking skills.
- The job market for people with skills in physics is strong. key to many doors of opportunity that open up to challenging, meaningful, and rewarding careers in industry, government …
- It is challenging
- To understand how things work
- Because Einstein says so????



Is Physics Right for Me?

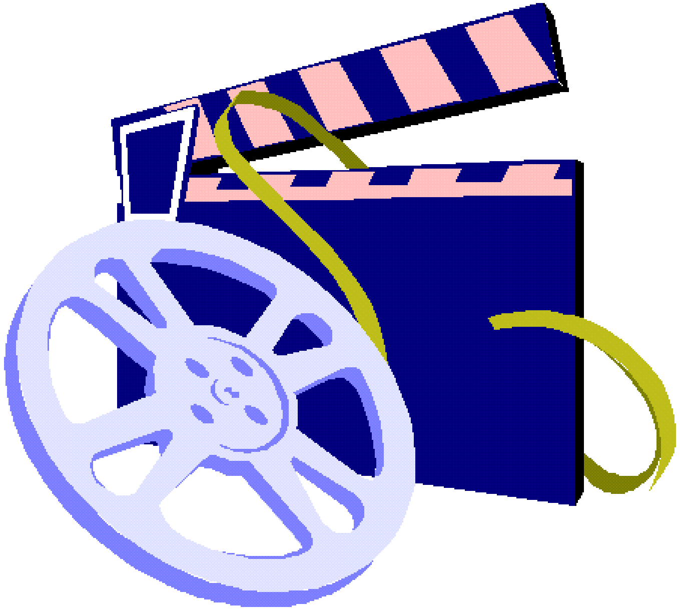
- **Strong in Mathematics, especially in problem solving**
- **Like to experiment with instrumentation & measurement**
- **you enjoy learning and want to REALLY understand things**

Career Branches in Physics

- Research (NASA)
- Education
- Engineering
- Medicine
- Meteorology
- roller coaster designers

EDUCATIONAL VIDEO

- Careers in Chemistry and Physics



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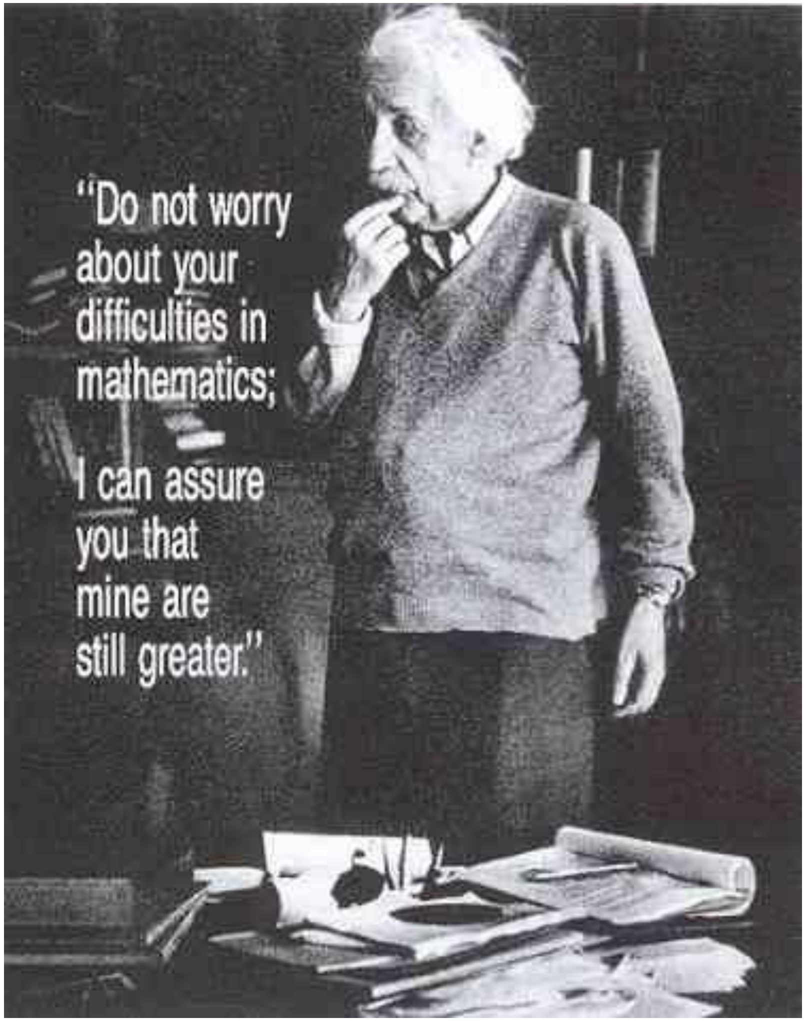
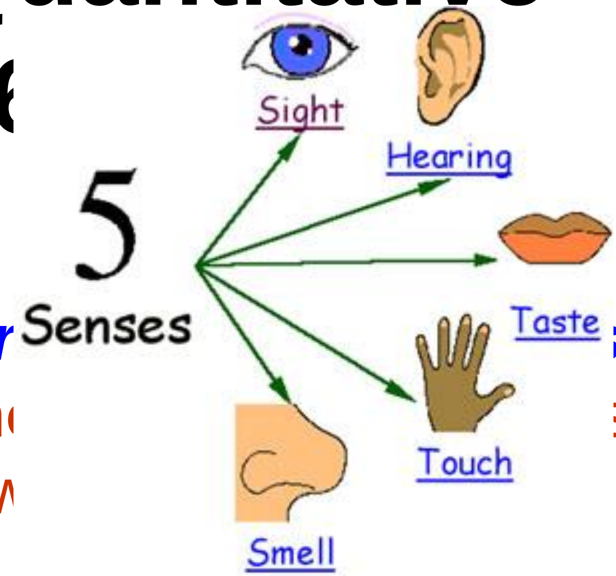
- **Section 3: Topic 1**

Units and Measurements


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

Qualitative and Quantitative Descriptions (p.6



- **QUALITATIVE DESCRIPTIONS**

  are descriptions made by obser ***ses*****,** such as the smell of a flower or th s eyes. They include observations w measured.

This bird has a large wingspan

- **QUANTITATIVE DESCRIPTIONS**

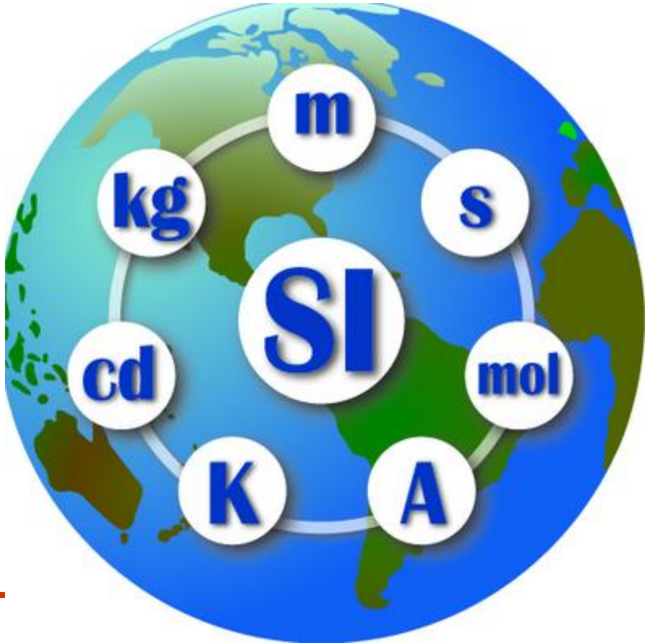
  are descriptions that are based on measurements or counting (i.e. they are numerical), such as the number of petals a flower has or how tall a person is. They deal with quantities.

This bird has a wingspan of two meters.

SI MEASURMENTS

- Scientists all over the world have agreed on a single measurement system called **Le Système International d'Unités**, **abbreviated SI**

SI has seven base units most other units are derived from these seven



BASE AND DERIVED UNITS-p. 689

- **Base** **units** ***are units that are defined.***

Table 1. SI base units

Base quantity	SI base unit: Name	SI base unit: Symbol
length	meter	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
thermodynamic temperature	kelvin	K
amount of substance	mole	mol
luminous intensity	candela	cd

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

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- **Section 3: Topic 2**

Conversions

litres

metres

grams

Converting Base Units

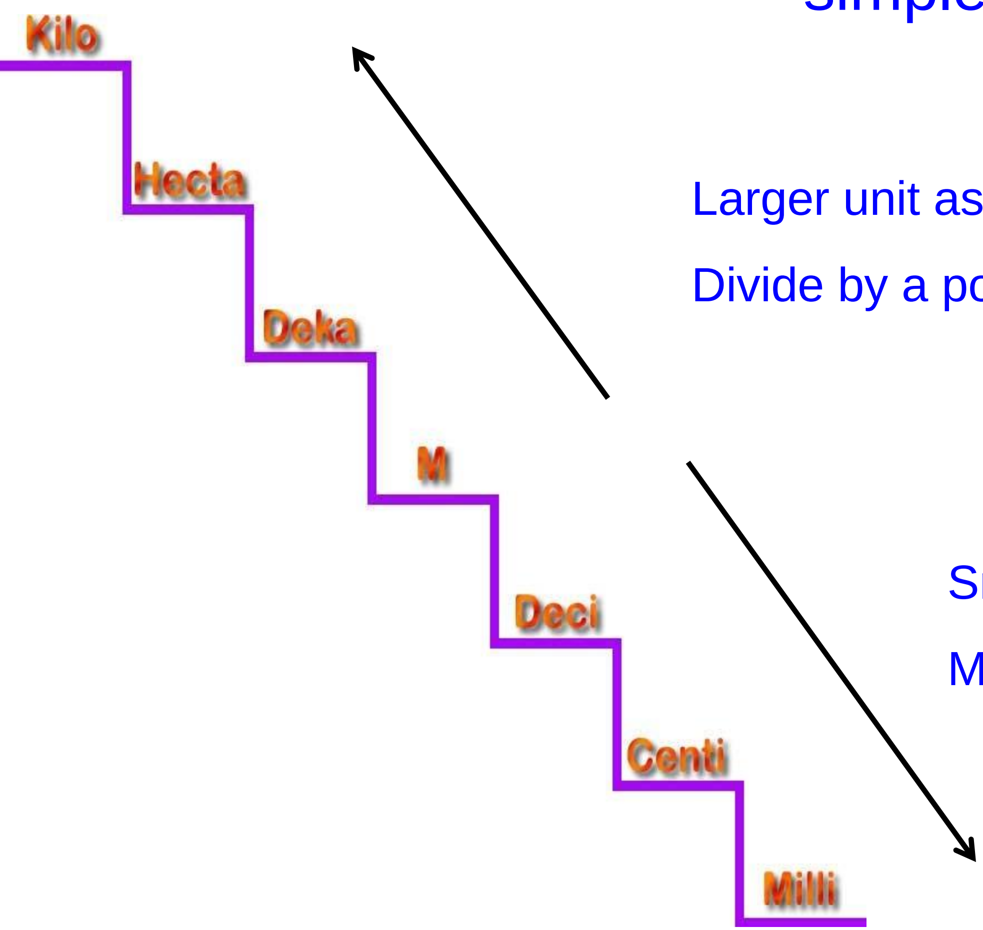
kilometres

centimetres

kilograms

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!

Convert the following measurements:

a) 125 cm => m

b) 2234 m => km

c) 23 mm => cm

d) 45 g => kg

e) 300 ml => kl

f) 1 200 000 mm => km

Converting Base Units

Using conversion factor

CONVERTING UNITS

- **Sometimes it is more convenient to express a value in different units.**

- **Converting units is not a hard thing to do. In fact, it really just involves multiplying and dividing.**

- ***To convert units, we need to multiply the quantity we want to convert by its 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:

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

Example 2

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

$$7a \times \frac{365day}{1a} \times \frac{24hours}{1day} x \frac{60\min}{1hr} \times \frac{60}{1\min} = 2.2075x10^{8} s$$

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

d) 0.0012 km/s => km/hr

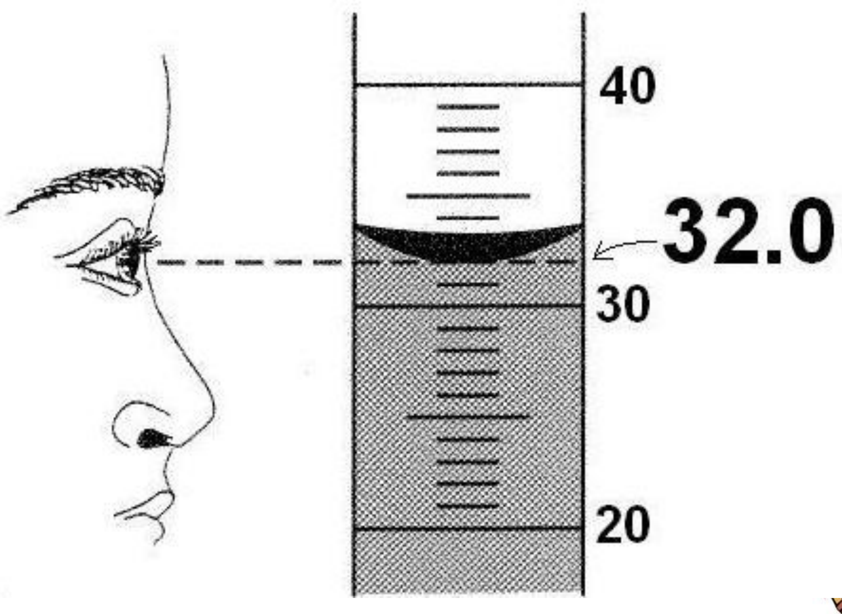
e) 300 ml => kl

f) 1 200 000 mm => km

Science 1206

- **Section 3: Topic 3**

Significant figures



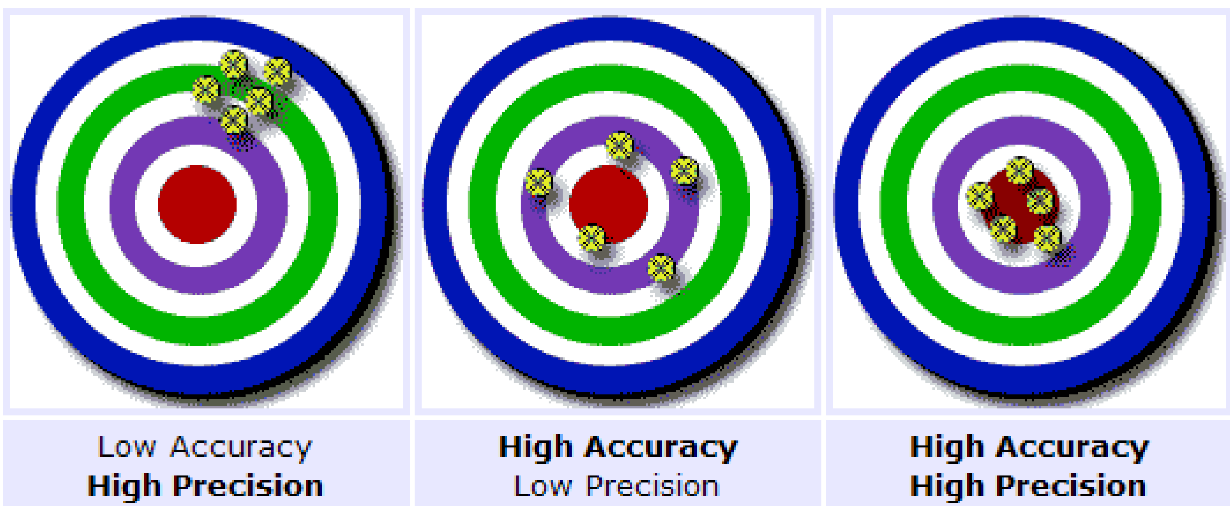

EXPLAIN SIGNIFICANT FIGURES TO ME LIKE I'M 5.000000 YEARS OLD.

ACCURACY AND PRECISION

Accuracy refers to the closeness of measurements to

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

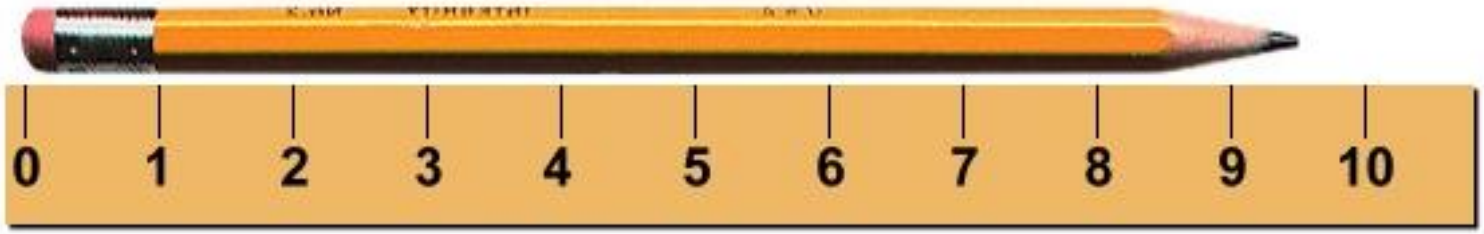
Precision is how close the measured values are to each other.



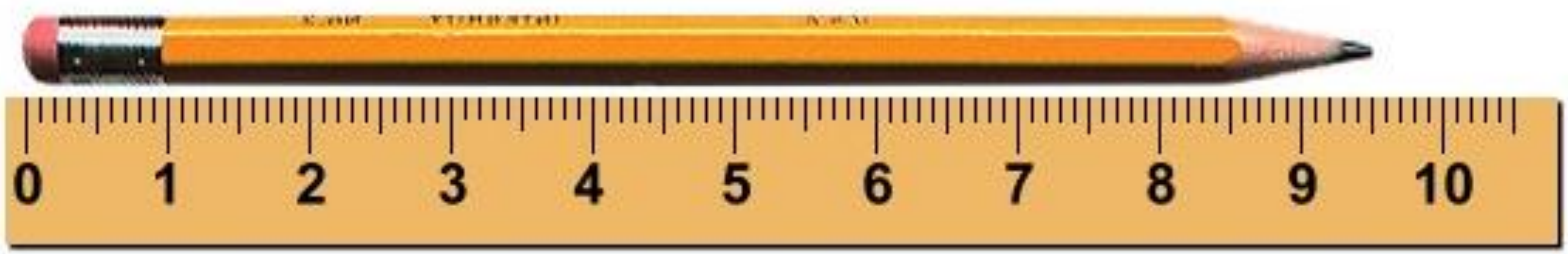
So, if you are playing soccer and you always hit the left goal post instead of scoring, then you are **not** accurate, but you **are** precise

Which ruler is more precise?

Pencil A:

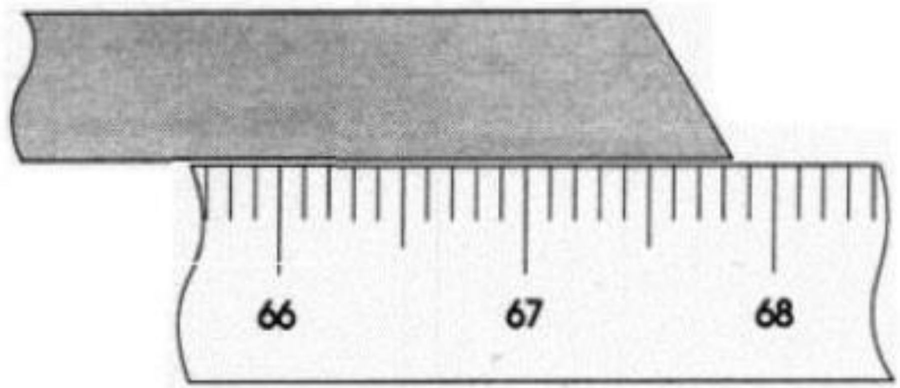


Pencil B



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.

Learning Check

What is the length of the wooden stick?

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

What Time is it?

- Someone might say “1:30” or “1:28” or “1:27:55”
- Each is appropriate for a different situation
- In science we describe a value as having a certain number of “significant digits”
- “1:30” likely has 2, 1:28 has 3, 1:27:55 has 5
- There are rules that dictate the # of significant digits in a value

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 them are considered significant zeros. However, for a whole number, only zeroes between two significant digits are considered significant.

EXAMPLE

45.8736	**6**	•All digits count
.000239	**3**	•Leading 0’s don’t
.00023900	**5**	•Trailing 0’s do
48000.	**5**	•0’s count in decimal form
48000	**2**	•0’s don’t count w/o decimal
3.980	**4**	•All digits count
1.00040	**6**	•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
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. Determine what your rounding digit is and look to the right side of it. If the digit is 0, 1, 2, 3, or 4 do not change the rounding digit. All digits that are on the right hand side of the requested rounding digit will become 0.

Ex: Rounding 1.2151 to 3 significant figures gives 1.22

#2. Determine what your rounding digit is and look to the right of it. If the digit is 5, 6, 7, 8, or 9, your rounding digit rounds up by one number. All digits that are on the right hand side of the requested rounding digit will become 0.

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**
1	

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

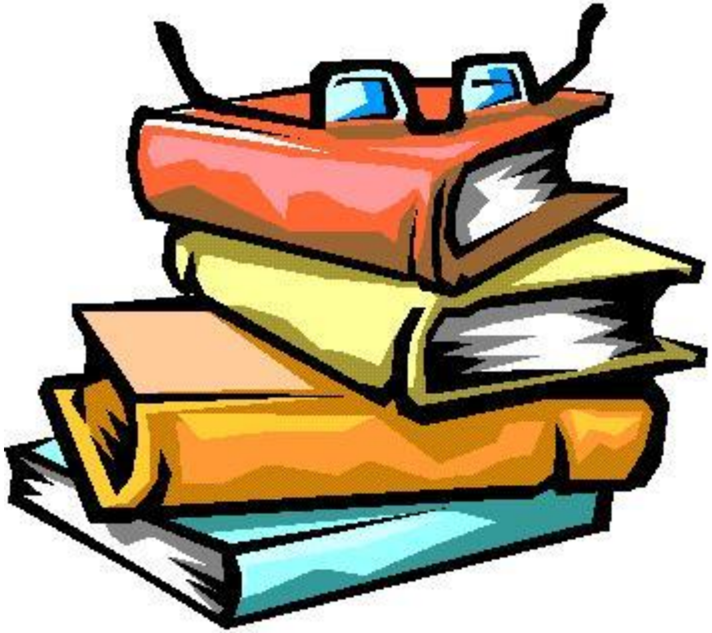
EXAMPLE 2

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

WORKSHEET

– **MEASUREMENT WORKSHEET #1**




STATISTICIAN
ESTIMATES SUGGEST 428,620 PEOPLE HAVE PERISHED.
OH MY GOD, WHAT? THERE'S NO WAY THEY KNOW THAT MANY SIGNIFICANT DIGITS!

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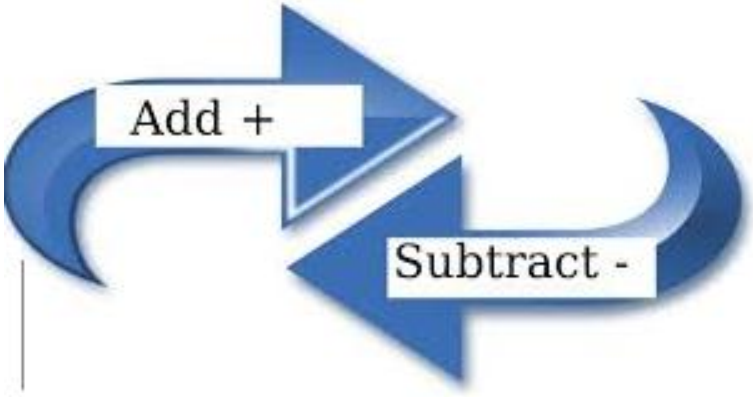
- **Section 3: Topic 4**

ADDING AND SUBTRACTING SIGNIFICANT FIGURES



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:

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

Answer is 641.63

ADDITION/SUBTRACTION

25.5
+34.270
59.770
59.8

32

3

3

3

3

ADDITION AND SUBTRATION

.56 + .153 = .713

82000 + 5.32 = 82005.32

10.0 - 9.8742 = .12580

10 – 9.8742 = .12580

.71

82000

.1

0

Look for the last important digit

i)

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

ii)

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

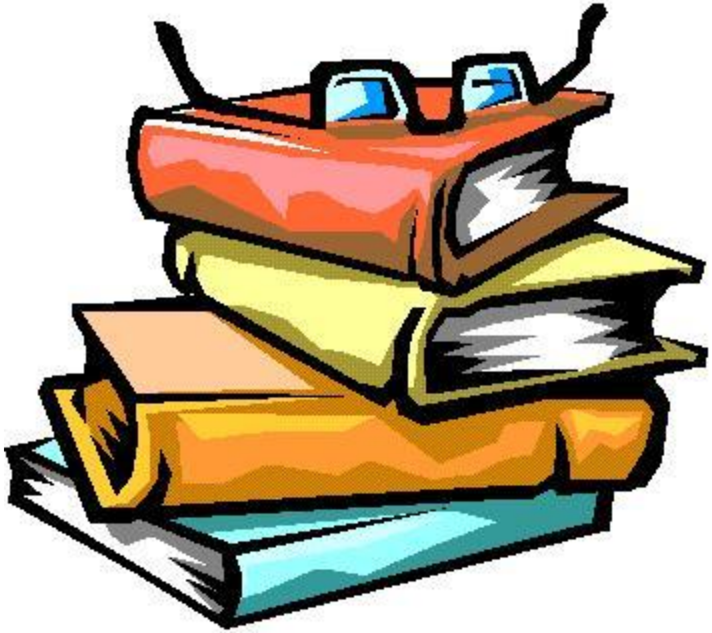
iii)

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

WORKSHEET

– **WORKSHEET MEASUREMENT #2**

– **ADDITION AND SUBSTRACTION**
OF SIGNIFICANT DIGITS



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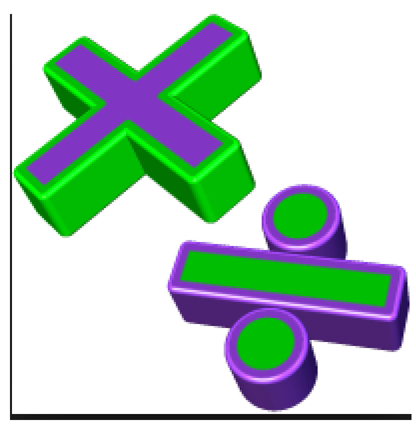
- **Section 3: Topic 5**

MULTIPLYING AND DIVIDING SIGNIFICANT FIGURES



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/DIVISION

$32.27 \times 1.54 = 49.6958$ **49.7**

$3.68 \div .07925 = 46.4353312$ **46.4**

$1.750 \times .0342000 = 0.05985$ **.05985**

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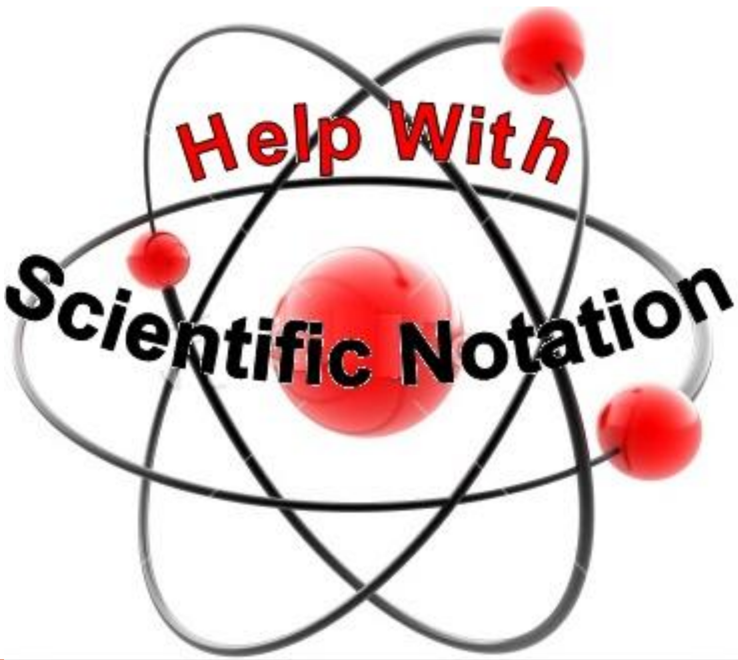
- **Section 3: Topic 6**

SCIENTIFIC NOTATION



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 x 10^8

- **a small number**

Charge on an electron => 0.0000000000000000001602 C

=> 1.602 x 10^{-19}

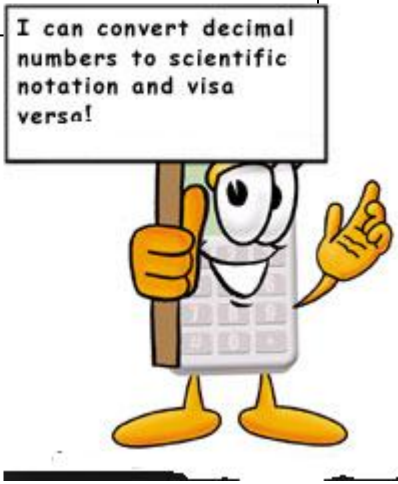
2) helpful for indicating how many significant figures are present in a number

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

Scientific notation

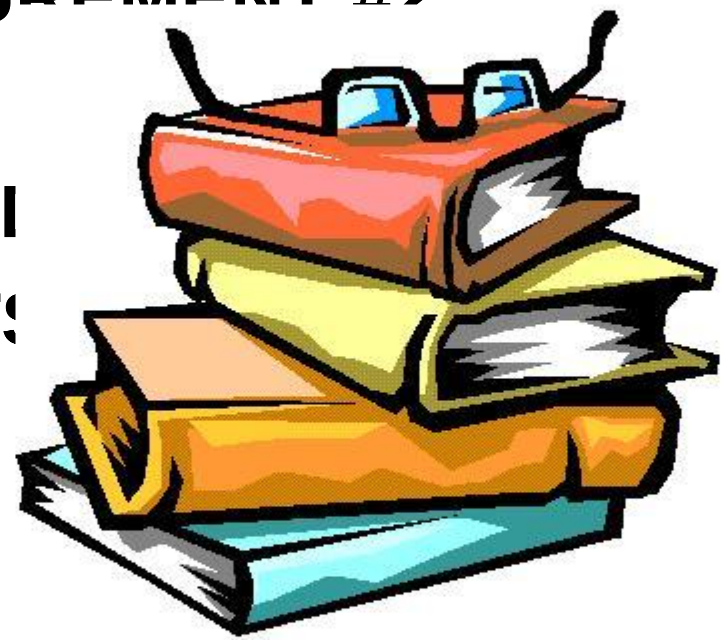


- Read "Scientific Notation" on page 621
- **Complete the chart below**

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}

WORKSHEET

– **WORKSHEET MEASUREMENT #2**



– **MULTIPLICATION AN**

OF SIGNIFICANT DIGIT

&

SCIENTIFIC NOTATION

EDUCATIONAL VIDEO

BILL NYE SCIENCE GUY

MEASUREMENT

Bell Aliant

Science 1206

- **Section 3: Topic 7**

Sources of Error

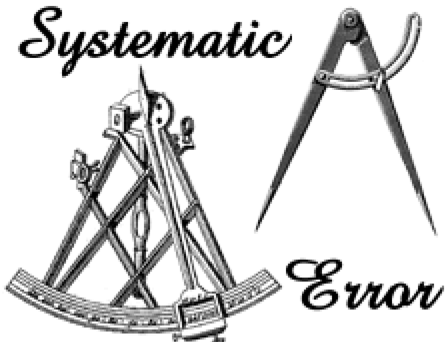
and

Percent Discrepancy

No matter how careful we are and no matter how expensive our equipment is, no measurement made is ever exact. The **accuracy (correctness)** and **precision (number of significant figures)** of any measurement is always limited by a variety of factors:

- the skill of the observer (that is you or your lab partner)
- calibration of the measuring equipment
- the environment in which the experiment is performed.

Sources of Error



Two types of errors are possible

1. **SYSTEMATIC ERROR (YOU CAN FIX)**

They are often due to a problem that persists throughout the entire experiment and is usually the result of a mis-calibrated device, or a measuring technique that always makes the measured value larger (or smaller) than the "true" value. You can usually fix these errors by inspecting and recalibrating equipment regularly

Examples:

- Parallax : The change in relative position of an object with a change in the viewing angle

-a clock that runs slow or a ruler with a rounded end

- The balance arm on a triple beam balance is not exactly on the zero mark.

2. RANDOM ERROR (UNPREDICTABLE)

These errors usually result from the experimenter's inability to take the same measurement in exactly the same way to get exact the same value. They can be reduced by taking many measurements and then averaging them (and having the same person take the measurement each time

Example:

-a person measuring the length of an object using a ruler must estimate the last digit; another person may not estimate to the same digit

- You measure the mass of a wooden block four times using the same balance and get slightly different values: 57.46 g, 57.48 g, 57.45g, and 57.47g

PERCENT DISCREPANCY

The simplest way to express accuracy mathematically is percent discrepancy.

The difference between the value determined by your experimental procedure and the generally accepted value

$$\% \text{ Discrepancy} = \left| \frac{\text{Experimental value} - \text{accepted value}}{\text{accepted value}} \right| \times 100$$

Example: A student measures the acceleration due to gravity and finds it to be 9.72 m/s^2. If the accepted value is 9.81 m/s^2, what is the percent discrepancy.

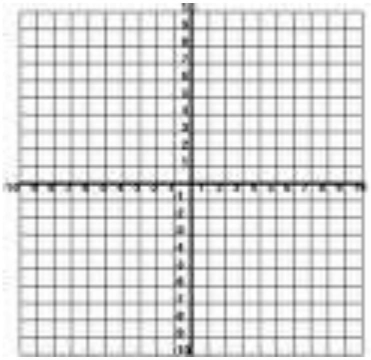
Activity

- Extra Read Text P.5
- Text Practice Problems: See handout sig figs, conversion and other

Science 1206

- **Section 3: Topic 8**

Graphing



Step 1. Identify dependent variable and independent variable

INDEPENDENT VARIABLE

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

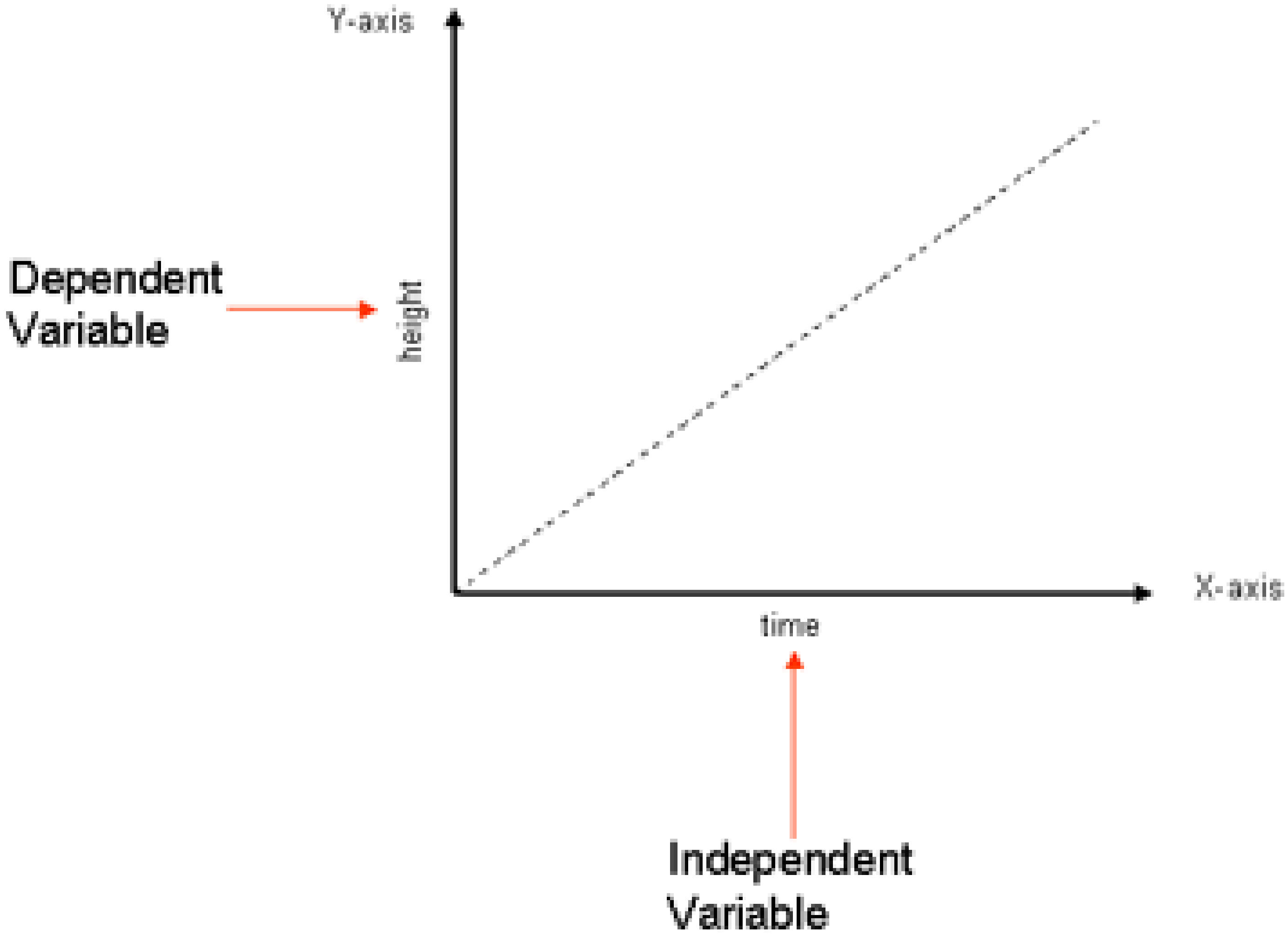
- **DEPENDENT VARIABLE**

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

  Ex: distance
- is always plotted on the y-axis

- Graphing Experimental Results, Page 700
- &Often when we've done an experiment, we wish to communicate our results to others. The most effective way to do this is often by graphing the data.

- Example: A Running White-Tailed Deer, page 362



REMEMBER DID

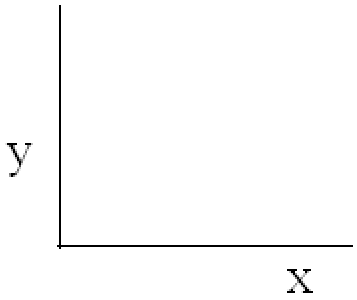
Example: A Running White-Tailed Deer

TIME	DISTANCE
0	0
1	11
2	25
3	40
4	51
5	66
6	78

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!



Step #3: Put a title on the graph

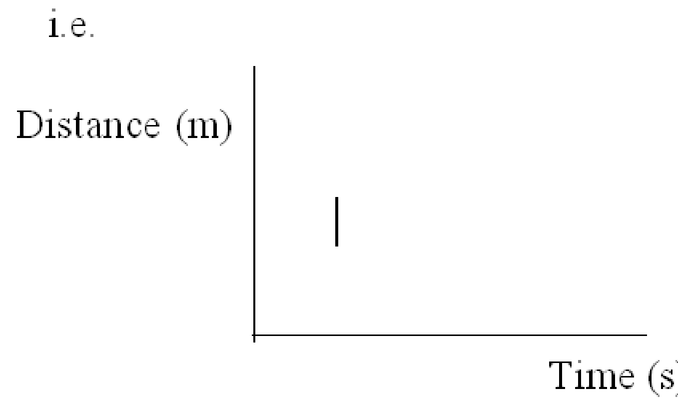
Titles of graphs are usually "Y versus X" or Dependent Variable versus Independent Variable. For example. A graph will be given the title "distance versus Time." (NOT ditance divided by time, or distance minus time.)

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?).

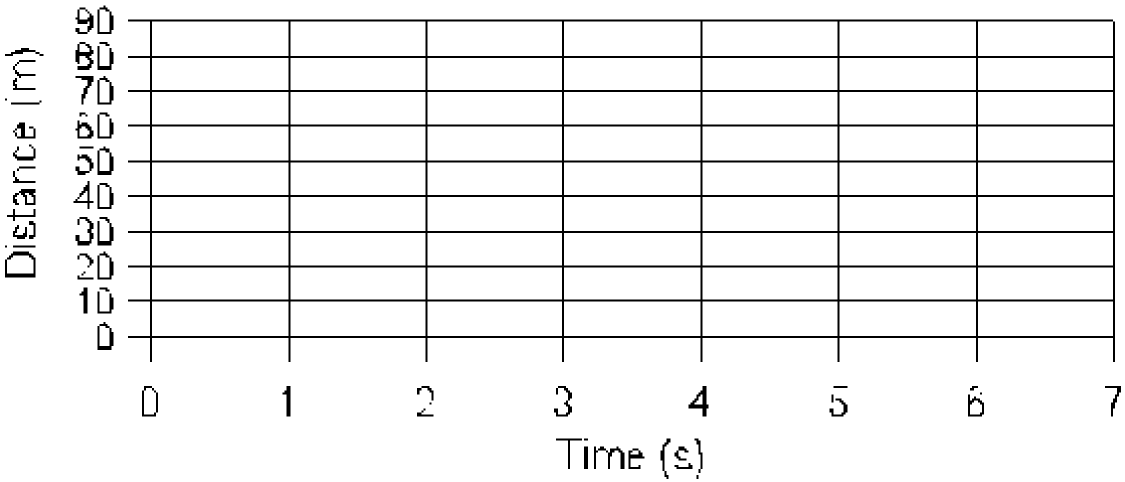


However, people frequently forget to put a label on the axis that describes what those numbers are, and even more frequently forget to say what those units are.

- .

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.



i.e. For Distance:

Range = Maximum Value - Minimum Value

= 78 m - 0 m

= 78 m

For Time:

Range = Maximum Value - Minimum Value

= 6.0 s - 0 s

= 6.0 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”

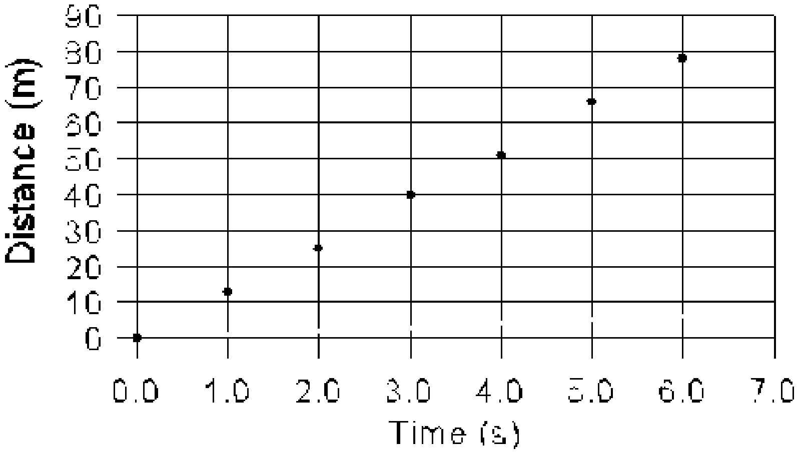
- i.e. For the x-axis: Each line equals 1 second

  For the y-axis: Each line equals 10 m

Step #7: Plot the Points

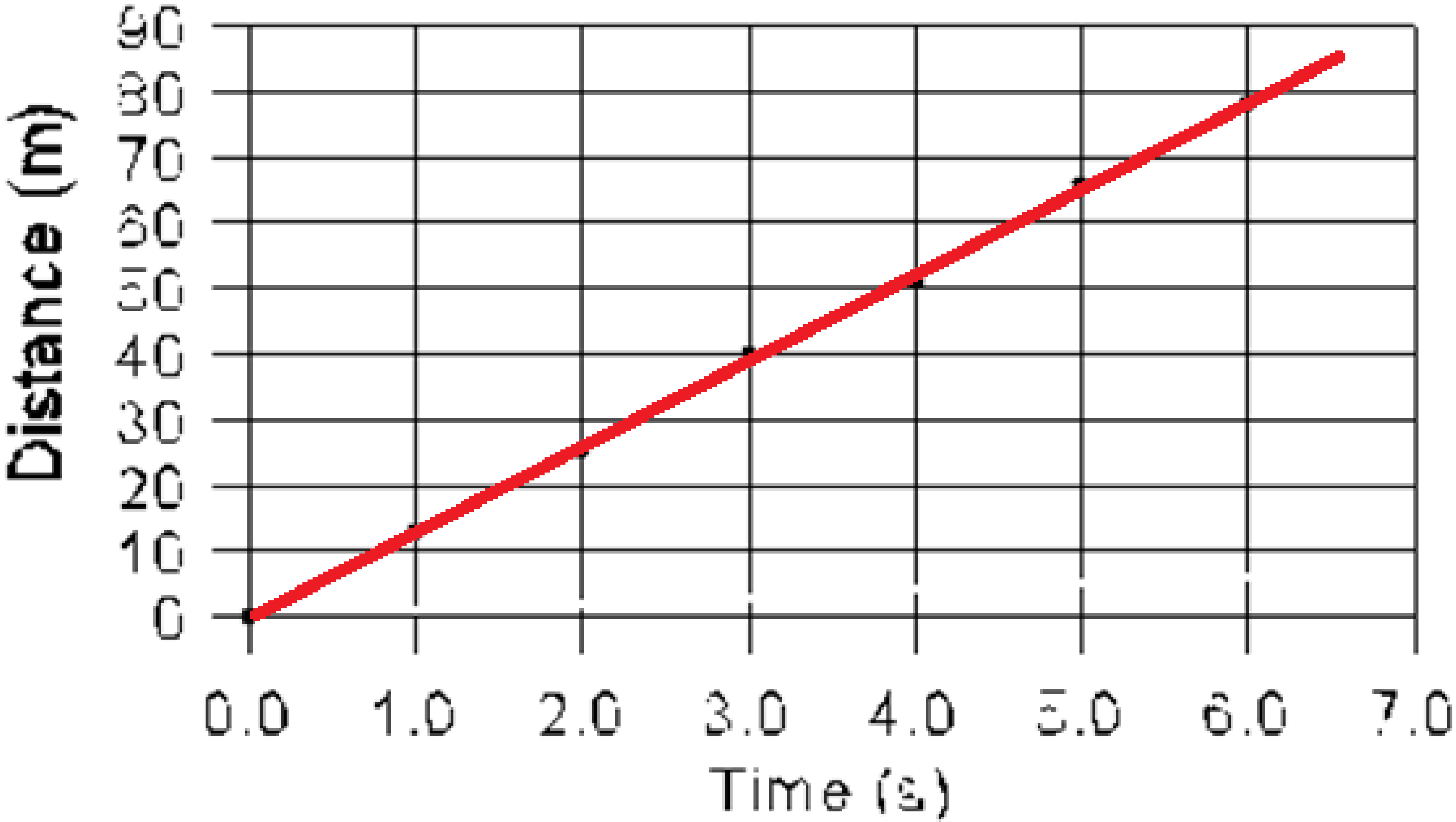
- Start with the first pair of values from the data table, in this case 0 s and 0 m.

- .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.



Step #6: 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.



Distance (m)
90
80
70
60
50
40
30
20
10
0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
Time (s)

Distance-Time Graphs, p.363-364

- 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.

Ex 1: In the previous example of the running white-tailed deer, the slope is found by,

$$\text{Slope} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{d_2 - d_1}{t_2 - t_1} = \frac{(66\text{ m} - 25\text{ m})}{(5.0\text{ s} - 2.0\text{ s})}$$

= **14 m/s**

Ex 2: In the second class example,

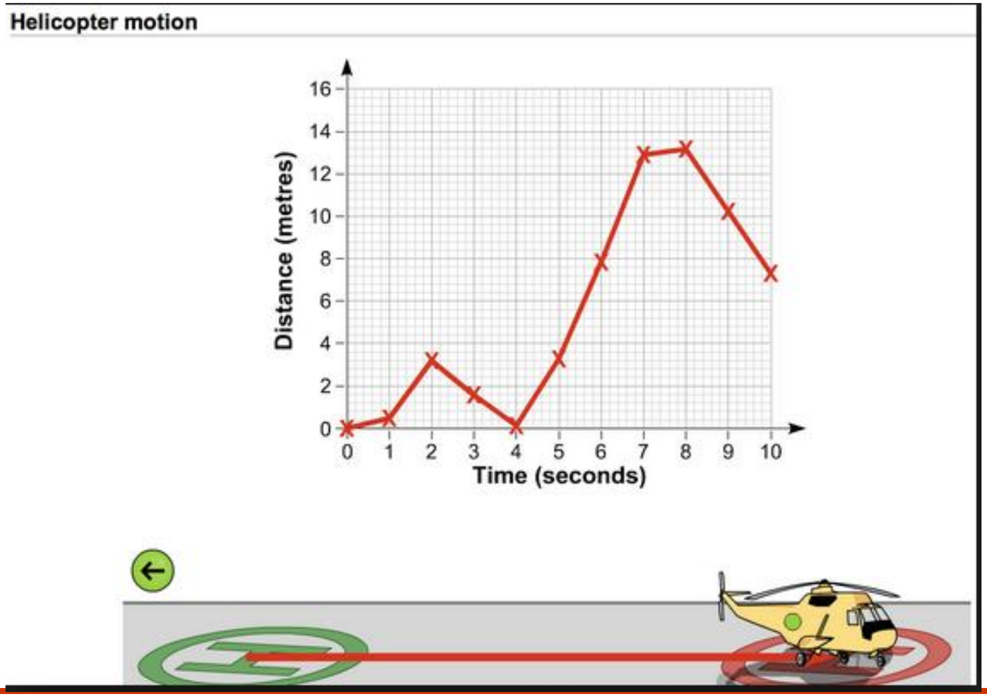
$$\text{Slope} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{d2 - d1}{t2 - t1} = \frac{(38\text{ m} - 10\text{m})}{(120.0\text{ s} - 30.0\text{s})}$$

= 0.31 m/s

Science 1206

- **Section 3: Topic 9**

Mathematical Relationships

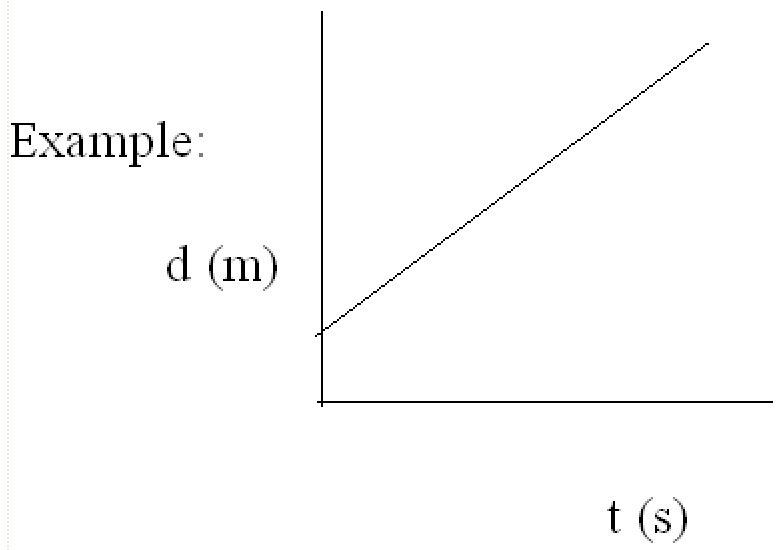


Types of Relationships

- 1. <u>DIRECT PROPORTIONALITY</u>
- occurs when a change in the independent variable causes a corresponding change in the dependent variable, as in the case of the straight line graph

- written mathematically as y ά x
- spoken as “ y is directly proportional to x”

Example



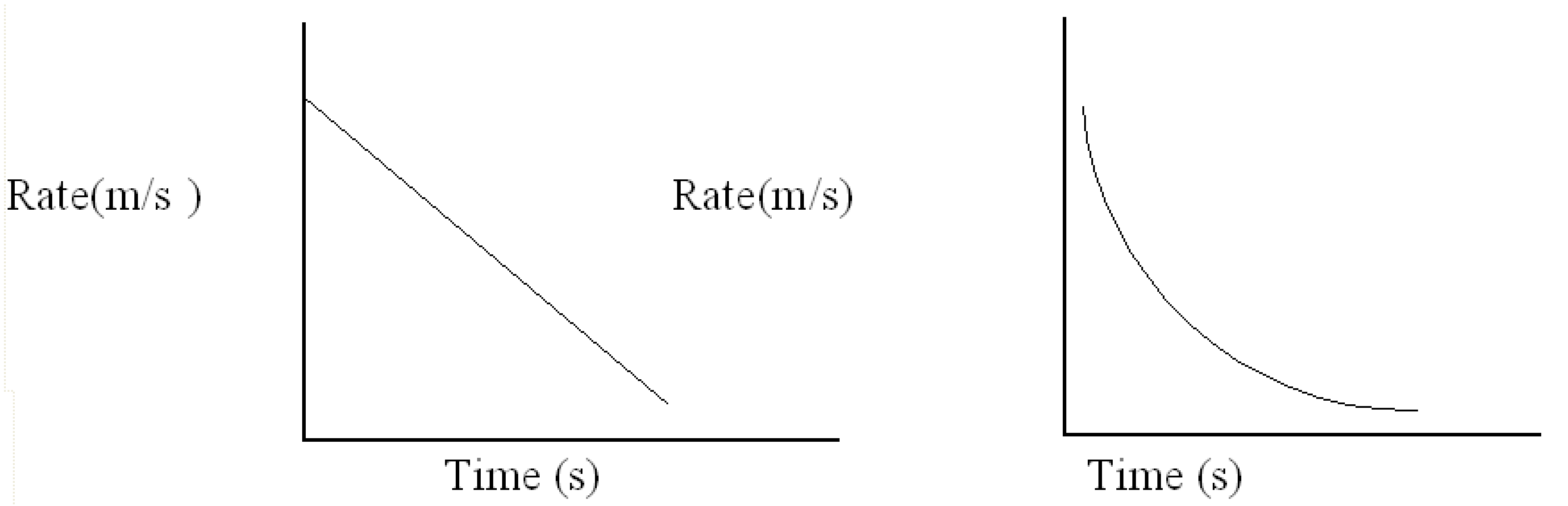
In the example above, d increases as t increases.

INVERSE (INDIRECT) PROPORTIONALITY

– .occurs when a change in the independent variable causes an inverse (or reciprocal) change in the dependent variable.

– written mathematically as y ά 1 /x

Examples



In Example A, rate **decreases** as time **increases** at a **constant rate**

In Example B, rate decreases as time increases at a **non-constant**

Writing an Equation for 2 Quantities Related by a Straight Line Graph

- **Recall: Running White-Tailed Deer Example**
- **When a line of best fit is a straight line, there is a simple relationship between the two variables. This relationship can be represented by a general mathematical equation:**
- **y = mx + b**
- **where**
  - **y** is the dependent variable = DISTANCE
  - **x** is the independent variable = TIME
  - **m** is the slope (steepness) of the line
  - **b** is the y-intercept (i.e. where the graph crosses the y-axis) - AT POINT (0,0)

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)!

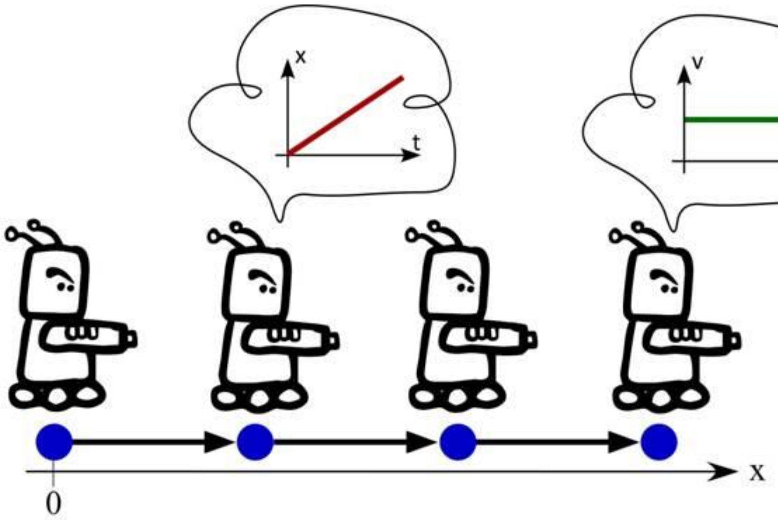
$$\text{SPEED (v)} = \frac{\Delta d}{\Delta t}$$

PHYSICS LABORATORY

- STUDY OF UNIFORM MOTION

- **Section 3: Topic 10**

Uniform Motion



"I'd like to give you a break, but we did have you doing a hundred and eighty-six thousand miles a second on the radar."


SPEED
MATTERS

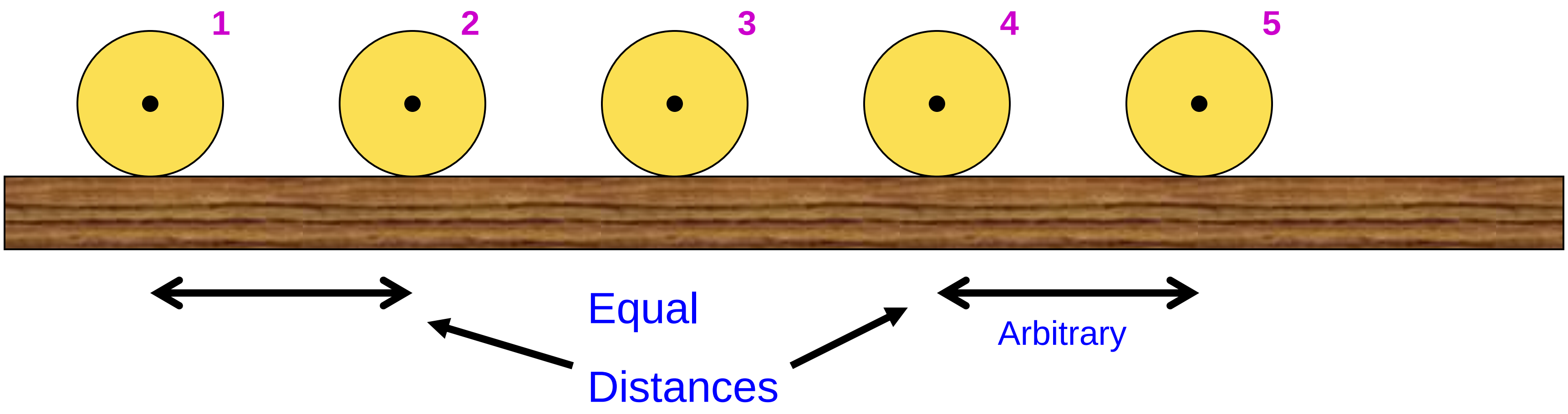
What is Uniform Motion?

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

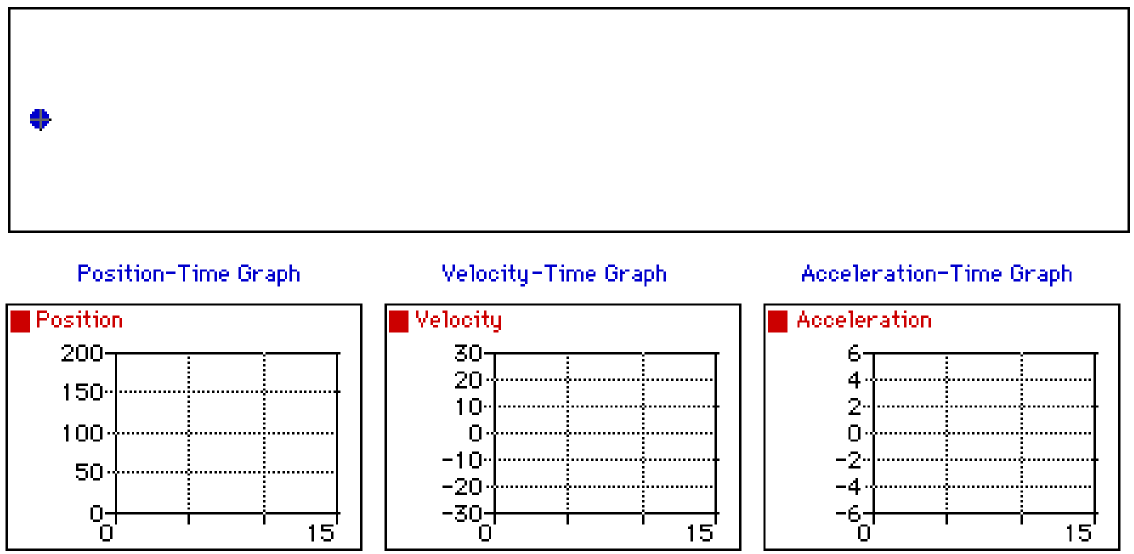
Uniform Motion



Rolling ball is an example of uniform motion.

1)Speed of the ball is constant (with no friction).

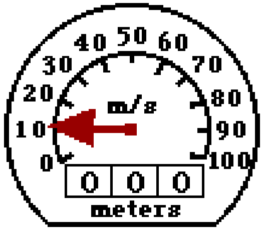
2) In a straight line



Position-Time Graph
Velocity-Time Graph
Acceleration-Time Graph
Position
200
150
100
50
0
0
15
Velocity
30
20
10
0
-10
-20
-30
0
15
Acceleration
6
4
2
0
-2
-4
-6
0
15

INSTANTANEOUS SPEED

- 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.**



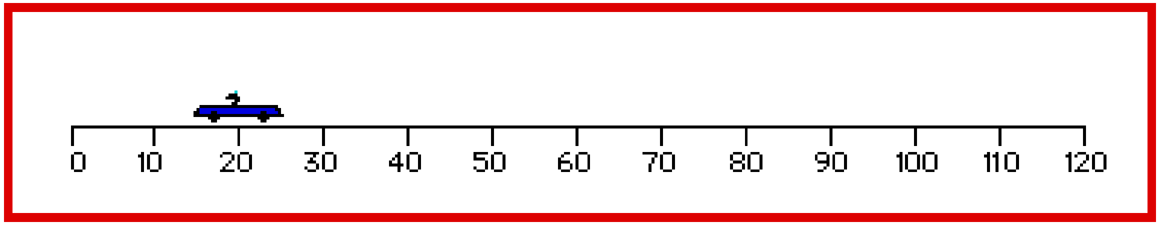
Units For Speed

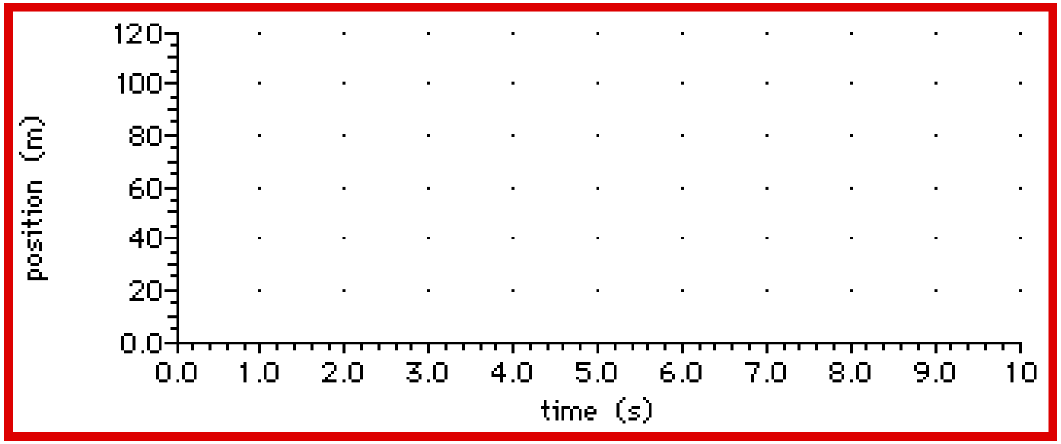
- Depends, but will always be a distance unit / a time unit
  - Ex. Cars: km/h
  - Jets: km/h
  - Snails: cm/s
  - Falling objects: m/s

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



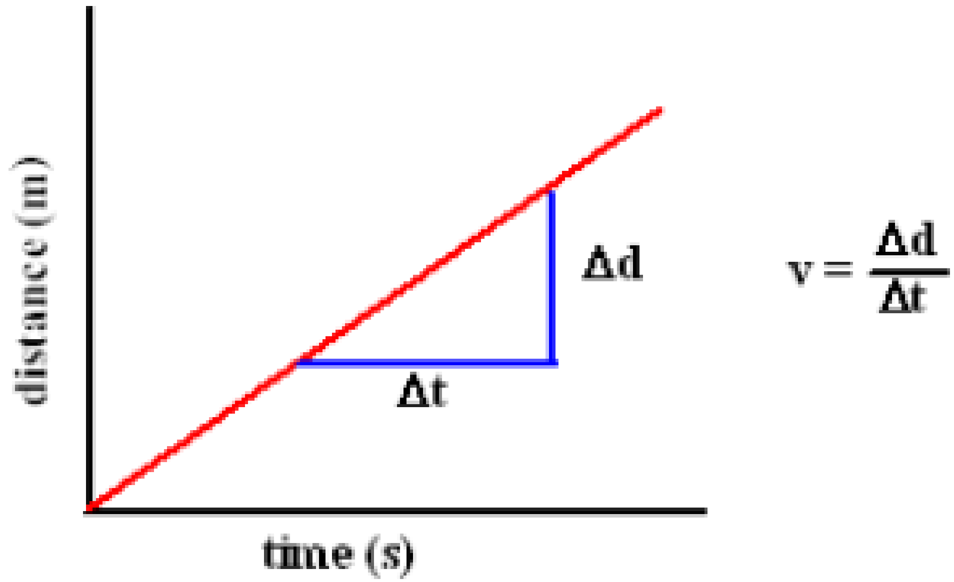


Graphing Speed
Distance vs. Time Graphs

Speed = Slope = Rise/Run

Rise/Run = 600 km/3 hr

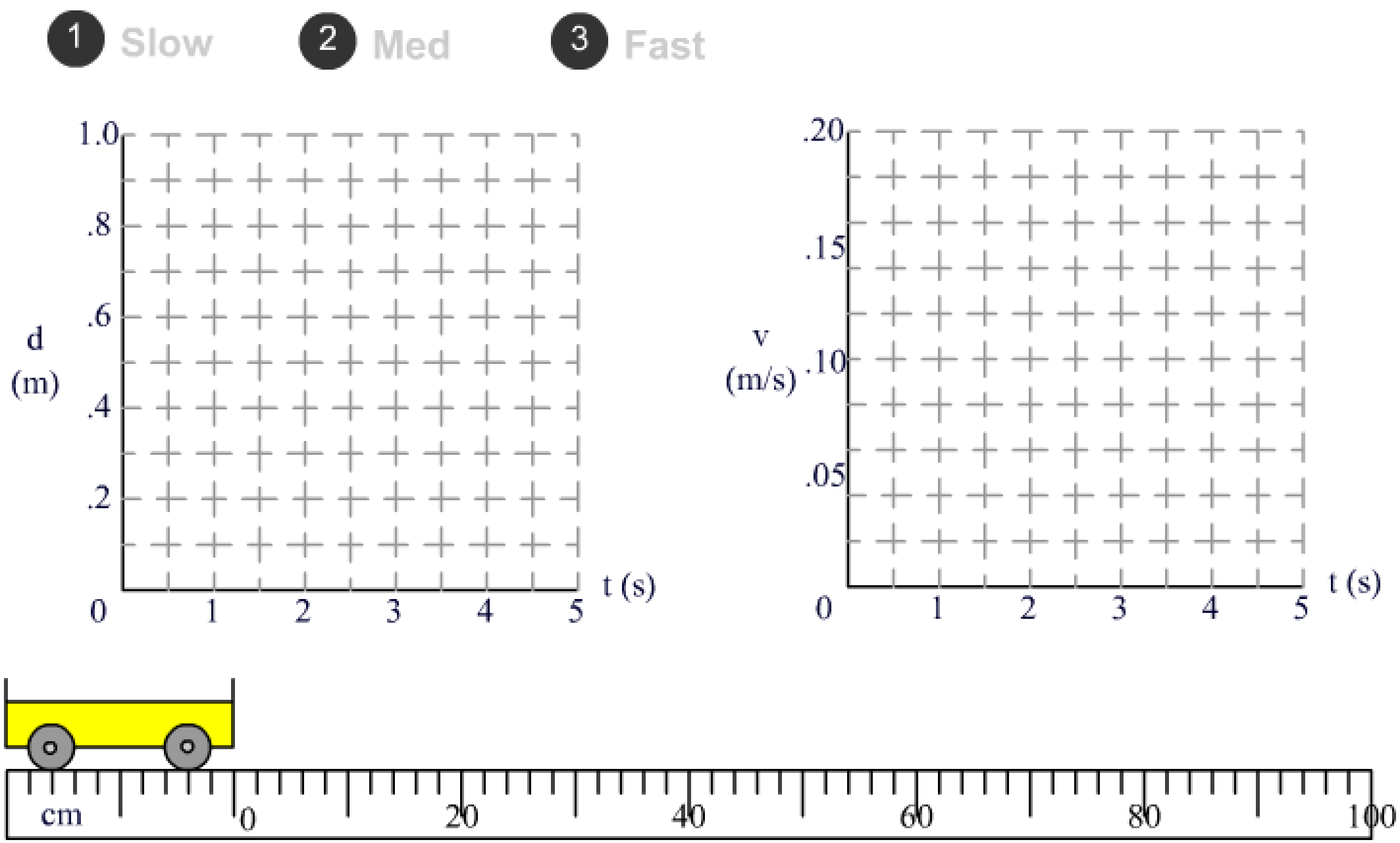
= 200 km/hr



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

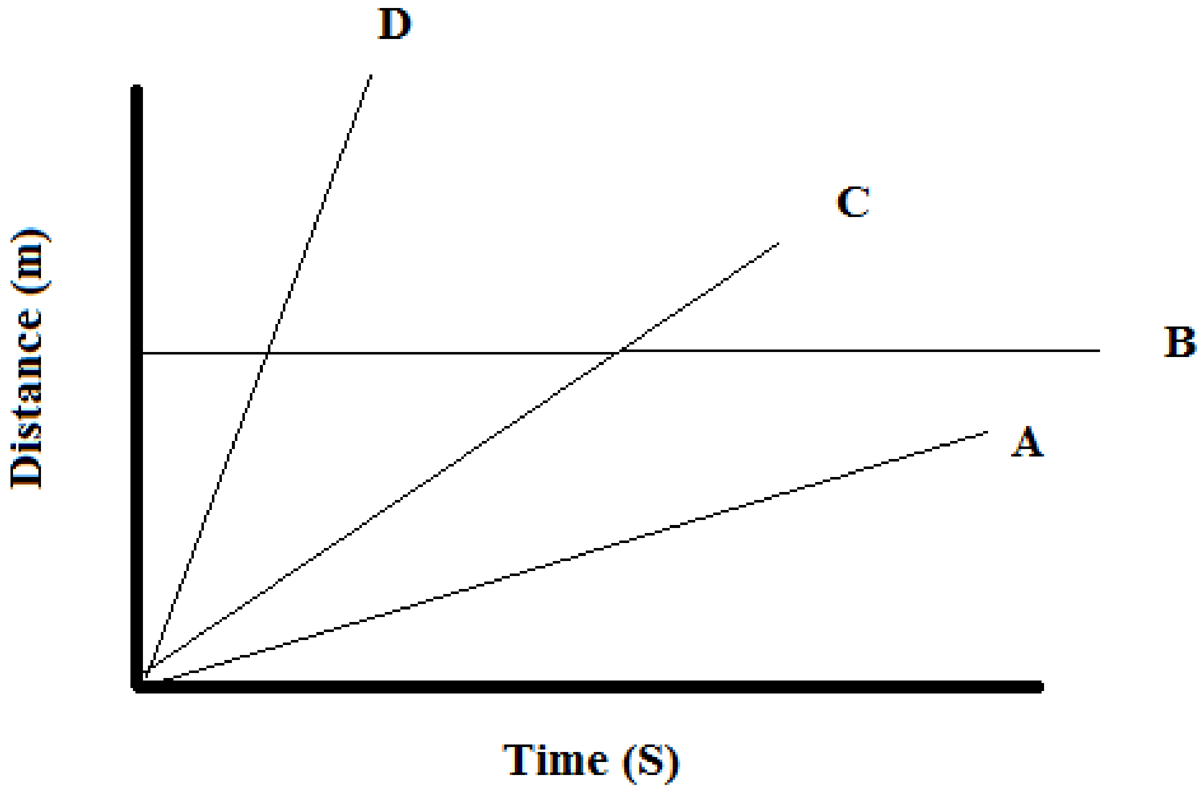
Since the slope is the same no matter what points are chosen, the object is moving at a CONSTANT speed, thus the instantaneous speed remains the same at all points.

Slopes and Speeds



The greater the slope, the faster an object is moving

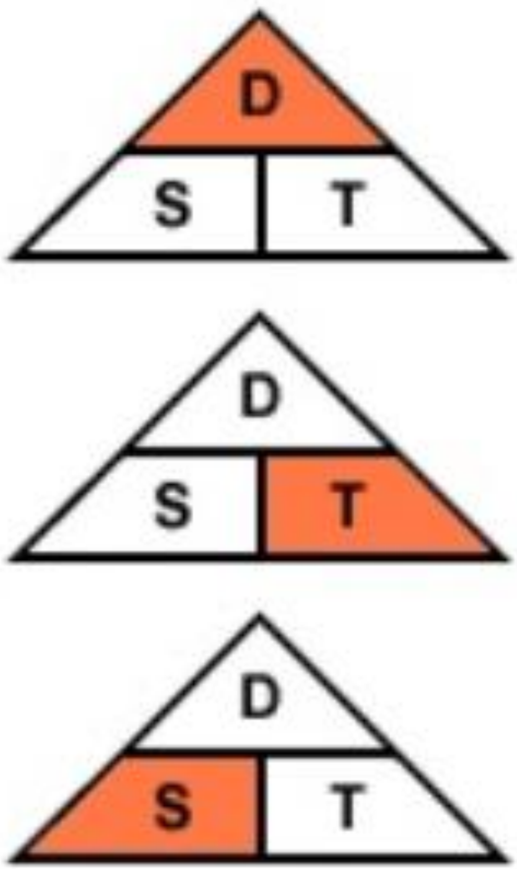
Which object is moving the fastest?



SPEED

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

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



Distance = Speed x Time

$$\text{Time} = \frac{\text{Distance}}{\text{Speed}}$$

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

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:

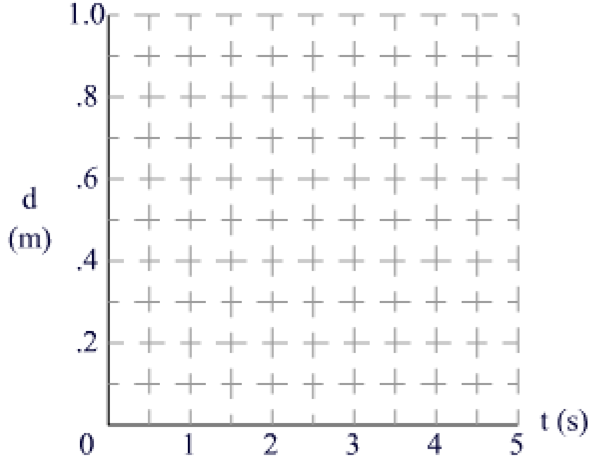
If you run a t 12 m/s for 15 minutes, how far will you go?

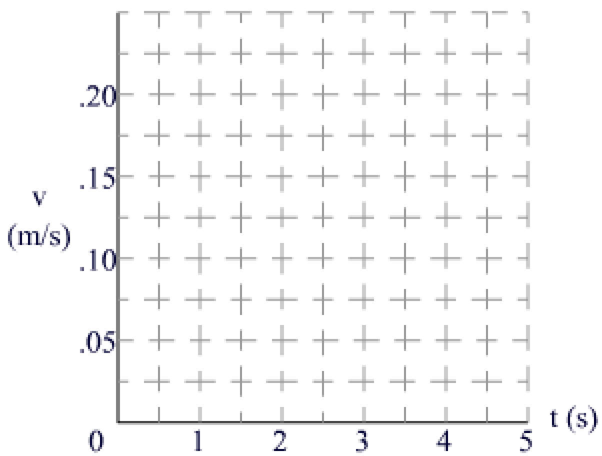
Example 5:

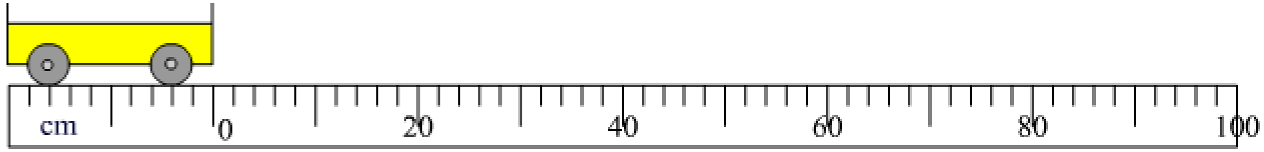
A bullet travels at 850 m/s. How long will it take a bullet to go 1 km?

Uniform Motion in Two Parts

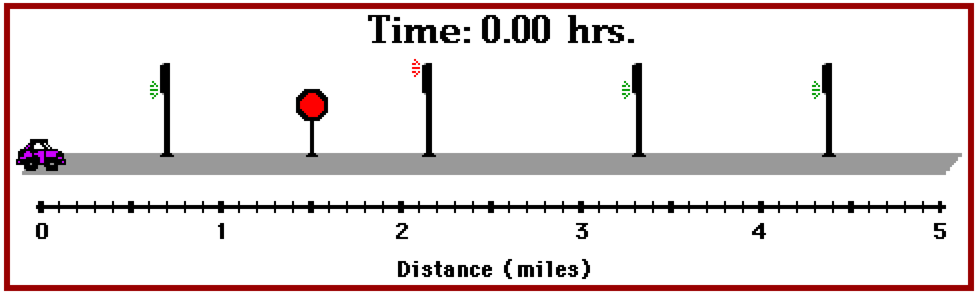
1 0 - 3 s   2 3 - 5 s   3 0 - 5 s







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:

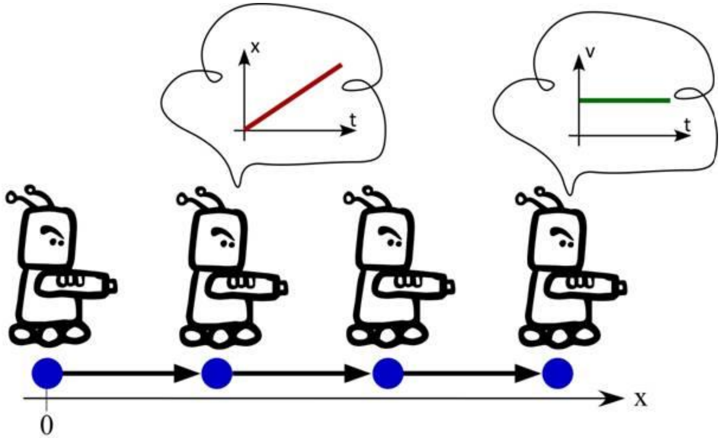
You go out for some exercise in which you run 12.0 km in 2 hours, and then bicycle another 20.0 km in 1 more hour. What was your average speed for the entire marathon?

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

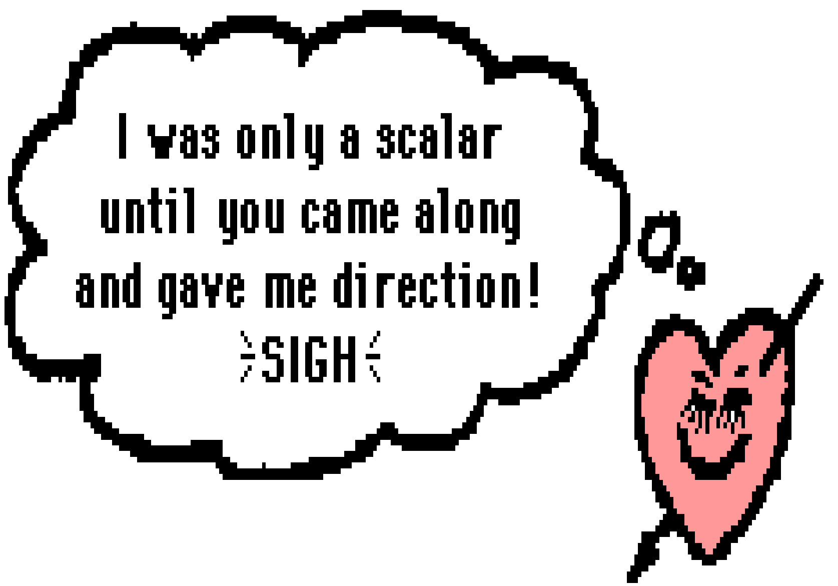
- Instantaneous Speed refers to the speed at which an object is moving at a particular moment in time.

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

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

- **Section 5: Topic 11**

SCALARS AND VECTORS

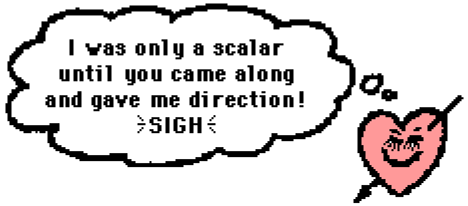


Scalar Quantity

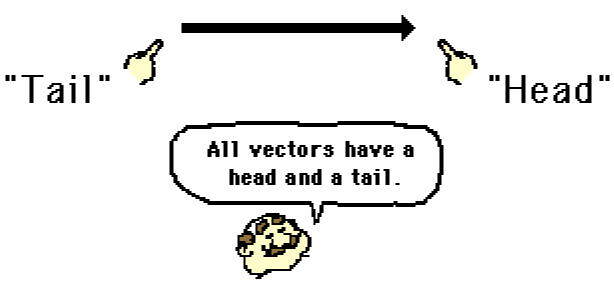
- **a quantity that involves size, but not direction ie. has a magnitude and units.**

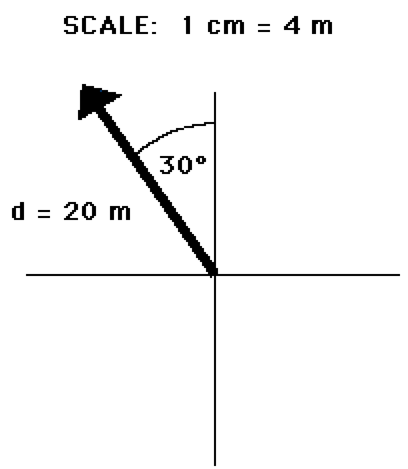
Scalar Example	Magnitude
Speed	20 m/s
Distance	10 m
Time	15 hours
Mass	95 kg

Vector Quantity



- **A quantity that involves direction ie. has a magnitude, units and direction.**
- **Eg. displacement, velocity**

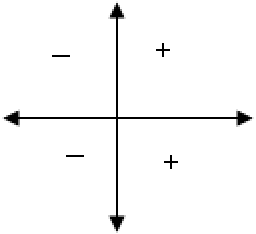




Direction

- Stated relative to a reference point (usually the origin or starting point).
- Can be indicated by:

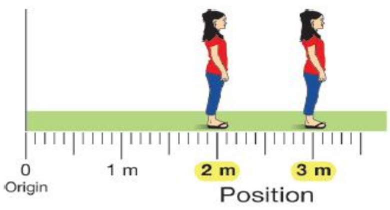
Geography	Space	Vector	Sign (+ / -)
North	Up	↑	+
South	Down	↓	-
West	Left	←	-
East	Right	→	+



Distance –Position- Displacement

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

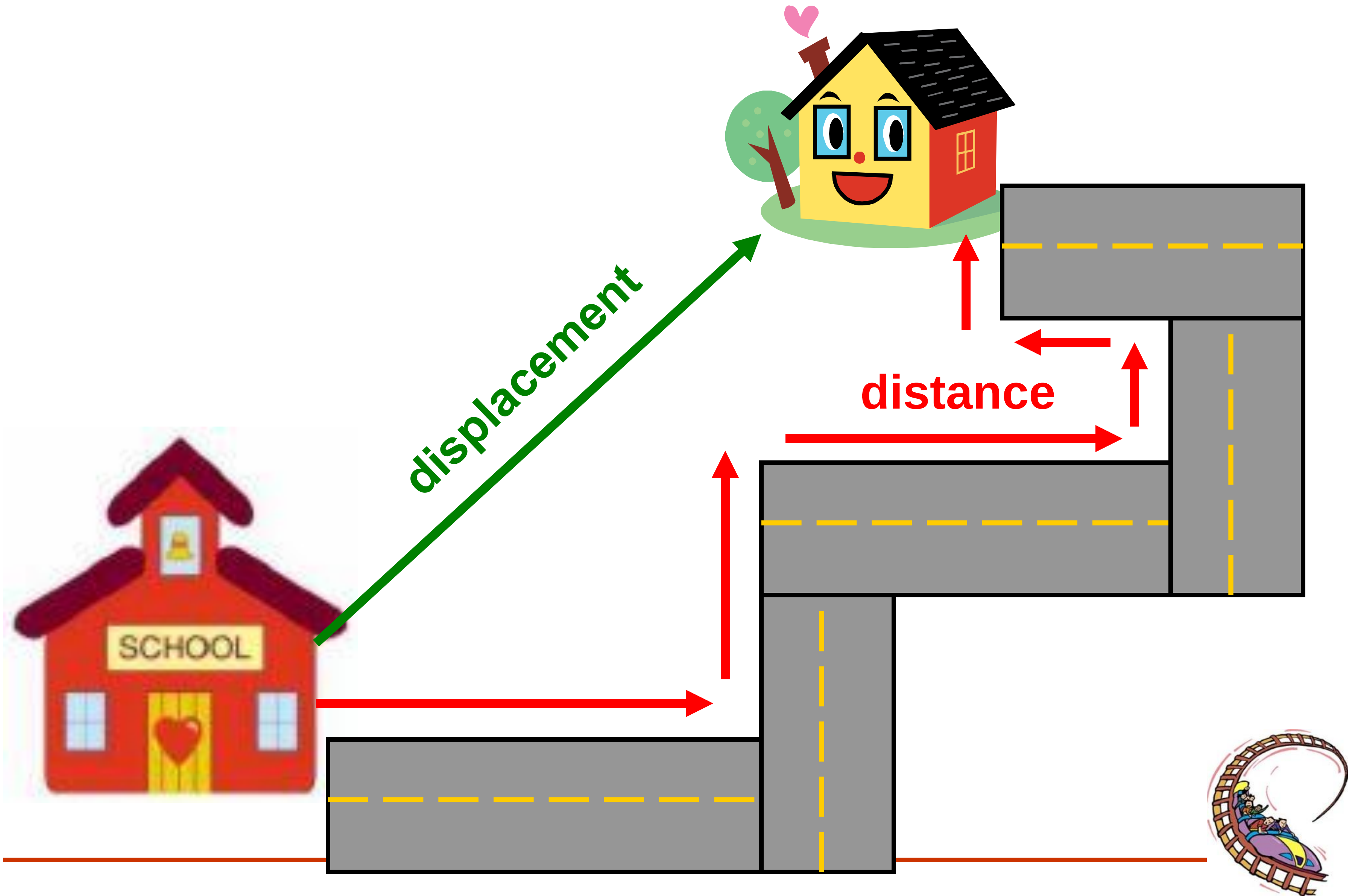
Position $(\vec{d})$ is a <u>vector quantity</u> which refers to the straight line distance and direction from a reference point. Location of an object at one instant



Displacement $(\Delta \vec{d})$ is a <u>vector quantity</u> 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

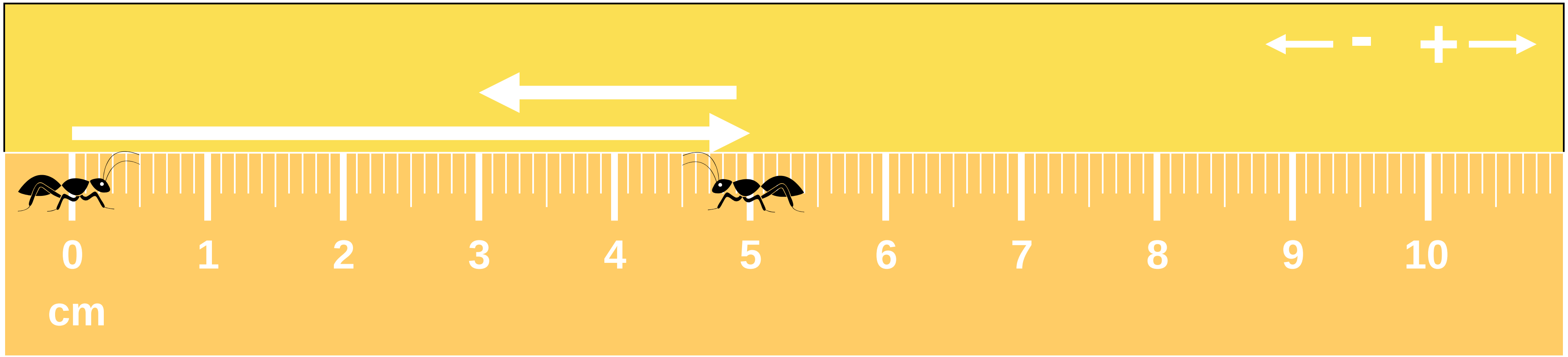
$$\overrightarrow{\Delta d} = \overrightarrow{d_2} - \overrightarrow{d_1}$$

Displacement Vs distance



Example

- Find the distance and displacement of the ant.



- Distance: 7 cm
- Displacement: +3 cm

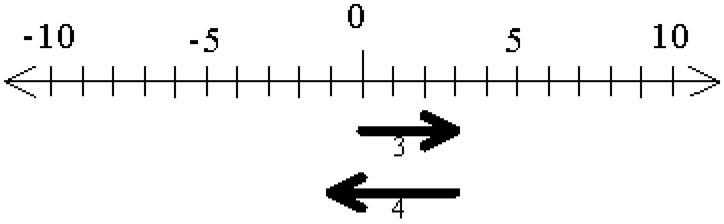
Example 1: One Dimension =>Adding Vectors

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

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*

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

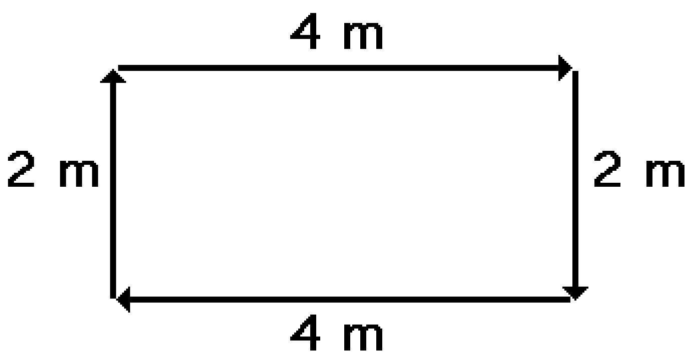
Example 2: Return Trip

A physics teacher walks 4 meters East, 2 meters South, 4 meters West, and finally 2 meters North.

A) What is the distance?

4.0m + 2.0 m + 4.0 m + 2.0 m = 12.0 m

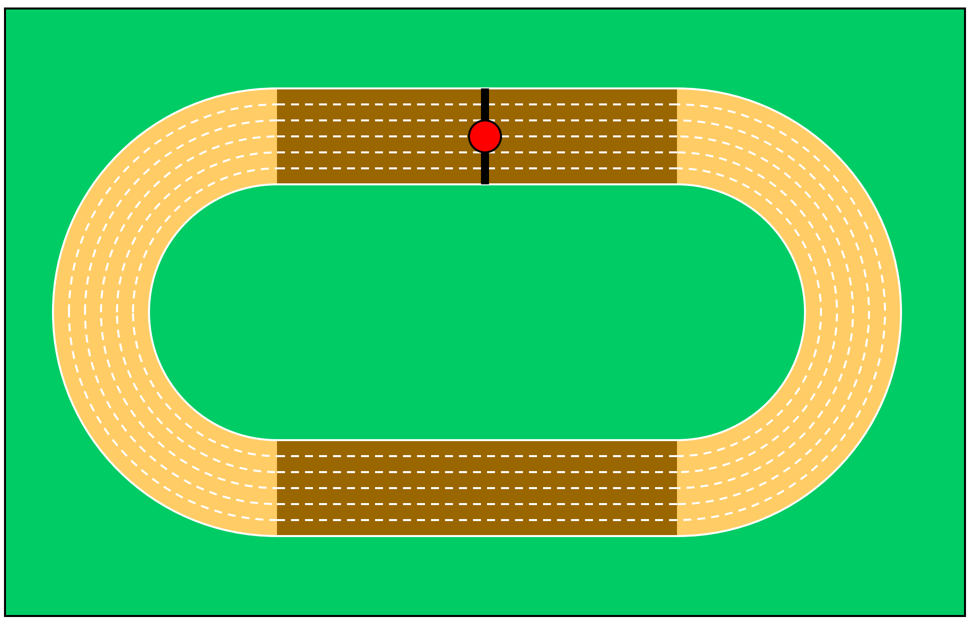
B) What is the displacement?



displacement = 0 m

Example 3

- An athlete runs around a track that is 100 meters long three times, then stops.
  - What is the athlete's distance and displacement?



- Distance = 300 m
- Displacement = 0 m
- Why?

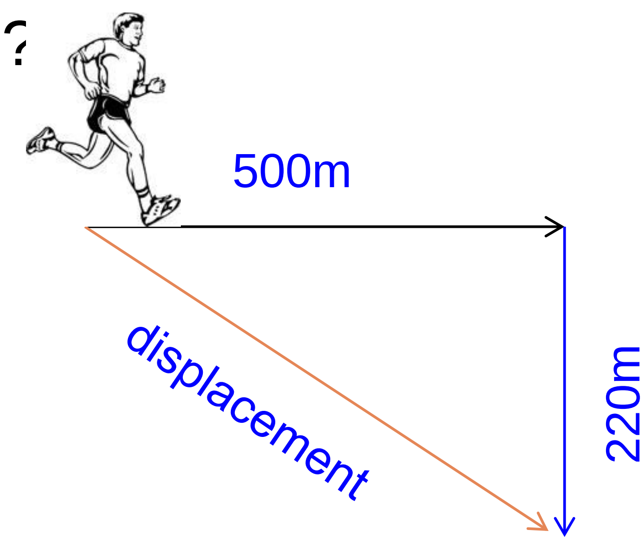
Example 4: Two Dimensions

A jogger runs 500 m [East], then turn and runs 220 m [South] before stopping for a short rest. What is the jogger's

A) Total Distance travelled?

Distance = 500 m + 220 m = 720 m

B) Displacement from his original position?



Magnitude

$$\vec{d}^{\,2} = (500)^2 + (220)^2$$

$$\vec{d}^{\,2} = 2500 + 48400$$

$$\vec{d}^{\,2} = 298400$$

$$\vec{d} = \sqrt{298400}$$

$$\vec{d} = 546m$$

Displacement = 546m [E 24^{O} S]

Student Questions:

1. A car travels 10 km [North] then turns and goes 8 km [South]. Which statement is correct?

(a) the distance is 18 km and the displacement is 2 km.

(b) the distance is 2 km and the displacement is 18 km.

(c) both the distance and the displacement are 18 km.

(d) both the distance and the displacement are 2 km.

2. Which statement is true?

(a) Displacement can never be equal to distance.

(b) Displacement can never be greater than distance.

(c) Displacement can never be less than distance.

(d) Displacement is always equal to distance.

3. A car moves to the right 100 m then goes to the left for 150 m. What is the displacement (assuming motion to the right is positive)?

(a) 250 m

(b) 50 m

(c) -50 m

(d) 100 m

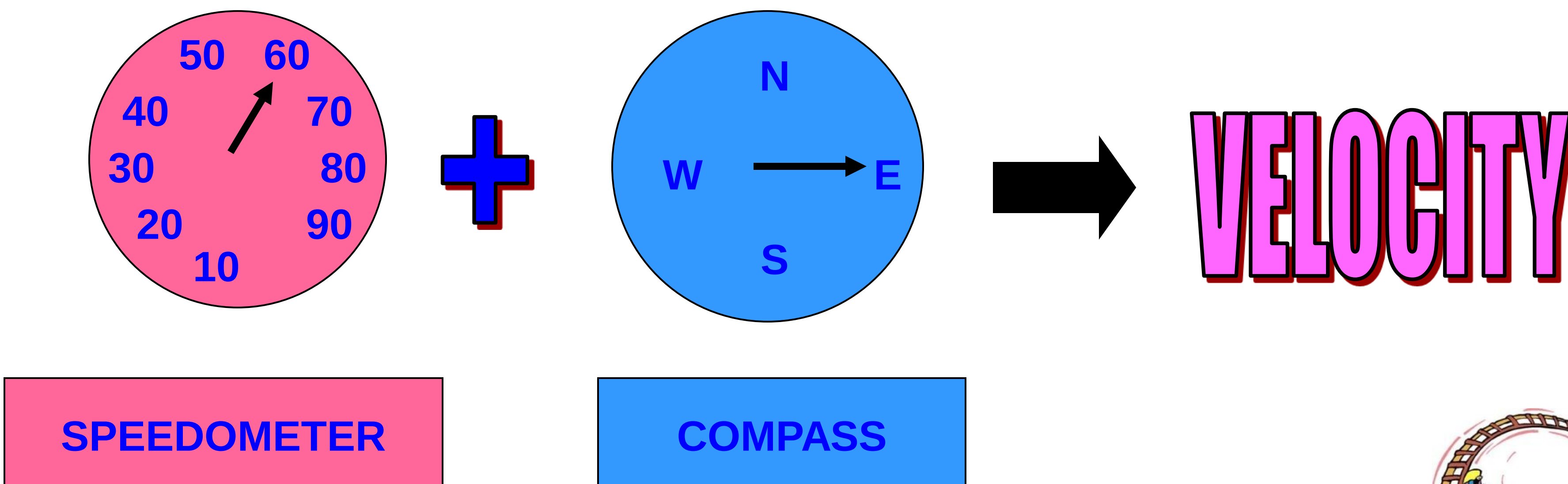
Speed & Velocity

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.

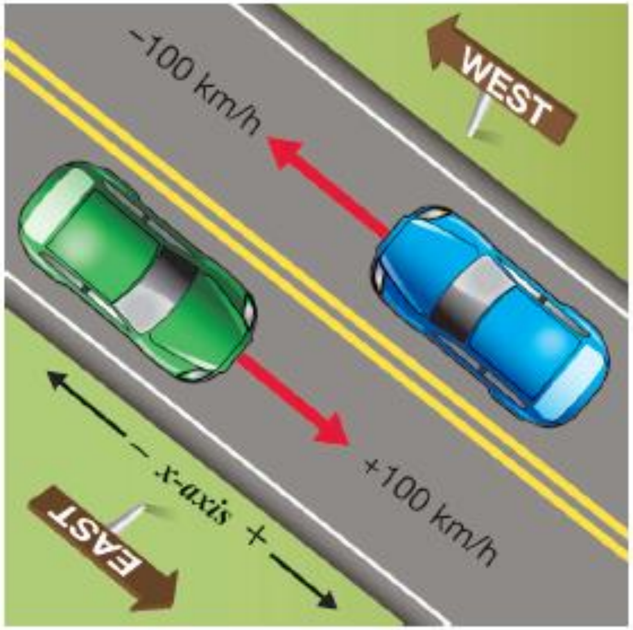
Speed is a scalar (direction doesn't count!)



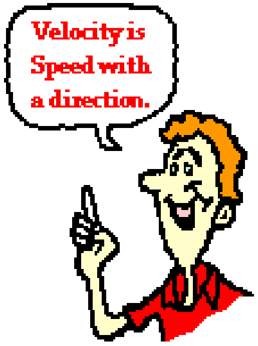
- The *velocity* of an object tells you both its speed and its direction of motion.

- 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.



Movie

Velocity and Displacement

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

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

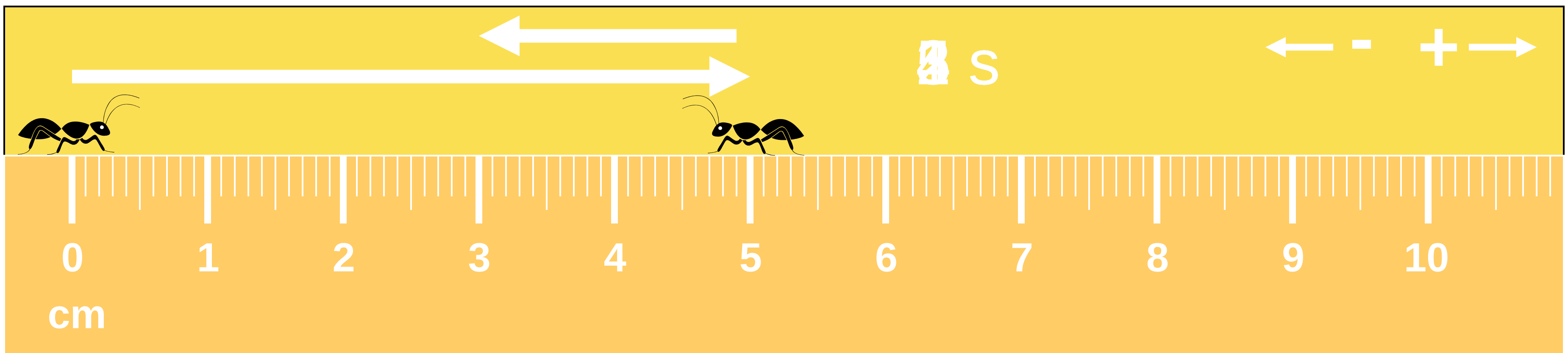
Speed and Distance

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

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

Pulling It All Together

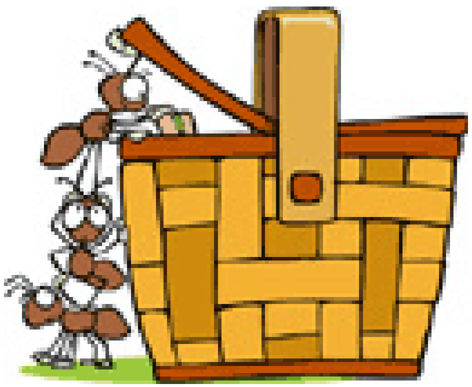
- Back to our !



  - Distance traveled: 7 cm
  - Displacement: +3 cm
  - Average speed: (7 cm) / (5 s) = 1.4 cm/s
  - Average velocity: (+3 cm) / (5 s) = +0.6 cm/s

Example 1

An ant on a picnic table walks 130 cm to the right and then 290 cm to the left in a total of 40.0 s. Determine the ant's distance covered, displacement from original point, average speed, average velocity.



- **Solution**

distance = *d* = total path of the ant = l30 cm + 290 cm = 420 cm

displacement = ***d*** = change in position of the ant =130cm+ (−290) cm

=−160 cm = 160 cm [left] of the starting point

average speed:

$$v_{av} = \frac{d_{tot}}{t_{tot}} = \frac{420\text{ cm}}{40.0\text{ s}} = 10.5 = 11\text{ cm/s}$$

average velocity:

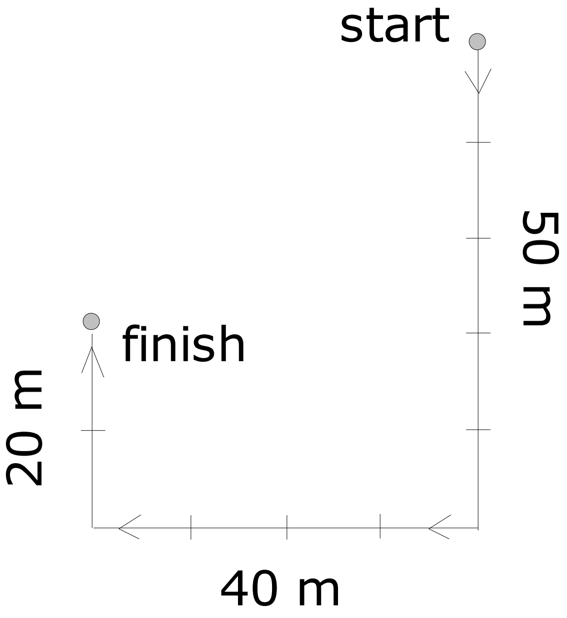
$$\mathbf{v}_{av} = \frac{\mathbf{d}_{tot}}{t_{tot}} = \frac{^{-}160\text{ cm}}{40.0\text{ s}} = {}^{-}4.0 = 4.0\text{ cm/s to the left (or West)}$$

The 'Ant's Prayer'...

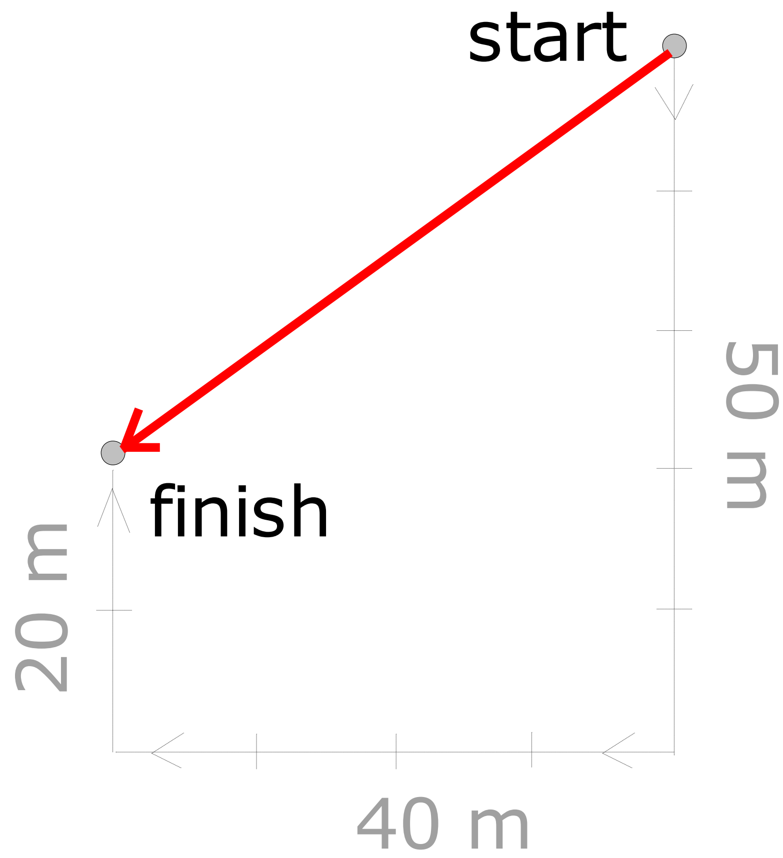
Example: 2

A rabbit takes a morning stroll and hops along three sides of the field as shown in the diagram.

How far has the rabbit traveled?



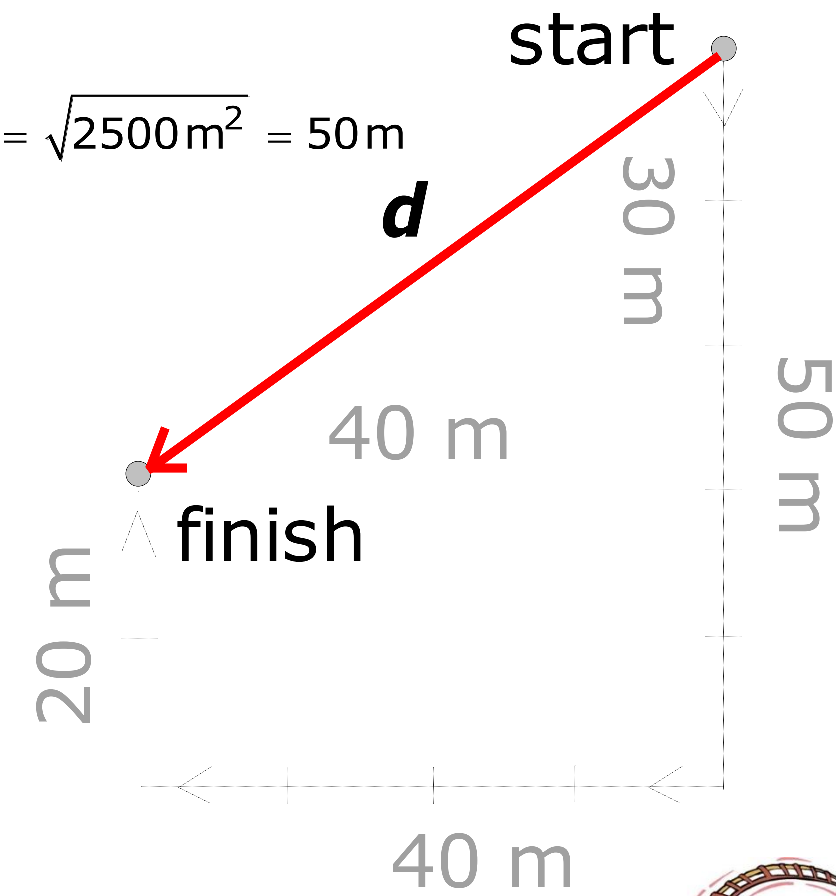
What is the displacement?



To determine the length of the red path, draw an extra line to make a right-angled triangle.

Applying Pythagoras:

$$\boldsymbol{d} = \sqrt{(30\,\text{m})^2 + (40\,\text{m})^2} = \sqrt{900\,\text{m}^2 + 1600\,\text{m}^2} = \sqrt{2500\,\text{m}^2} = 50\,\text{m}$$



To distinguish the red path from the total distance, it is given a special name: **displacement**.

We will use the symbol is ***d*** (in bold font), while the symbol for distance is a regular *d*.

What about speed and velocity?

Speed

1. First, by dividing **scalar** distance by the **scalar** time:

$$\frac{d}{t} = \frac{110\,\text{m}}{5.0 \times 10^1\,\text{s}} = 2.2\ \text{m/s}$$

$$= \text{speed} = v$$

Velocity

2. And next, by dividing the **vector** displacement by the **scalar** time:

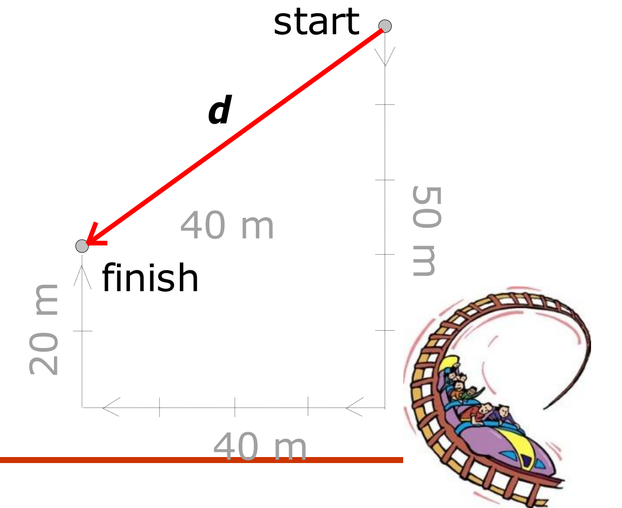
$$\frac{\mathbf{d}}{t} = \frac{50\ \text{m}\ [53^{\circ}\ \text{W of S}]}{5.0 \times 10^1\,\text{s}}$$

$$= 1.0\ \text{m/s}\ \ [53^{\circ}\ \text{W of S}]$$

$$= \text{velocity} = \mathbf{v}$$

Question?

Why is speed and velocity different?

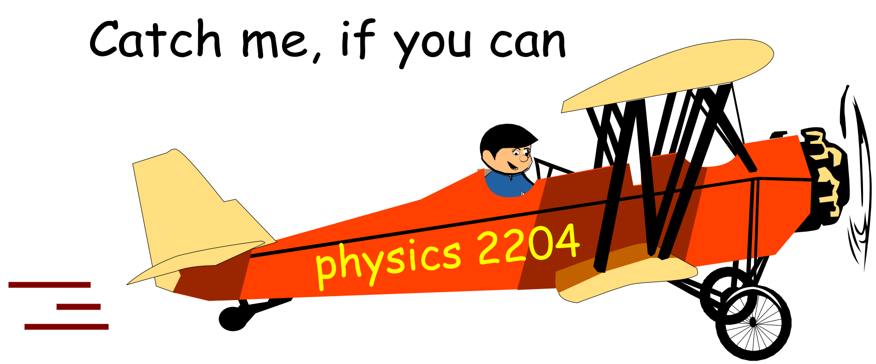


- **Section 3: Topic 12**

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.

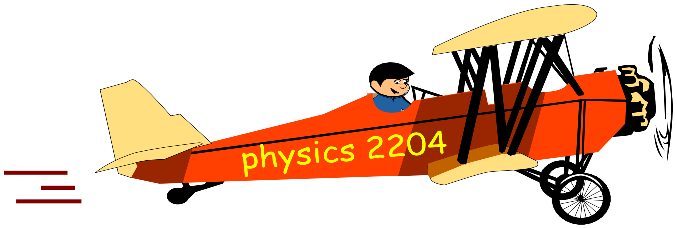
Uniformly acceleratedobject will change its velocity by the same amount each second. This is known as a uniform acceleration

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:

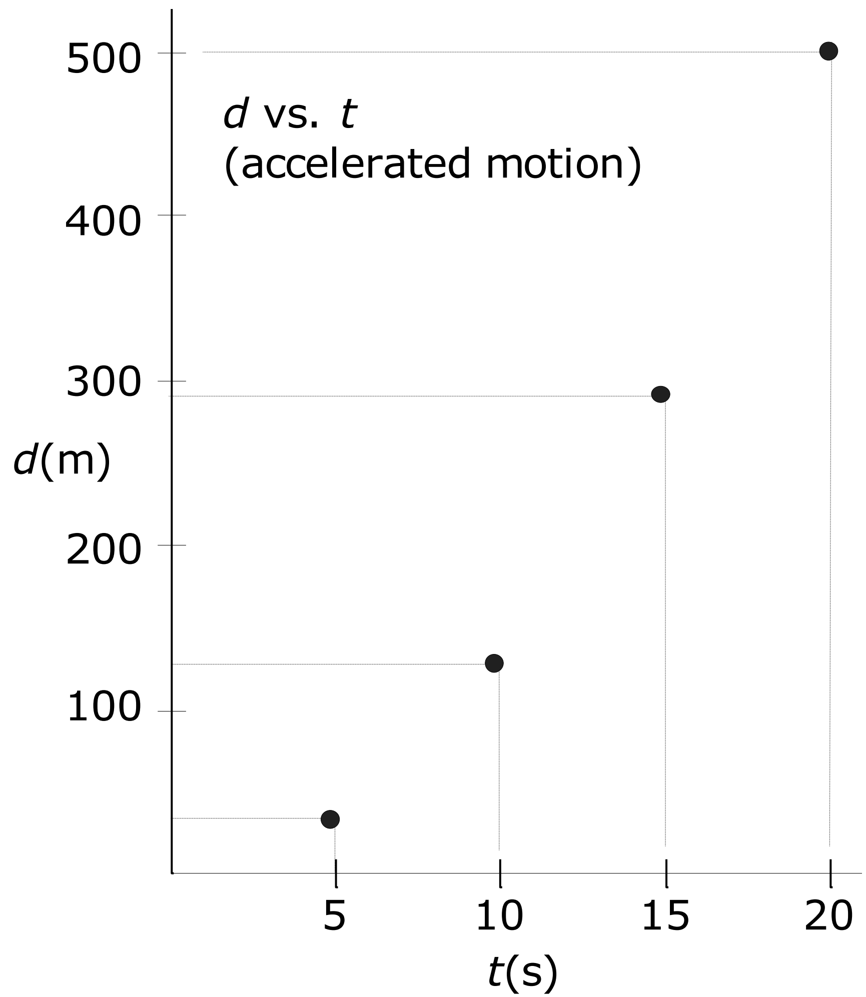
t(s)	d(m)
5	30
10	125
15	290
20	500



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.

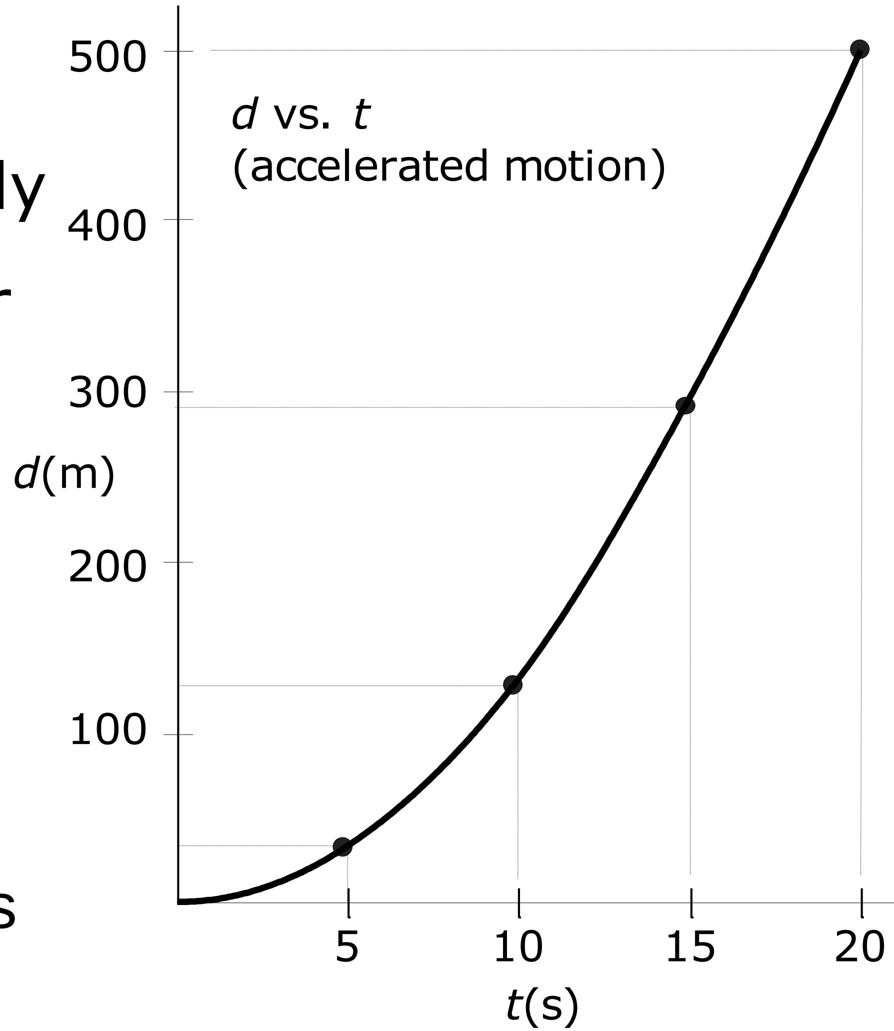
The *d-t* graph for uniformly

Accelerated 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:

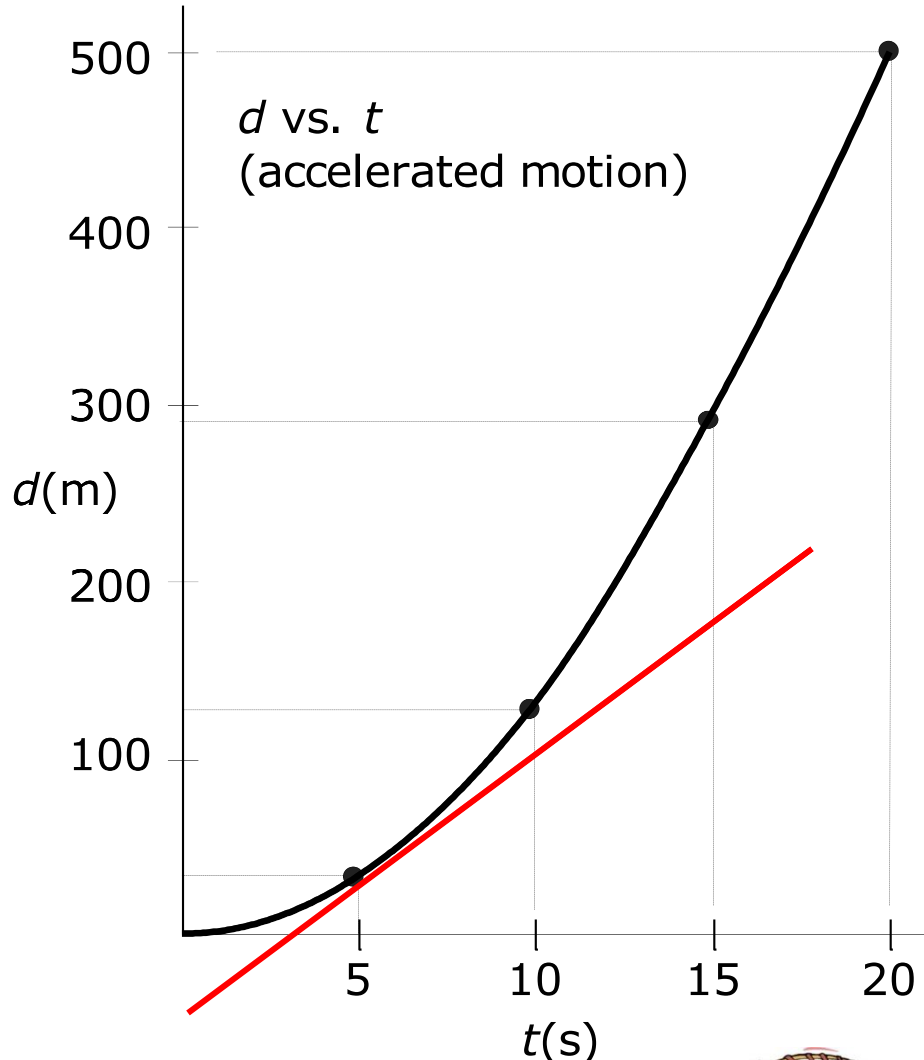
We use Tangents!

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



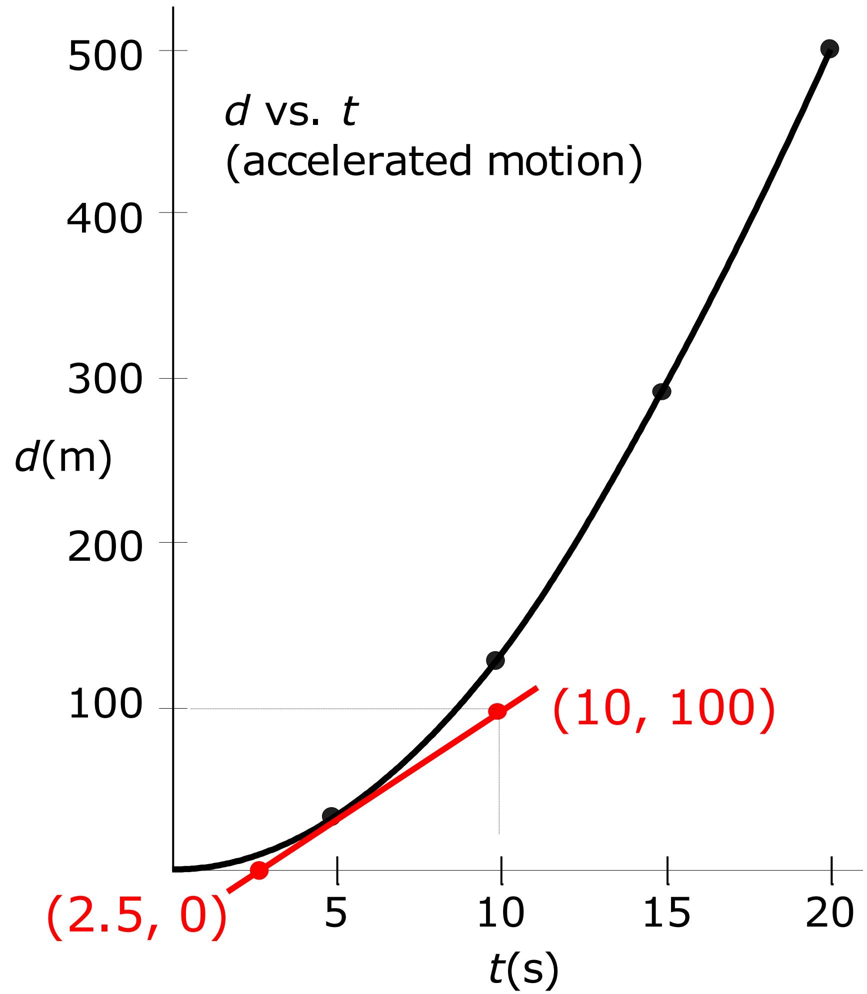
Choose two points on the tangent and find the slope of the tangent.

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

$$v_5 = \text{slope}$$

$$= \frac{100\,\text{m} - 0\,\text{m}}{10\,\text{s} - 2.5\,\text{s}}$$

$$= \frac{100\,\text{m}}{7.5\,\text{s}} = 13\,\text{m/s}$$



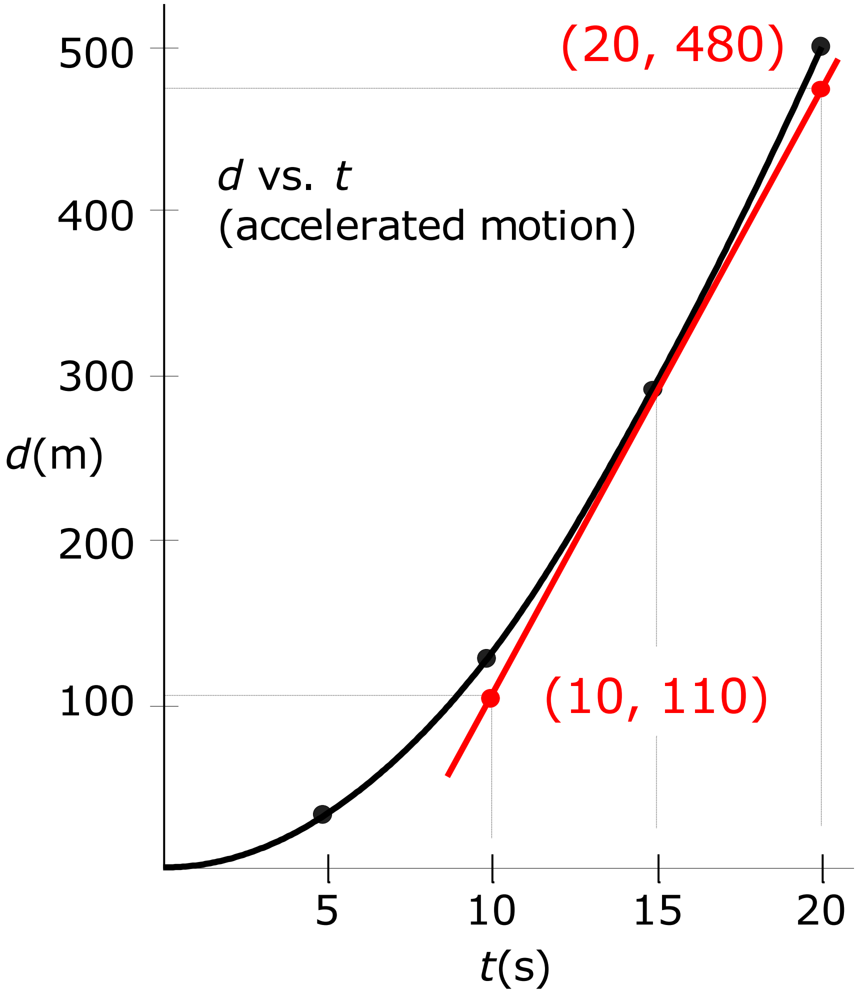
The speed at 5 s is 13 m/s

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:

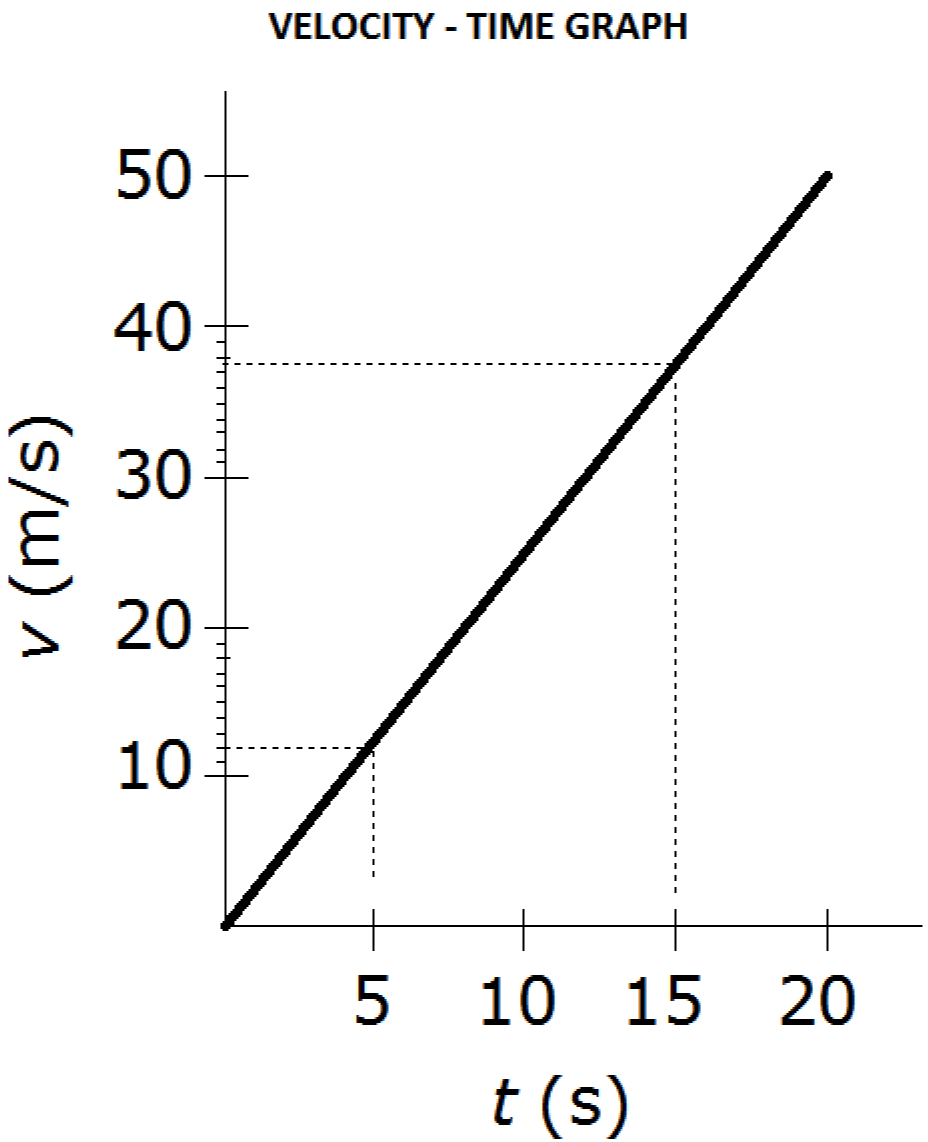
What do you notice about the steepness of the slopes?

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.

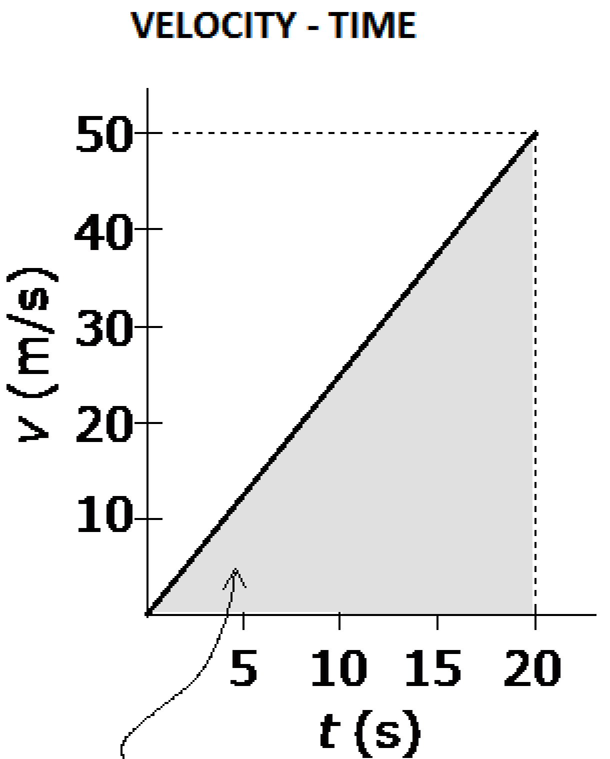


Question:

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**.



d=area

$=\frac{1}{2}$bh

$=\frac{1}{2}$(20 s x 50 m/s)

= 500 m

when t=20 s, d=500 m

Slope of a Velocity –Time Graph

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

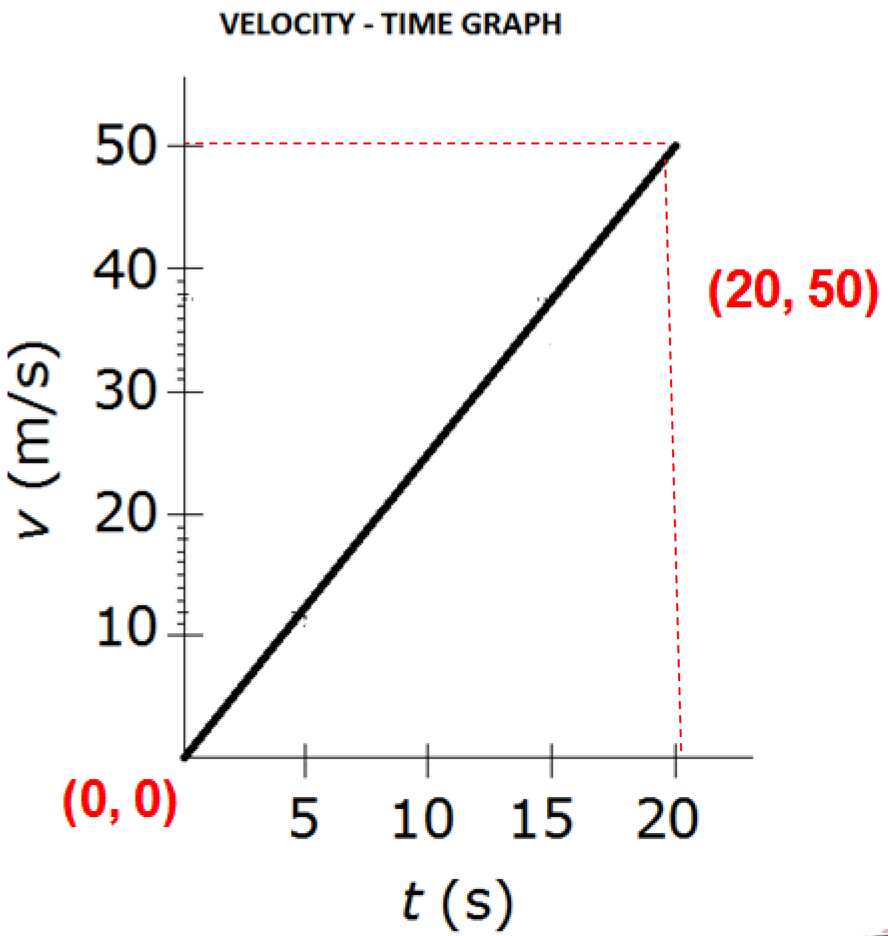
$$Slope = \frac{y_2 - y_1}{x_2 - x_1}$$

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

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

$$= 2.5m/s$$

$$= 2.5m/s^2$$

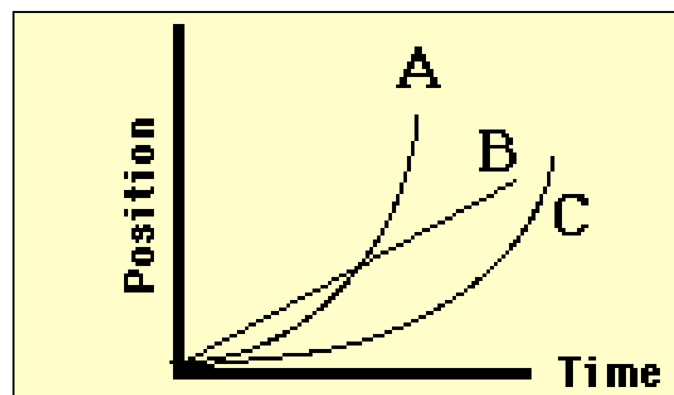


Check your Understanding…

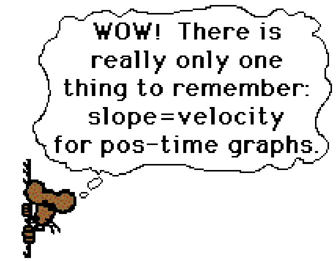
- Observe the animation of the three cars below. Which car or cars (red, green, and/or blue) are undergoing an acceleration?

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 is a 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.

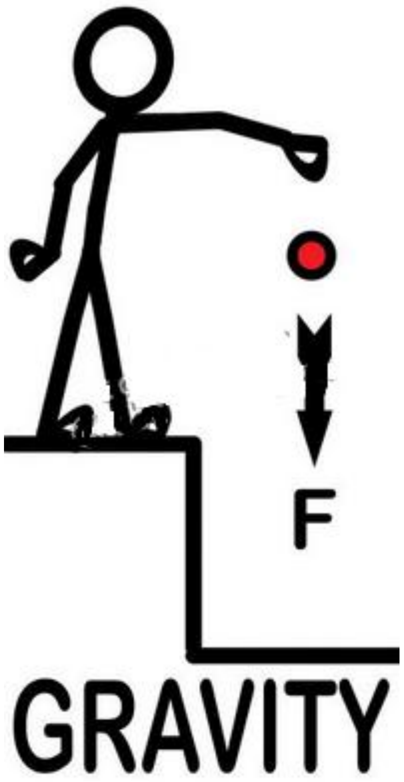
5. Area under a velocity-time graph is the displacement of the object.

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

PHYSICS LABORATORY

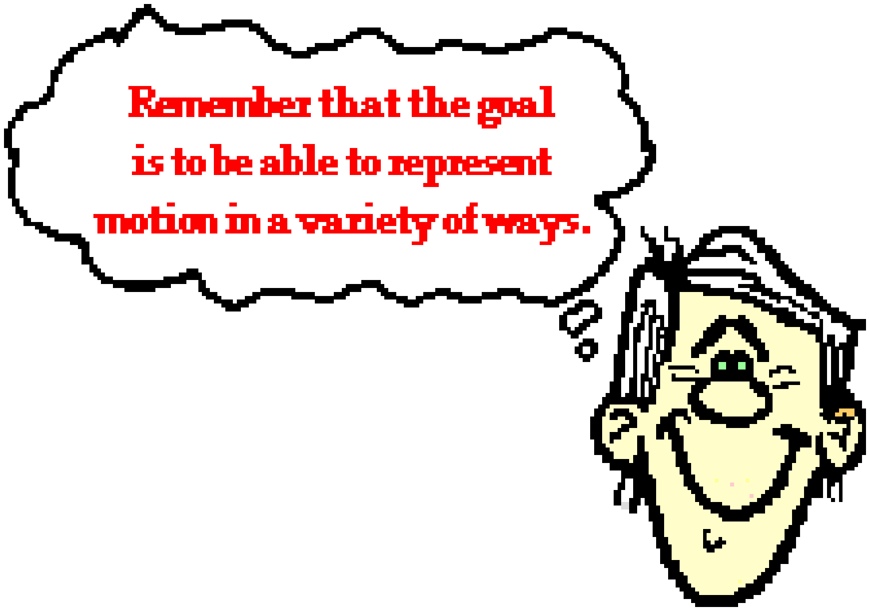
CORE LAB 2

- *Acceleration due to Gravity*



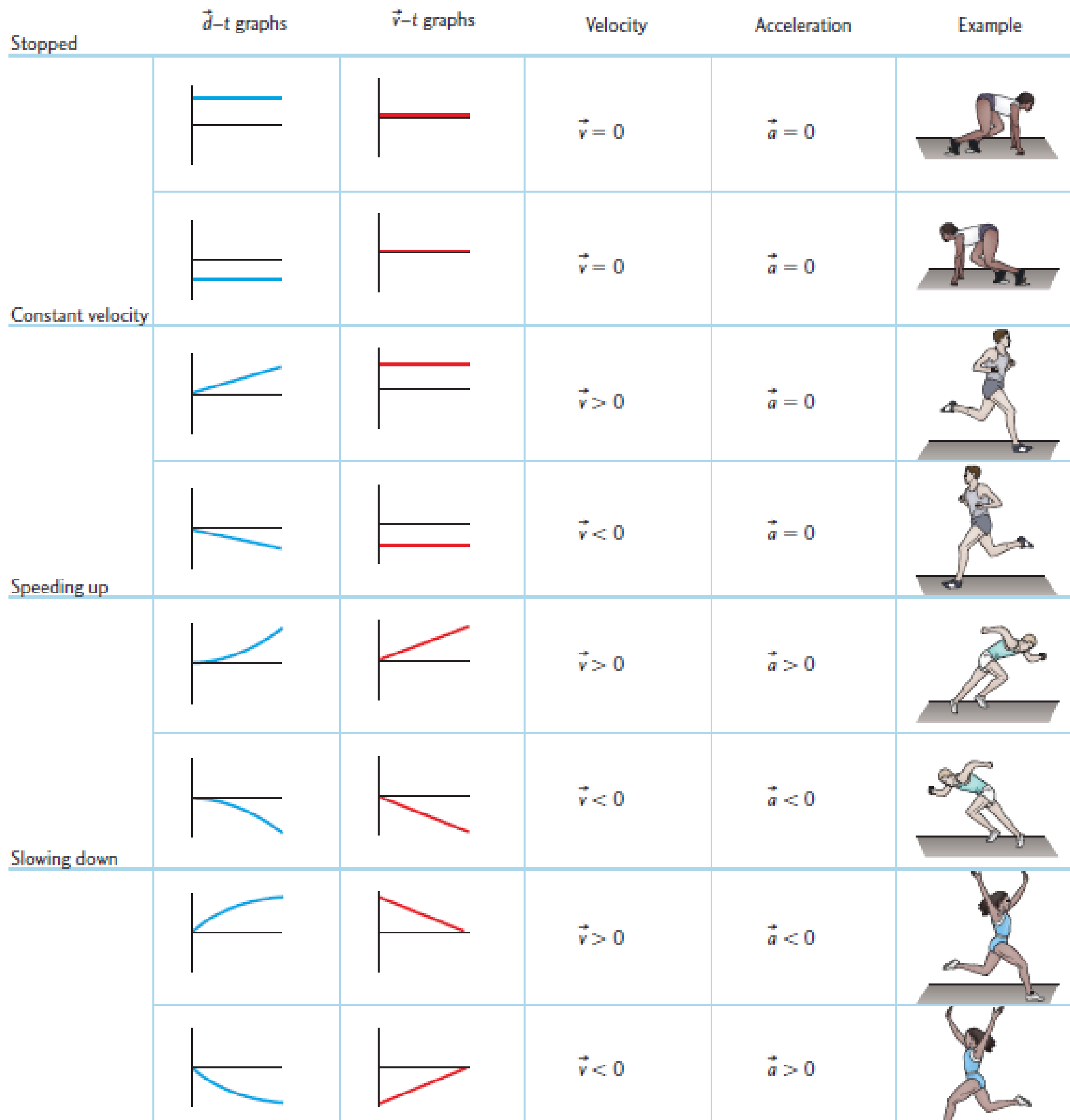
- **Section 3: Topic 13**

ANALYZING GRAPHS



In this section we will be interpreting a graphs of a variety of objects. One way to do this is MEMORIZE the chart.

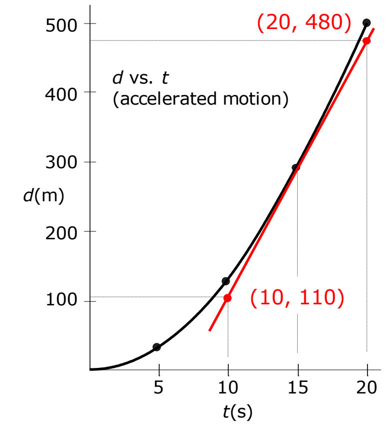
Fig.2.17



Review

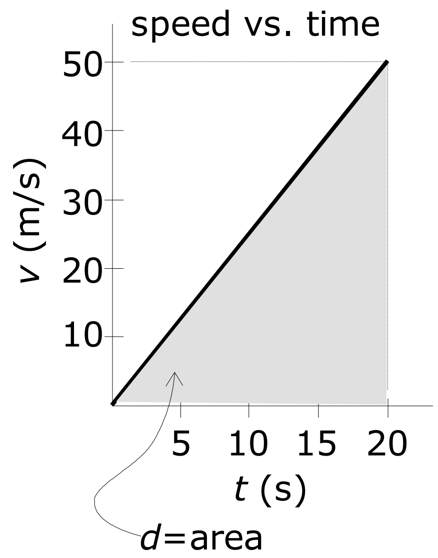
For graphs of distance vs. time

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



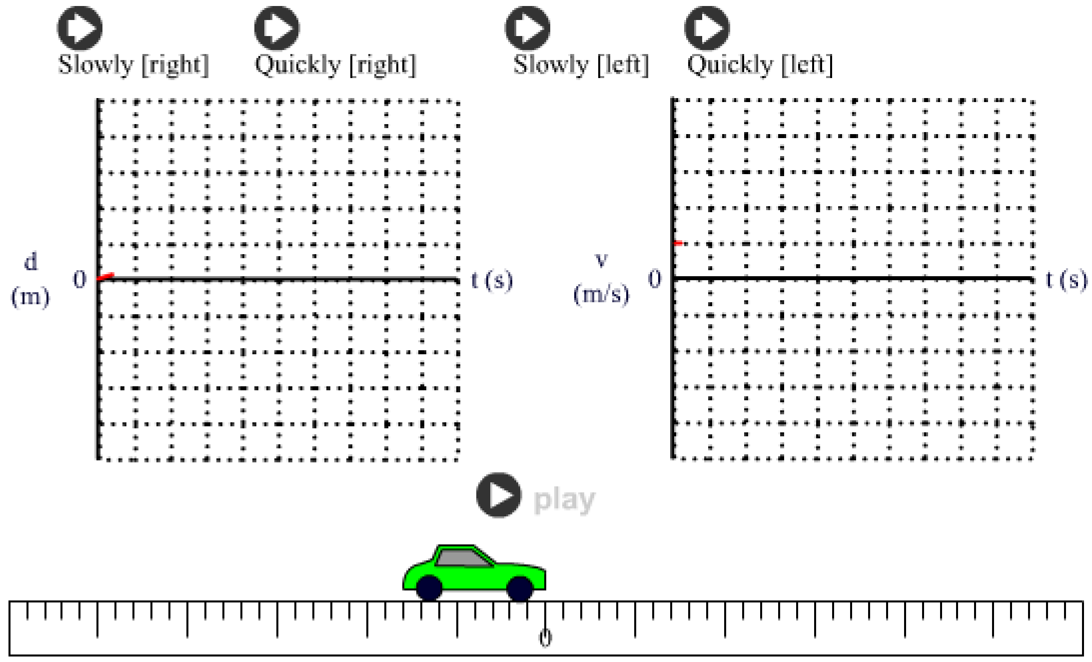
For graphs of speed vs. time

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



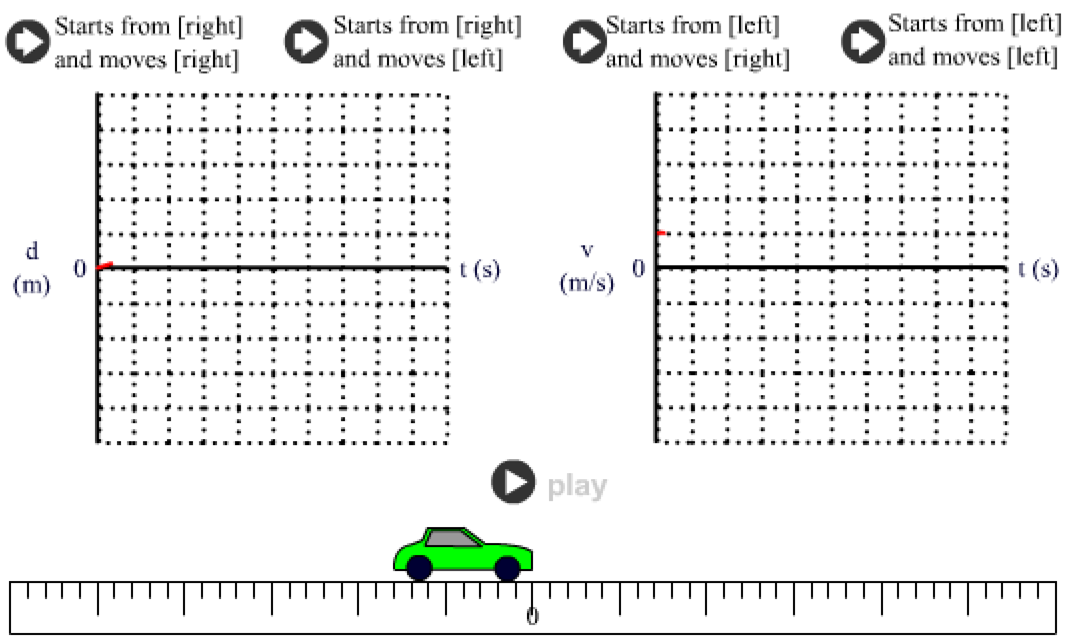
Motion # 1

Constant Velocity



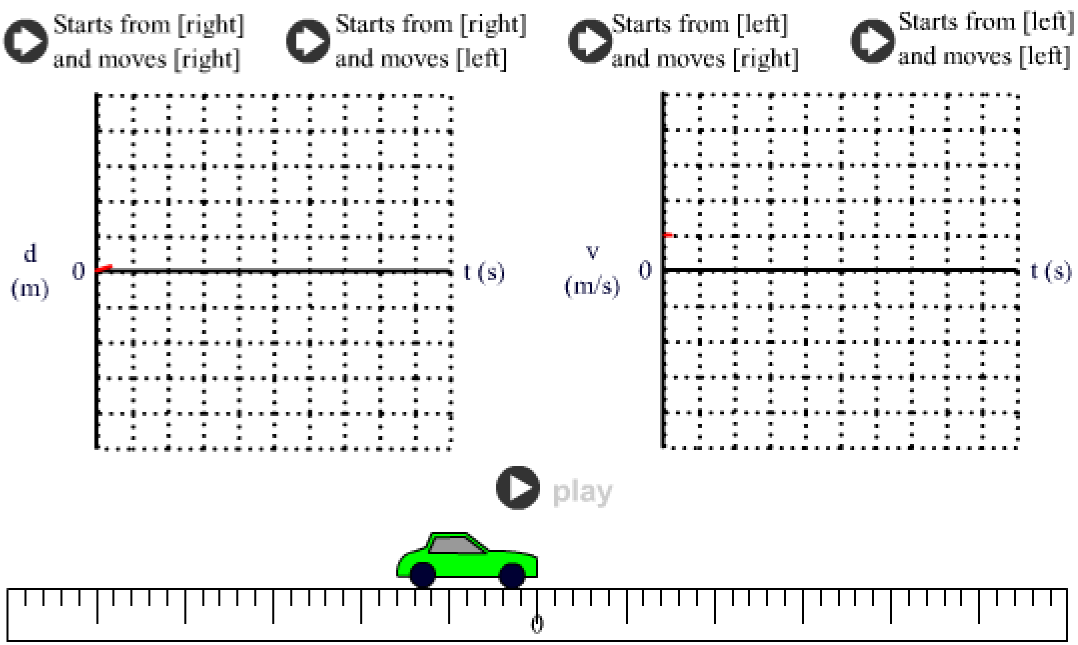
Motion # 2

Constant Velocity

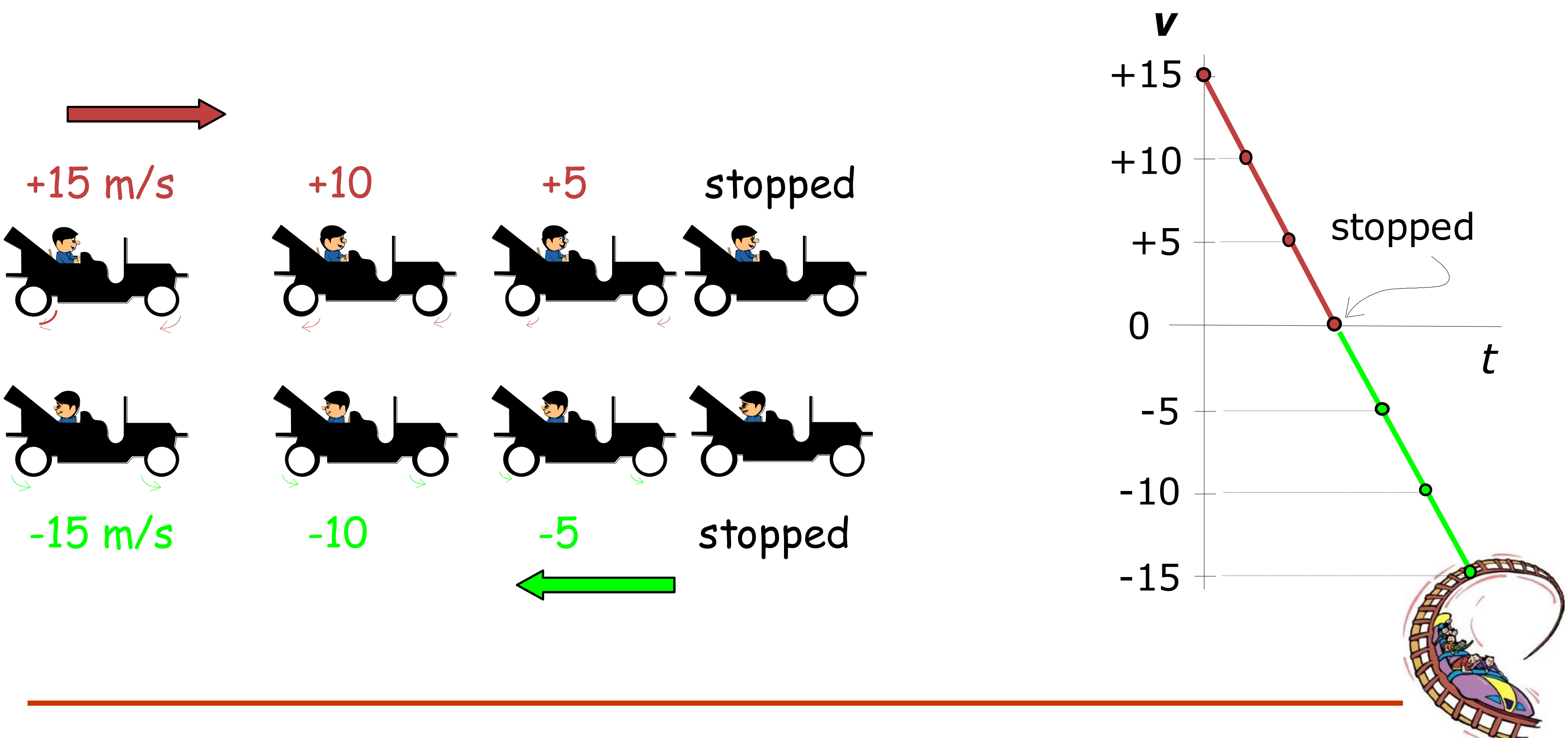


Motion # 3

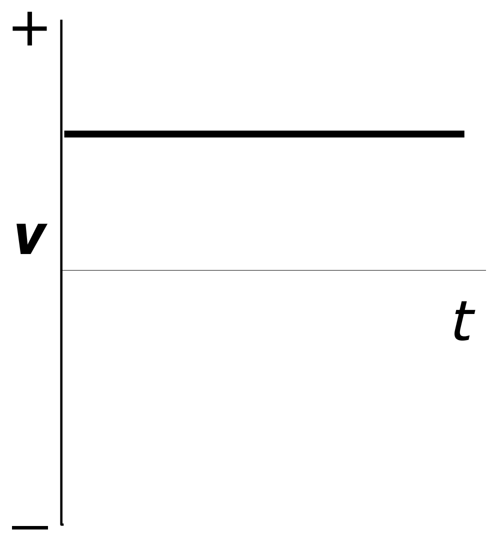
Accelerated Motion

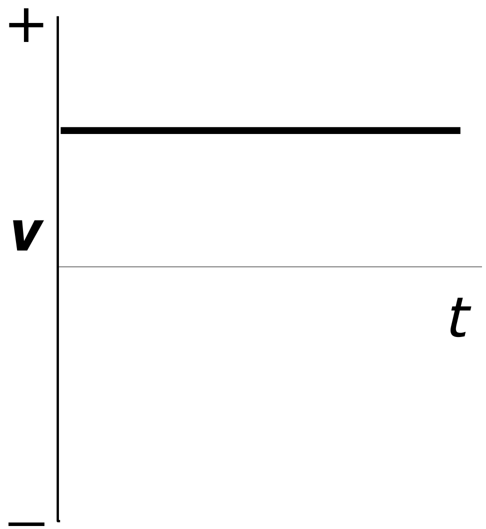


Velocity-time Graphs: The basics

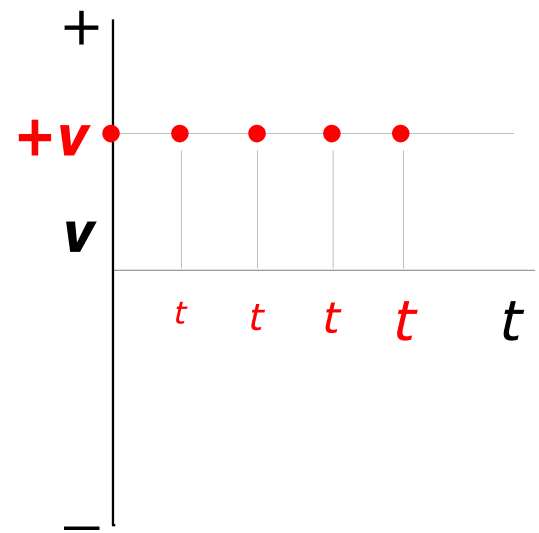


Describe the motion:





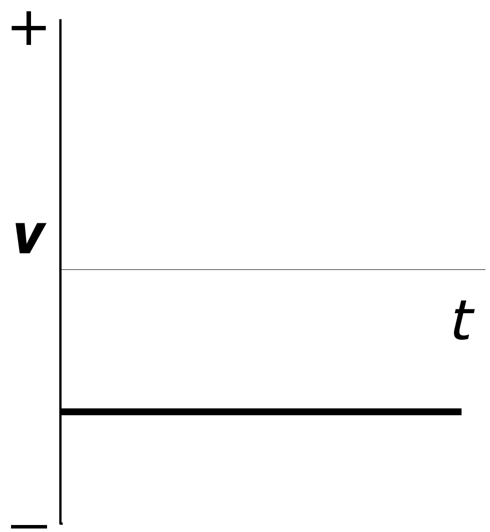
Explanation



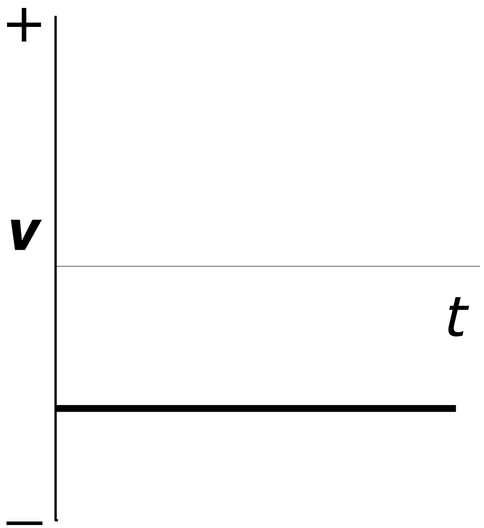
The object is moving at a fixed speed to the right.

As time goes on, the speed remains constant. All "*v*" values are in the "positive", first quadrant, meaning the object is traveling to the right.

Describe the motion depicted by the ***v***-t graph below



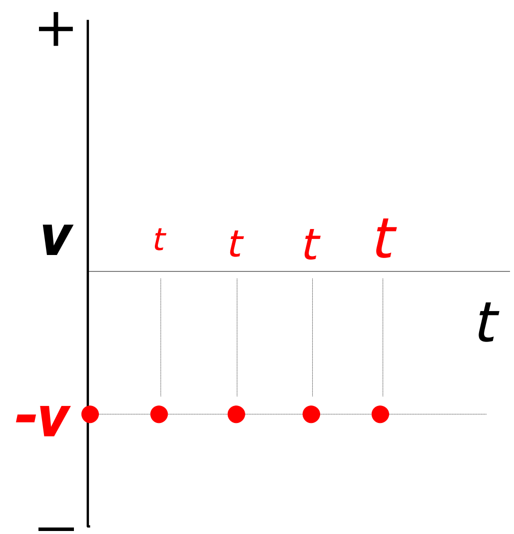
Describe the motion depicted by the ***v***-t graph below



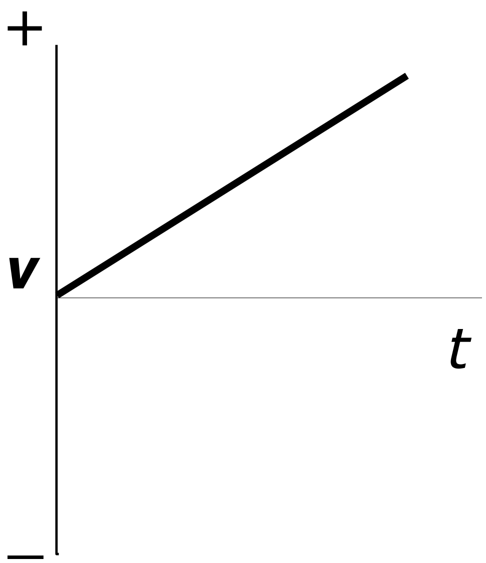
Answer

The object is moving at a fixed speed to the left.

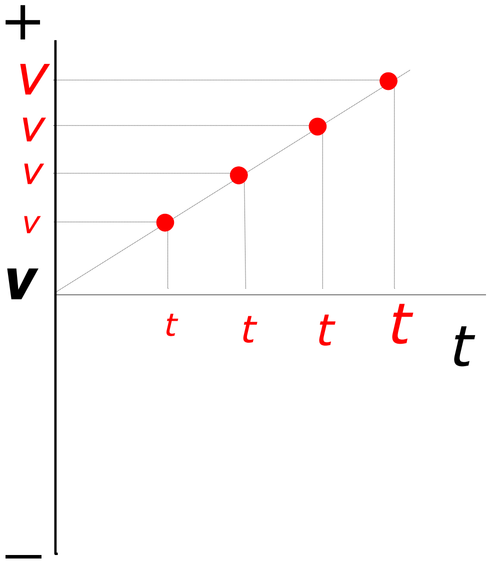
Explanation



As time goes on, the speed remains constant. All "*v*" values are in the "negative", fourth quadrant, meaning the object is traveling to the left.



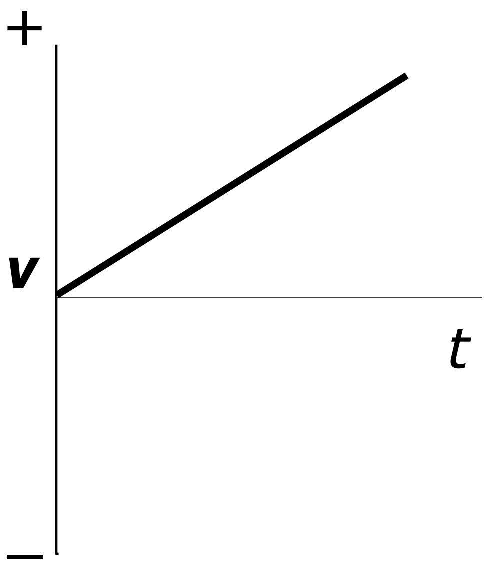
Explanation



Answer

The object starts from rest and accelerates to the right.

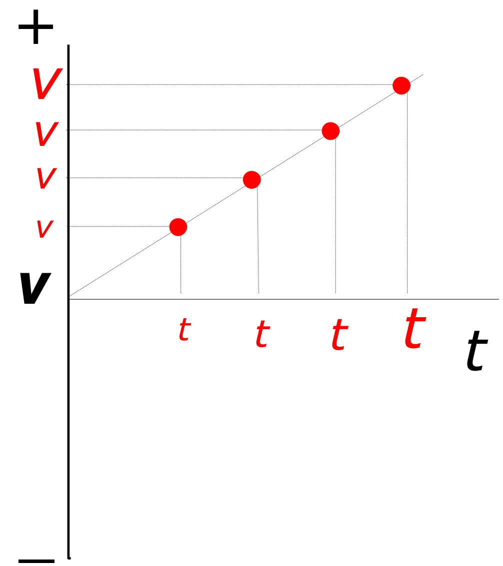
As time goes on, the speed increases from zero. All "*v*" values are positive meaning the object is traveling to the right.



Answer

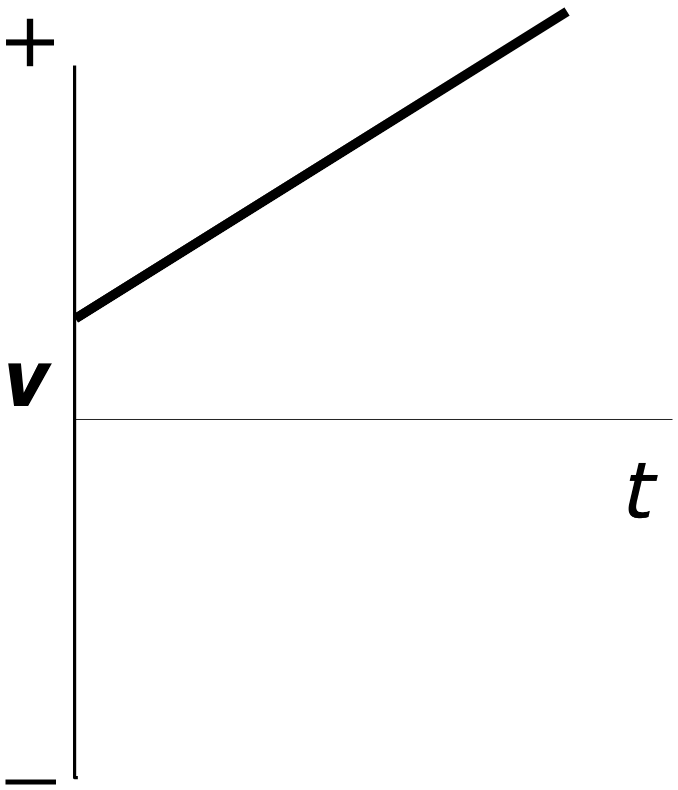
The object starts from rest and accelerates to the right.

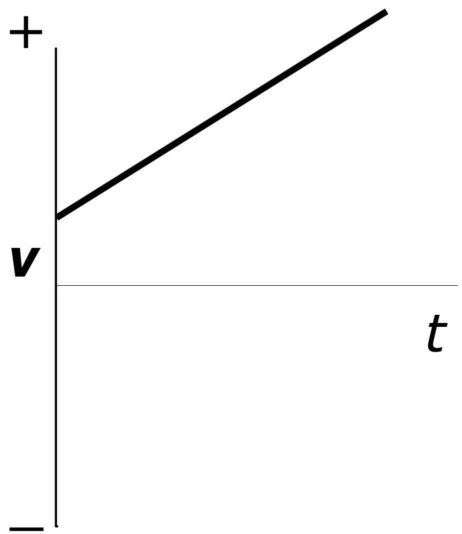
Explanation



As time goes on, the speed increases from zero. All "*v*" values are positive meaning the object is traveling to the right.

Describe the motion depicted by the ***v***-t graph below

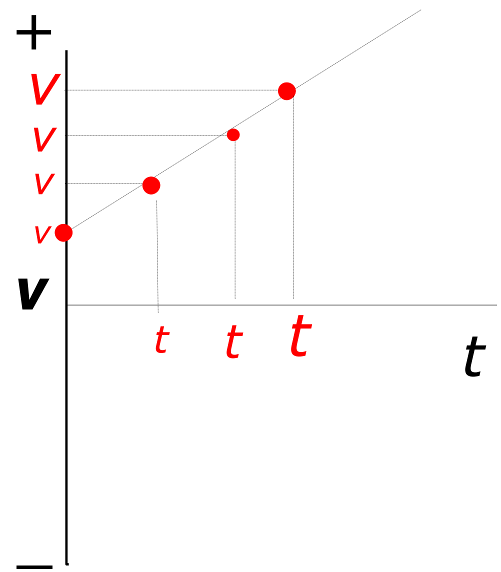




Answer

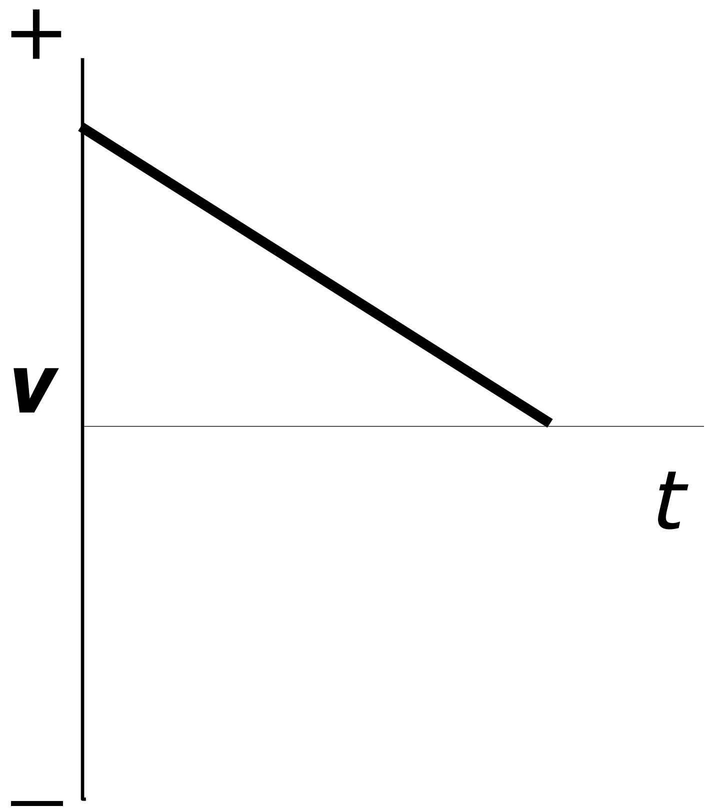
At time zero the object is already moving to the right. It continues to accelerate to the right.

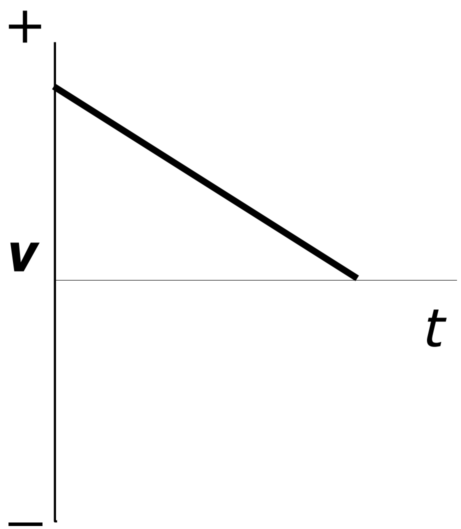
Explanation



At time zero, there is already a positive value for the speed. As time goes on, the positive speeds increase. That is, the object picks up speed to the right.

Describe the motion depicted by the ***v***-t graph below

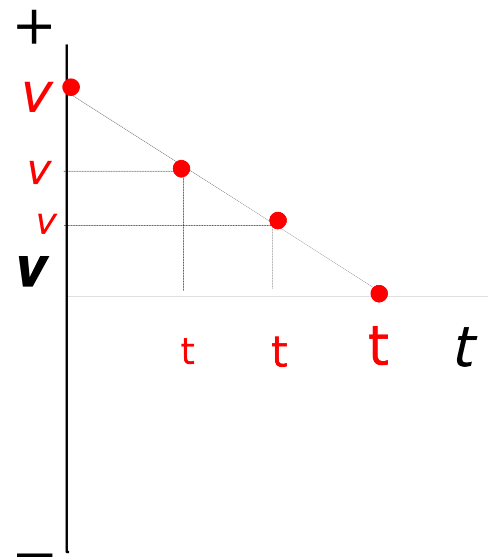




Answer

The object is moving to the right but accelerating to the left. It therefore slows down and stops.

Explanation



At time zero, there is already a positive value for the speed. As time goes on, the positive speeds **decrease**.   The object keeps moving to the right but slows down and stops.

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

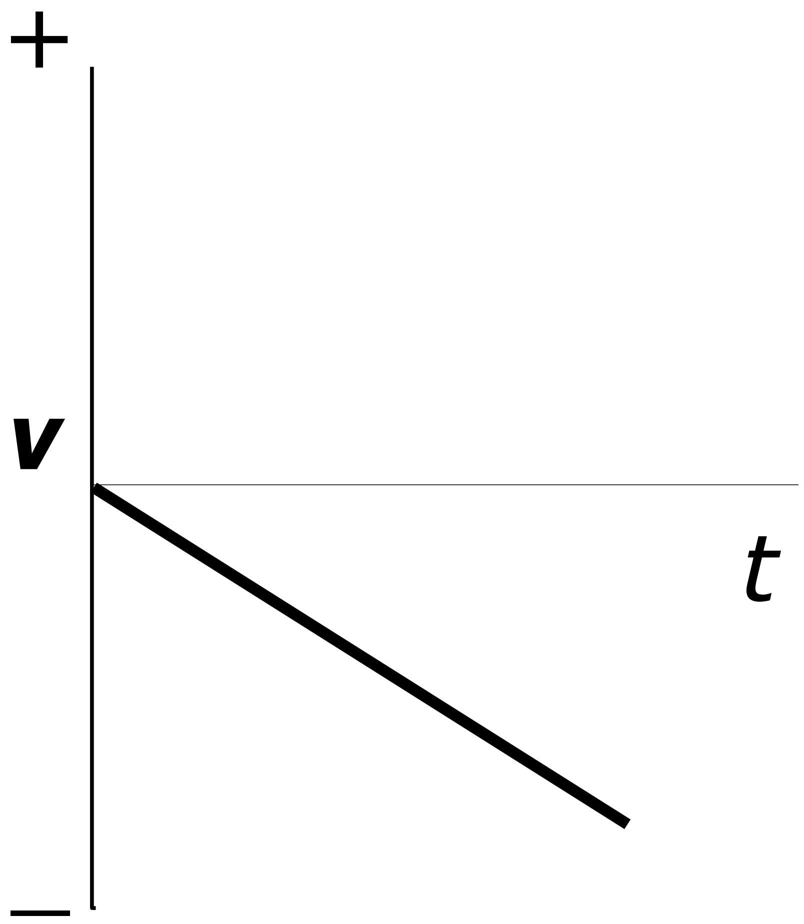
-whether the object is moving in the + or - direction

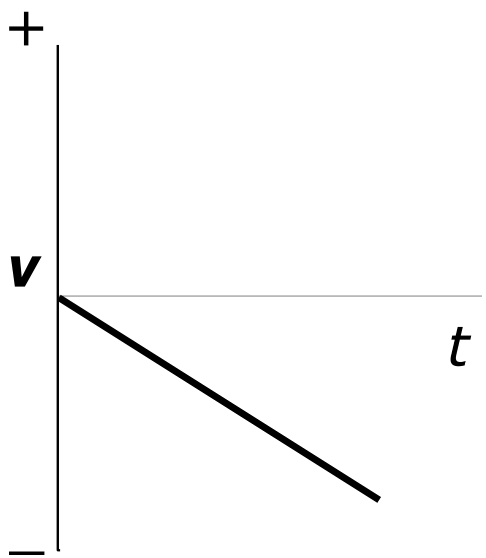
-whether the object is speeding up or slowing down

The general RULE OF THUMB is:

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

Describe the motion depicted by the ***v***-t graph below

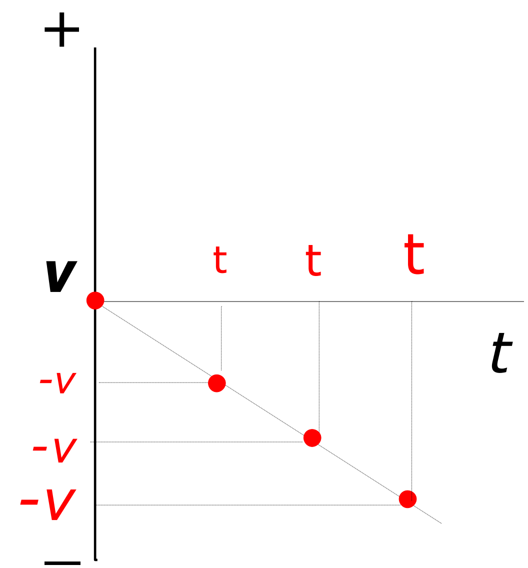




Answer

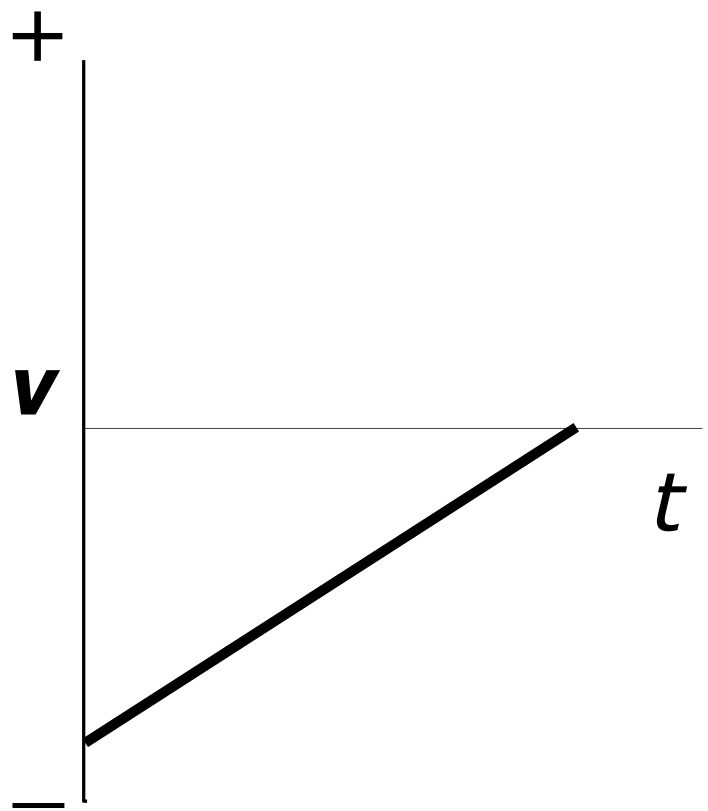
The object starts from rest and accelerates to the left.

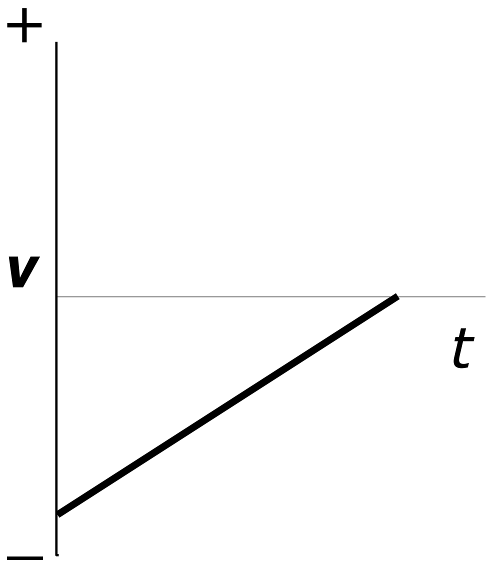
Explanation



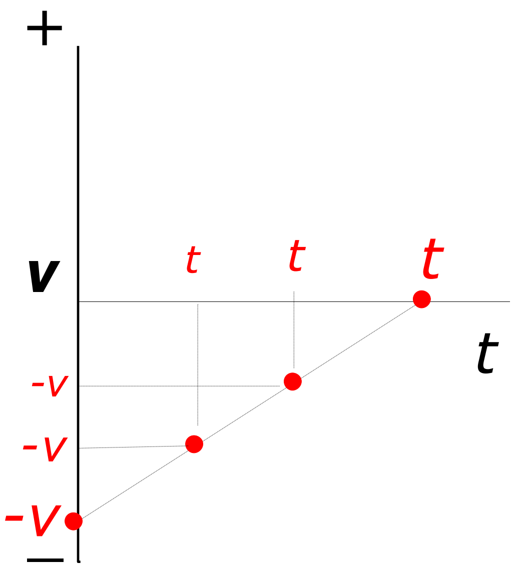
At time zero, the object is not moving. Then, as time goes on there is an increase in "negative" speeds as the object picks up speed to the left.

Describe the motion depicted by the ***v***-t graph below





Explanation

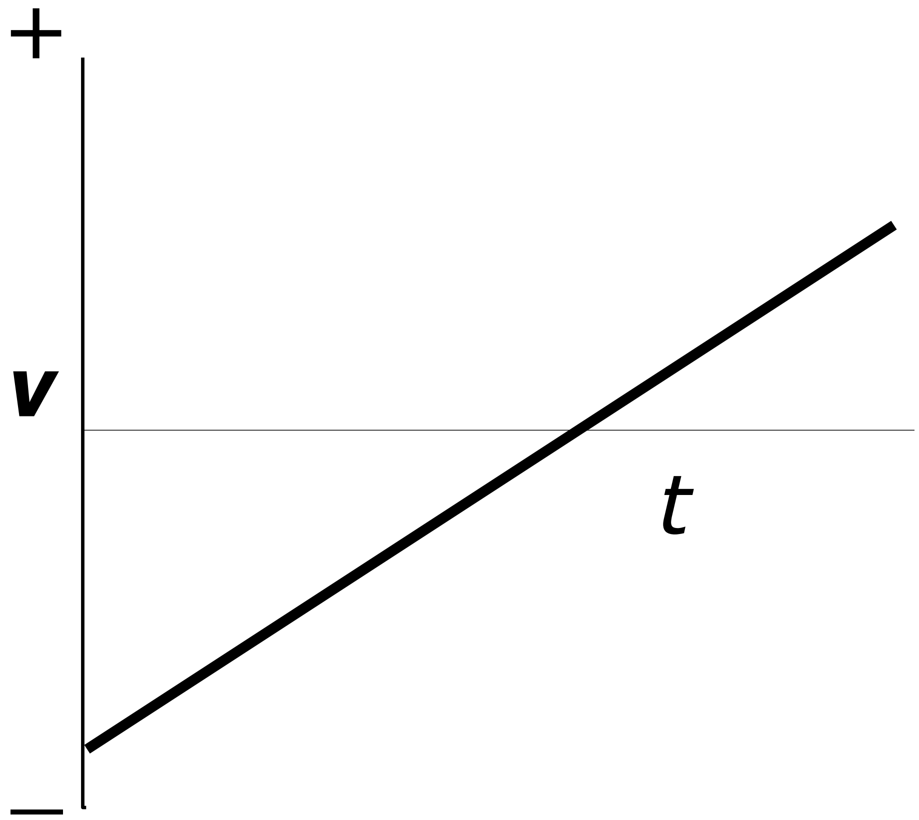


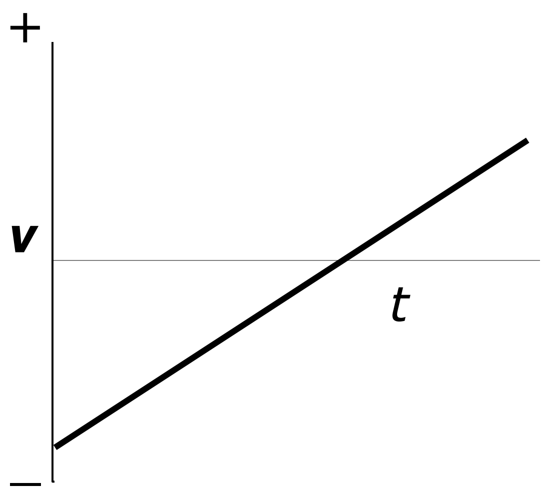
Answer

The object starts with an initial speed to the left but slows down and stops.

At time zero, the object has a maximum speed to the left . However, as time increases, speed decreases, and the object stops.

Describe the motion depicted by the ***v***-t graph below

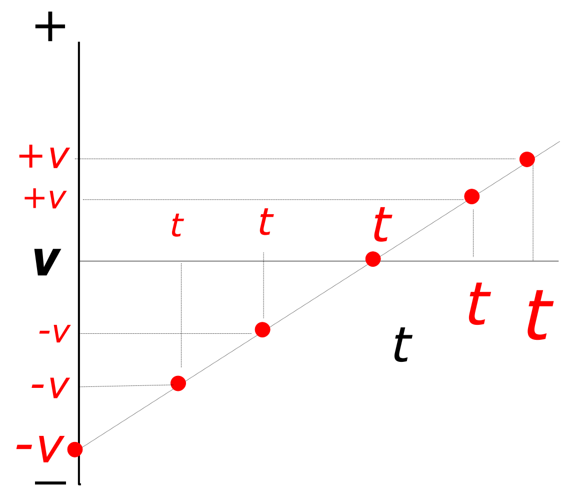




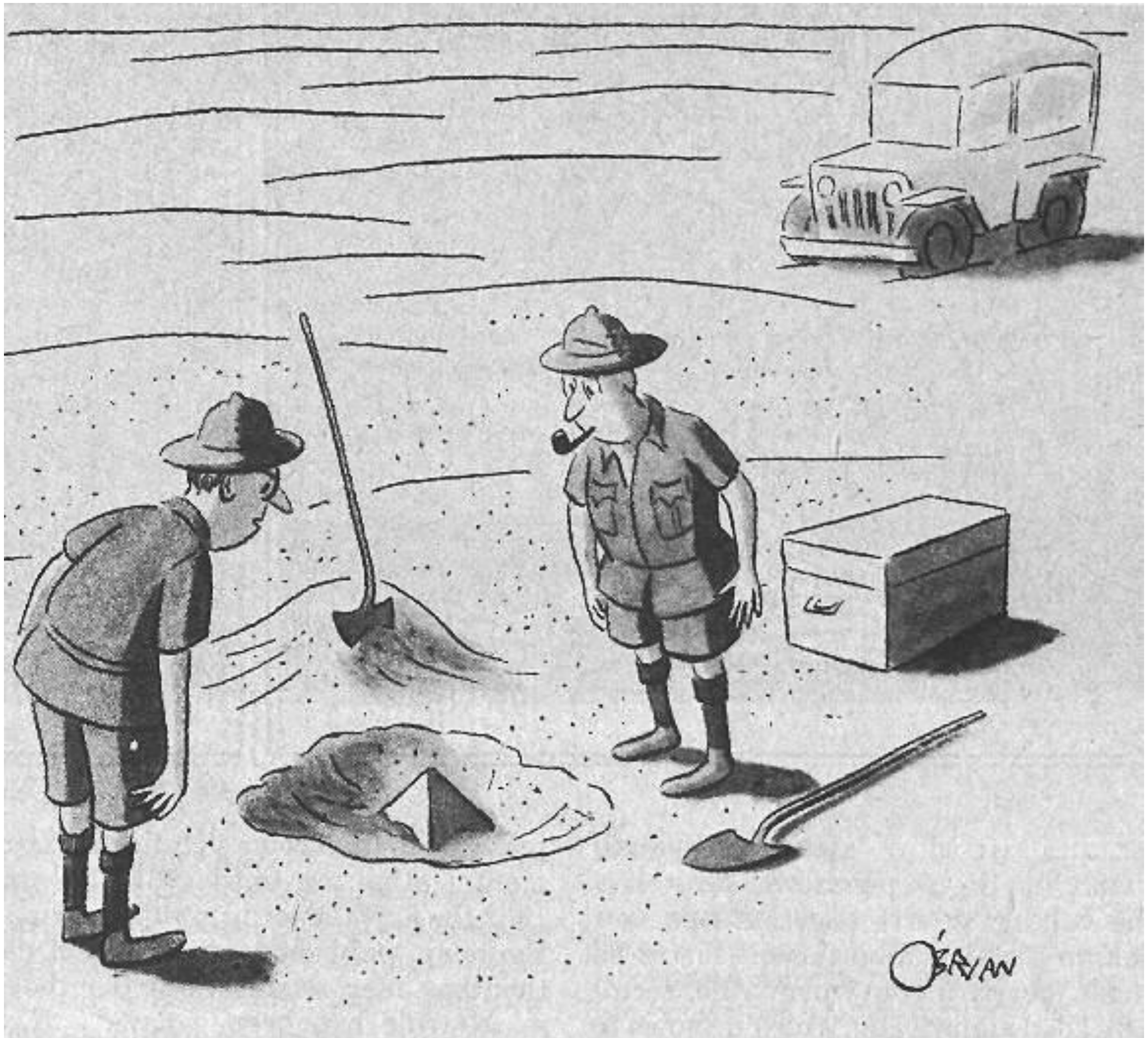
Answer

The object starts with an initial speed to the left and accelerates to the right.

Explanation

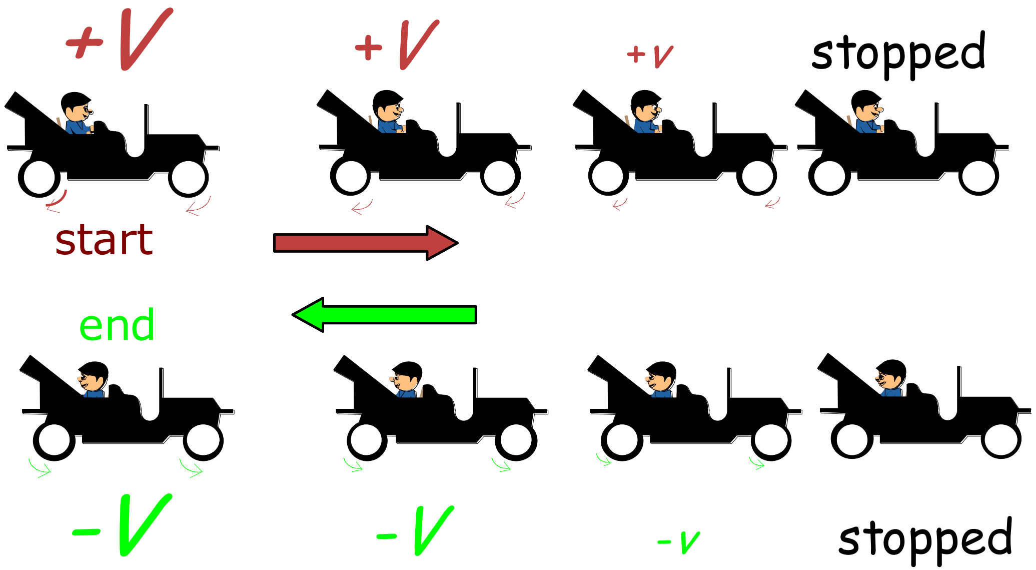


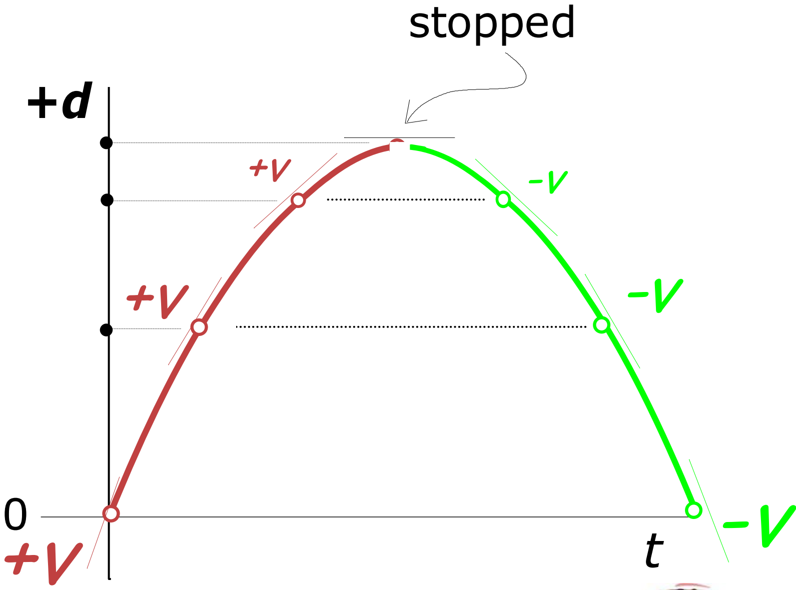
At time zero, the object has a maximum speed to the left . However, as time increases, speed decreases, and the object stops. But it continues to accelerate to the right, meaning that after its brief stop, it took off to the right.



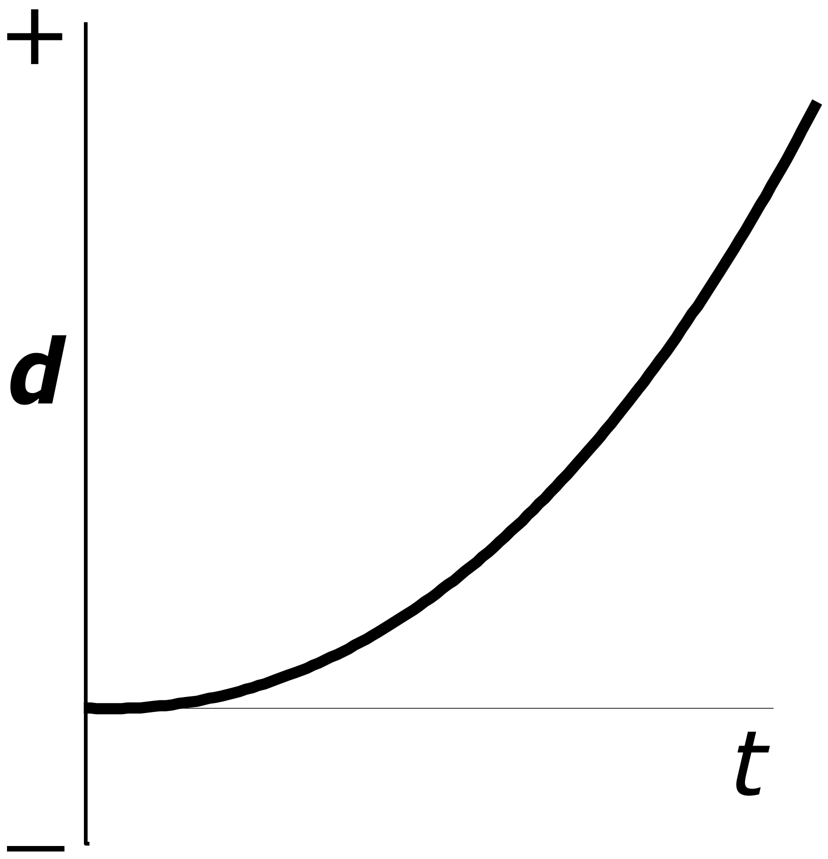
"This could be the discovery of the century. Depending, of course, on how far down it goes."

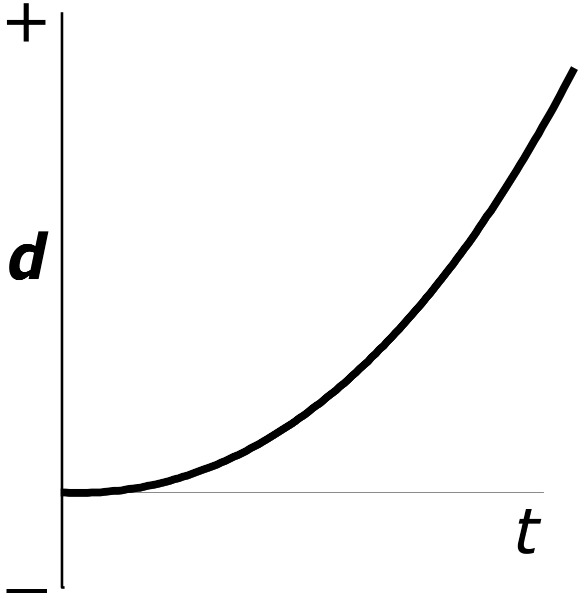
Displacement-time Graphs
(Accelerated Motion)





Describe the motion depicted by the ***d***-*t* graph below

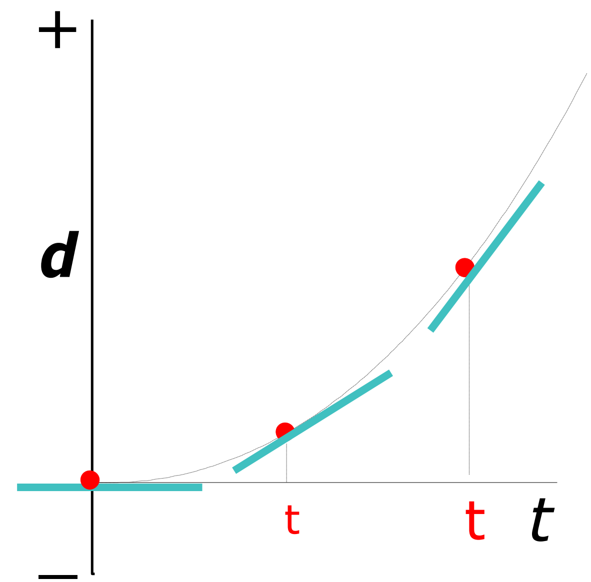




Answer

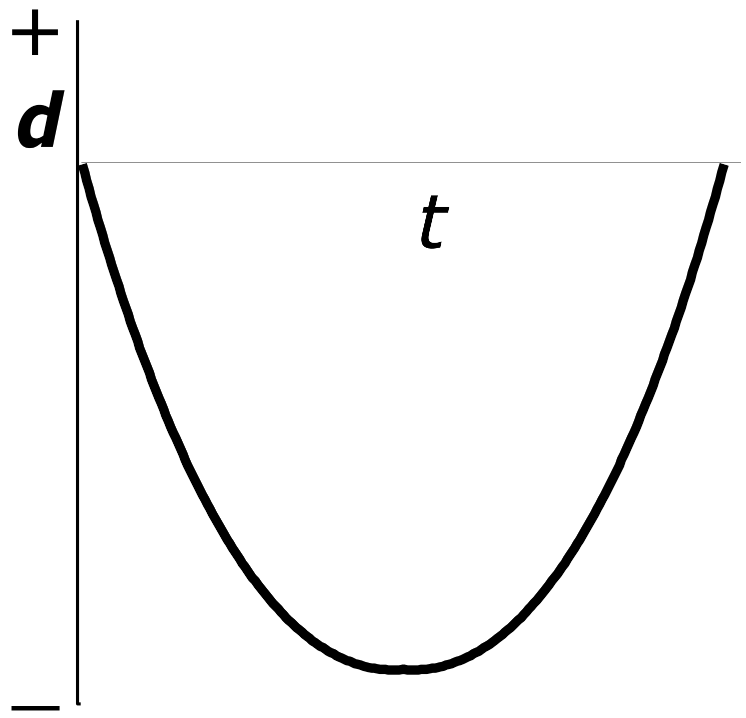
The object is accelerating to the right.

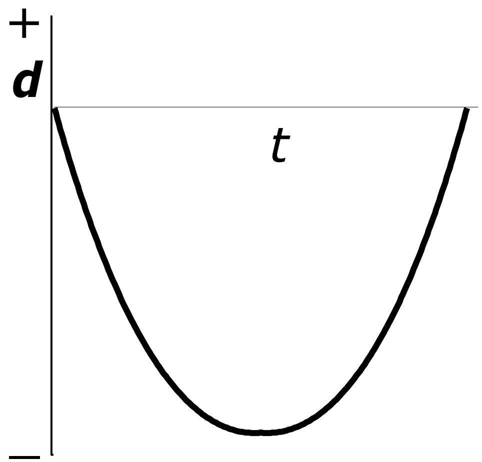
Explanation



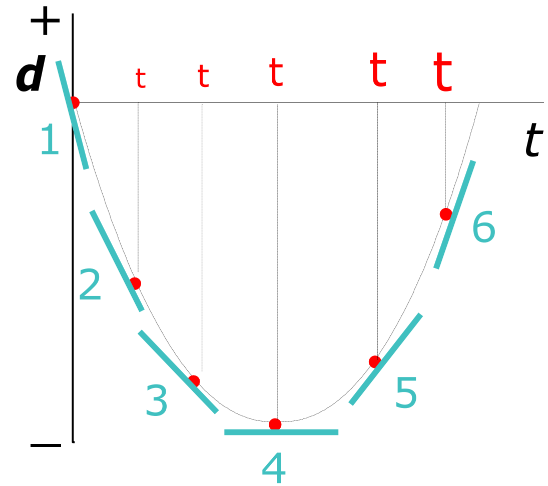
As time goes on, the tangents acquire larger and larger **positive** slopes, i.e. larger speeds to the right.

Describe the motion depicted by the ***d***-*t* graph below





Explanation

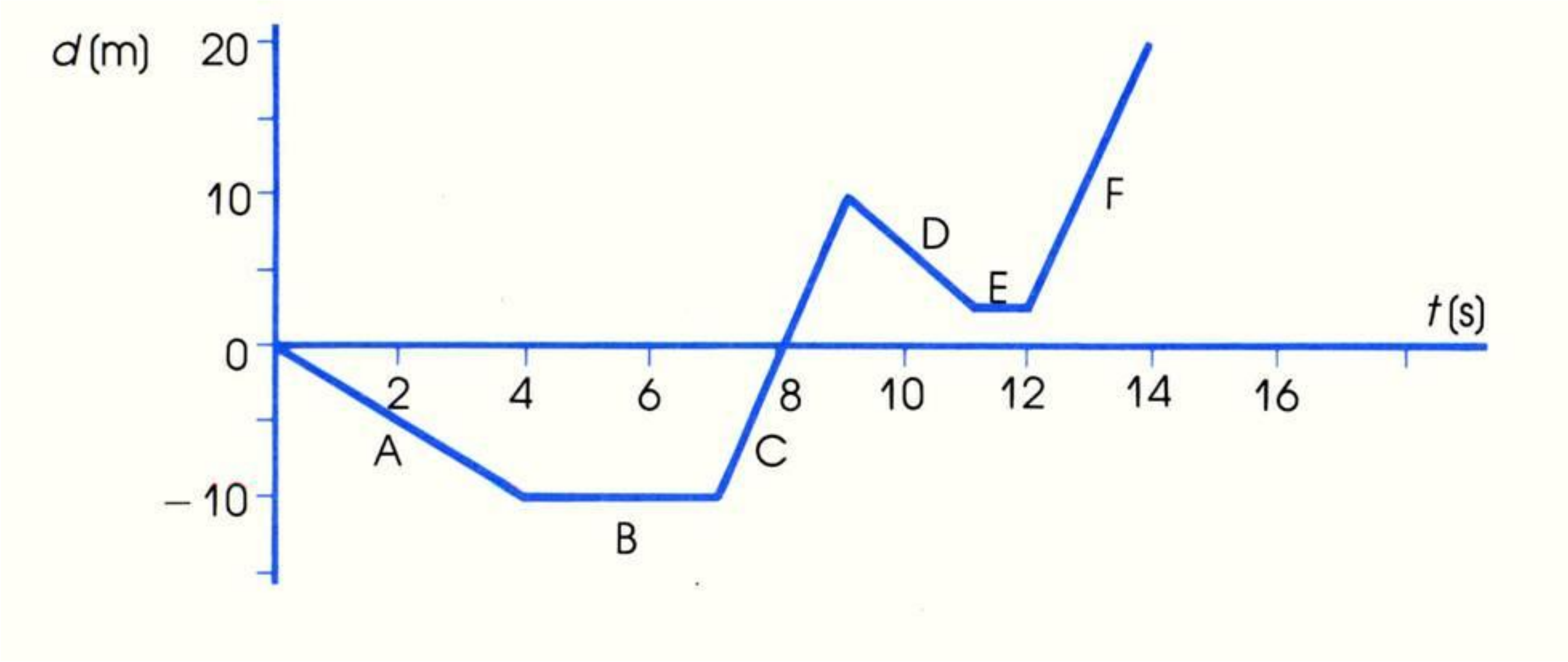


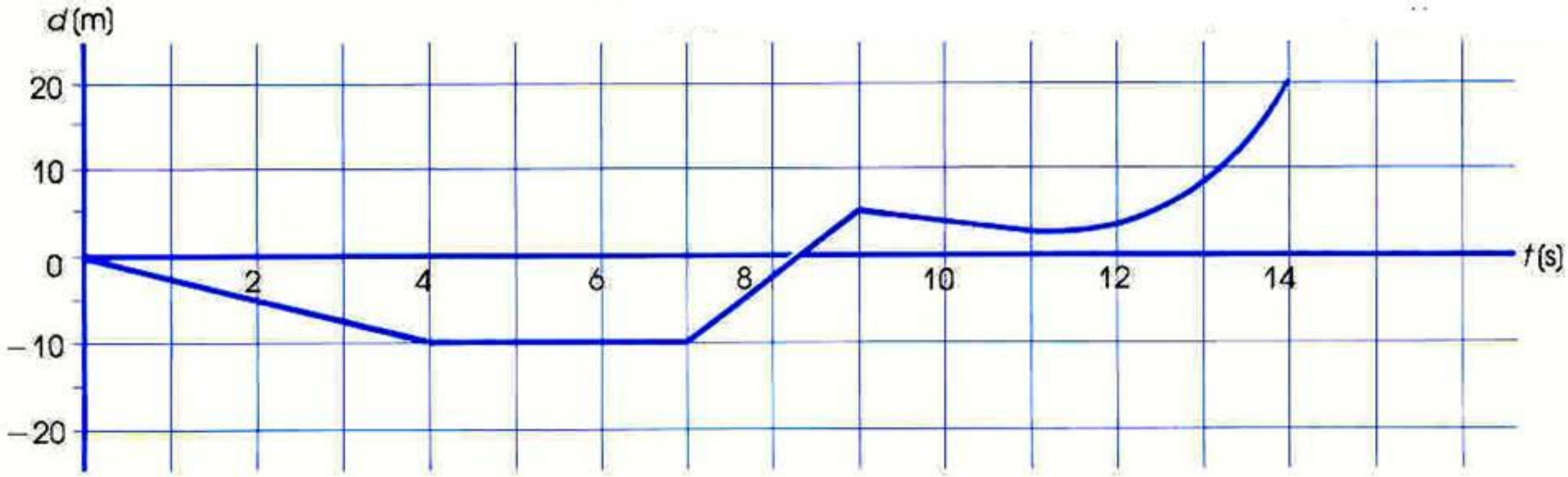
Answer

The object heads left but with ever **decreasing** speed. At half-time it stops very briefly and then **speeds up** to the right.

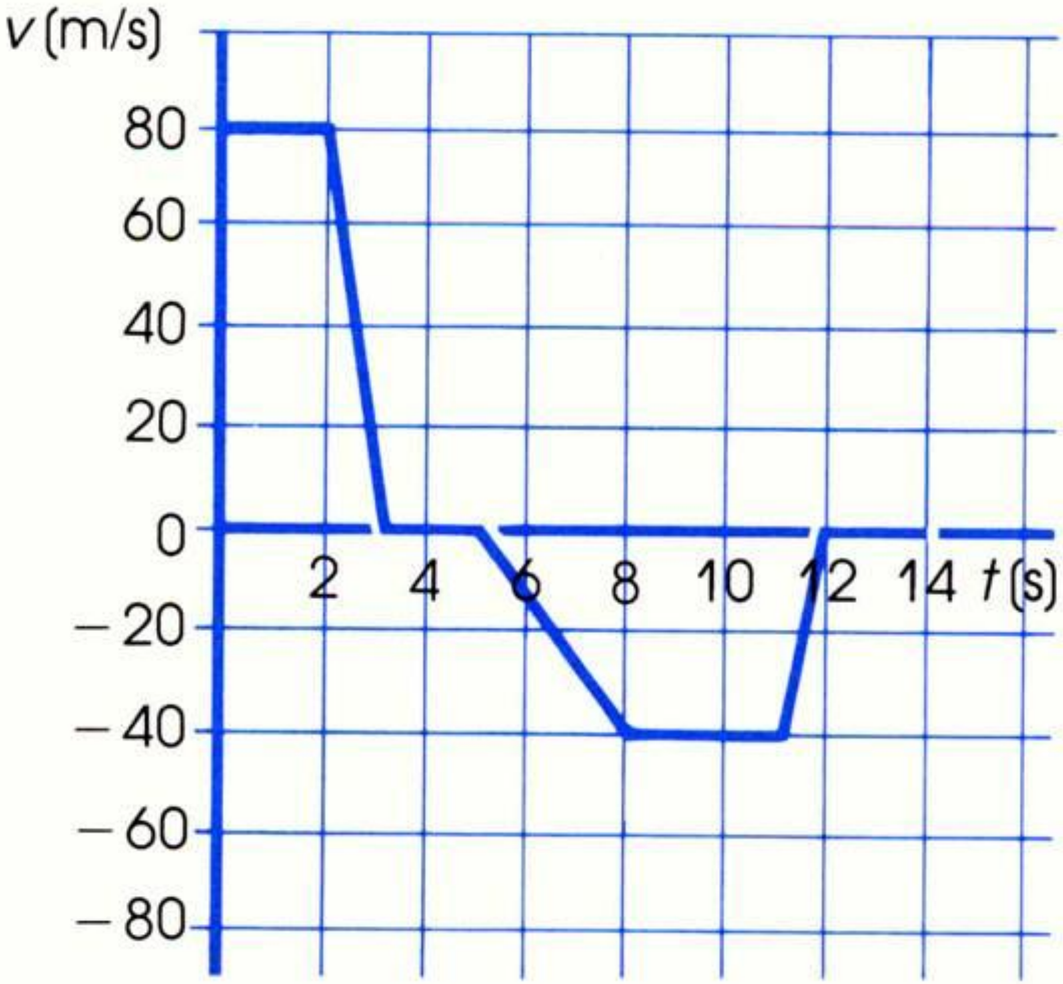
Tangents 1, 2, and 3 have **negative slopes** that are getting smaller. This means the object is moving to the **left** and **slowing** down. At 4 it is **stopped**. Then it **picks up** speed to the **right** as indicated by the **positive slopes** of 5 & 6.

Example 1: Describe the Following graph?

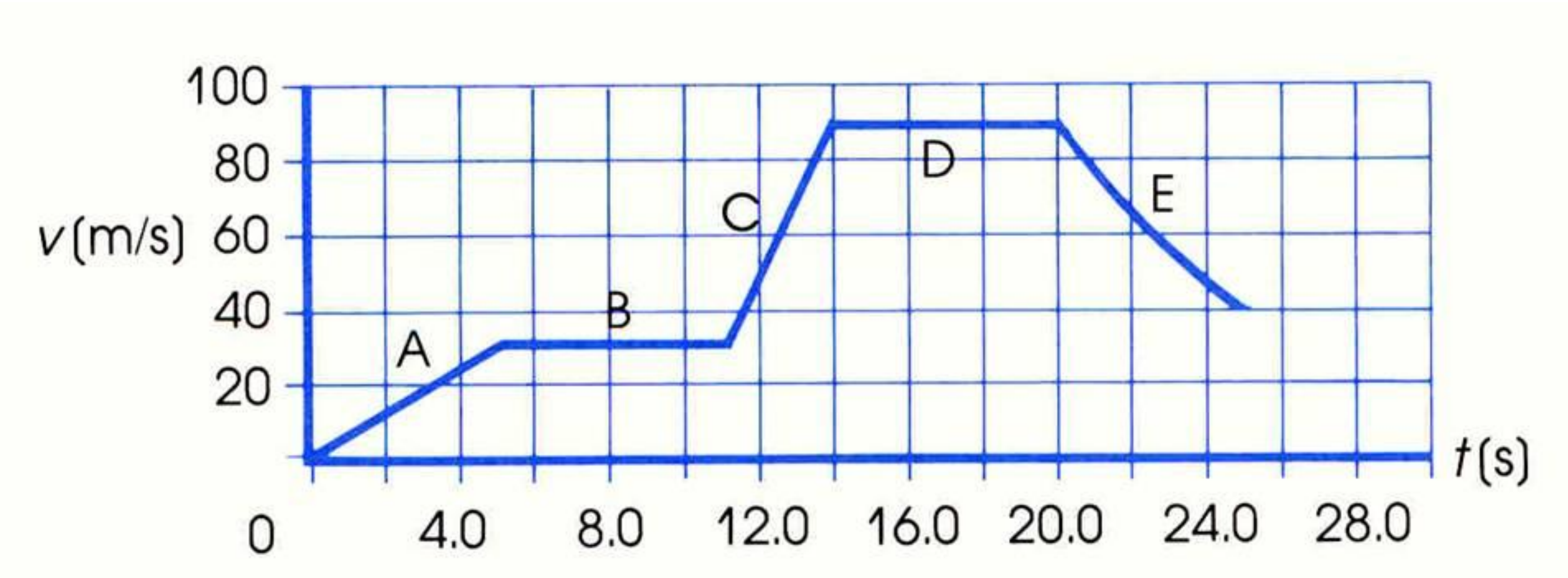



d (m)
20
10
0
−10
−20
2
4
6
8
10
12
14
t (s)

Example 1: Describe the Following graph?

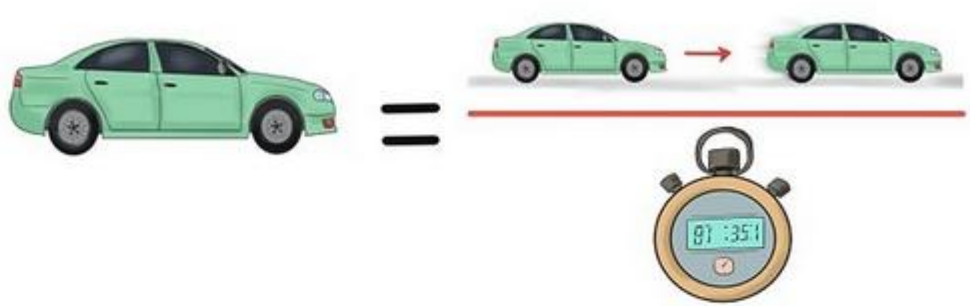


Example 1: Describe the Following graph?



- **Section 3: Topic 14**

Acceleration



How can you determine if your acceleration is to high?

Calculating Acceleration

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

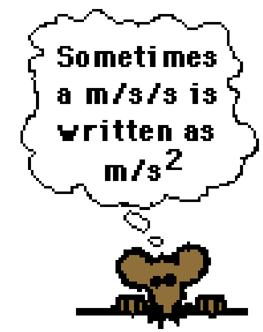
$$\text{Ave. acceleration} = \frac{\Delta\,\text{velocity}}{\text{time}} = \frac{v_f - v_i}{t}$$

A = acceleration

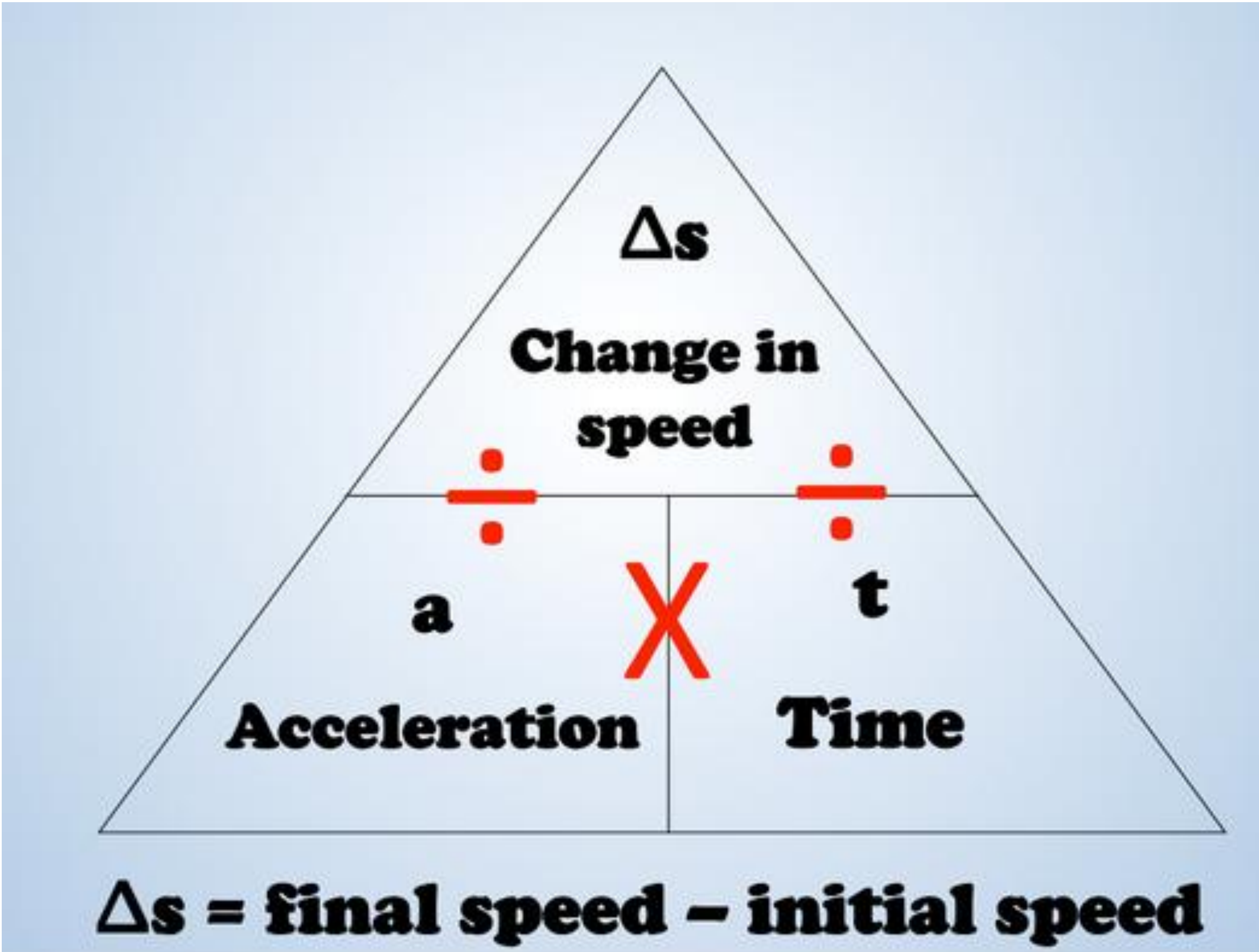
V_1 = initial velocity

V_2 = Final velocity

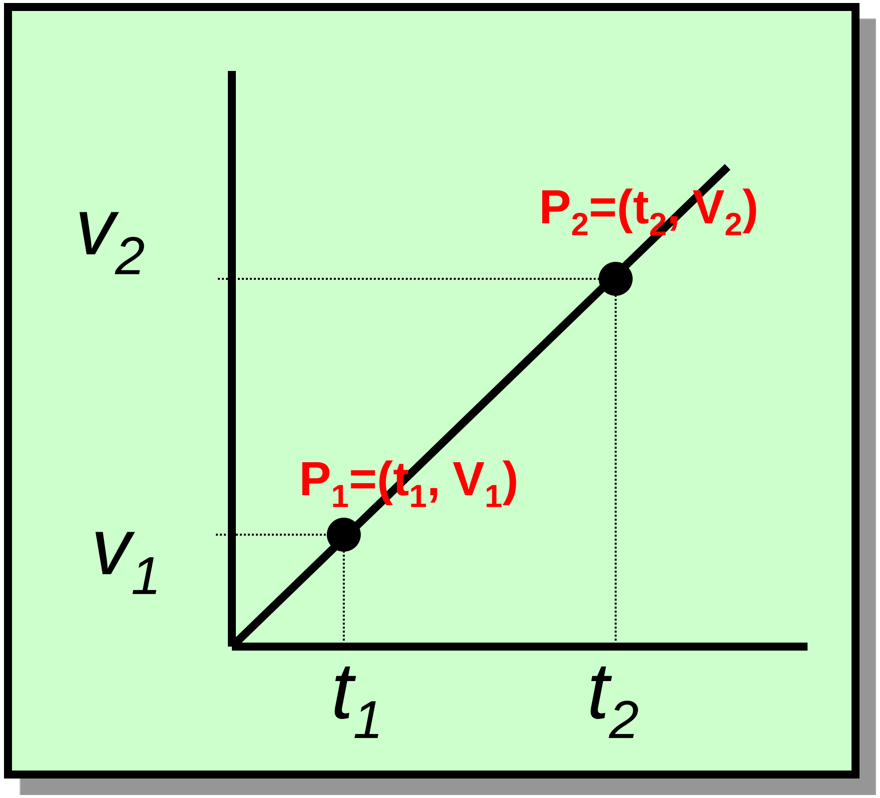
T = change in time



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


Δs
Change in speed
÷
÷
X
a
Acceleration
t
Time
Δs = final speed – initial speed

Where did this formula come from?



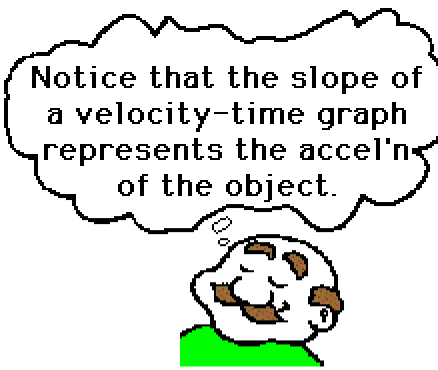
The **slope** of a line on a V-T graph provides the **acceleration** of the object

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

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

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

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



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:

Canadian Myriam Bedard won two gold medals in the biathlon in the 1994 Winter Olympics. If she accelerates at an average of 2.5 m/s^2 (E) for 1.5 s, what is her change in velocity at the end of 1.5 s?

Solution:

Example 4:

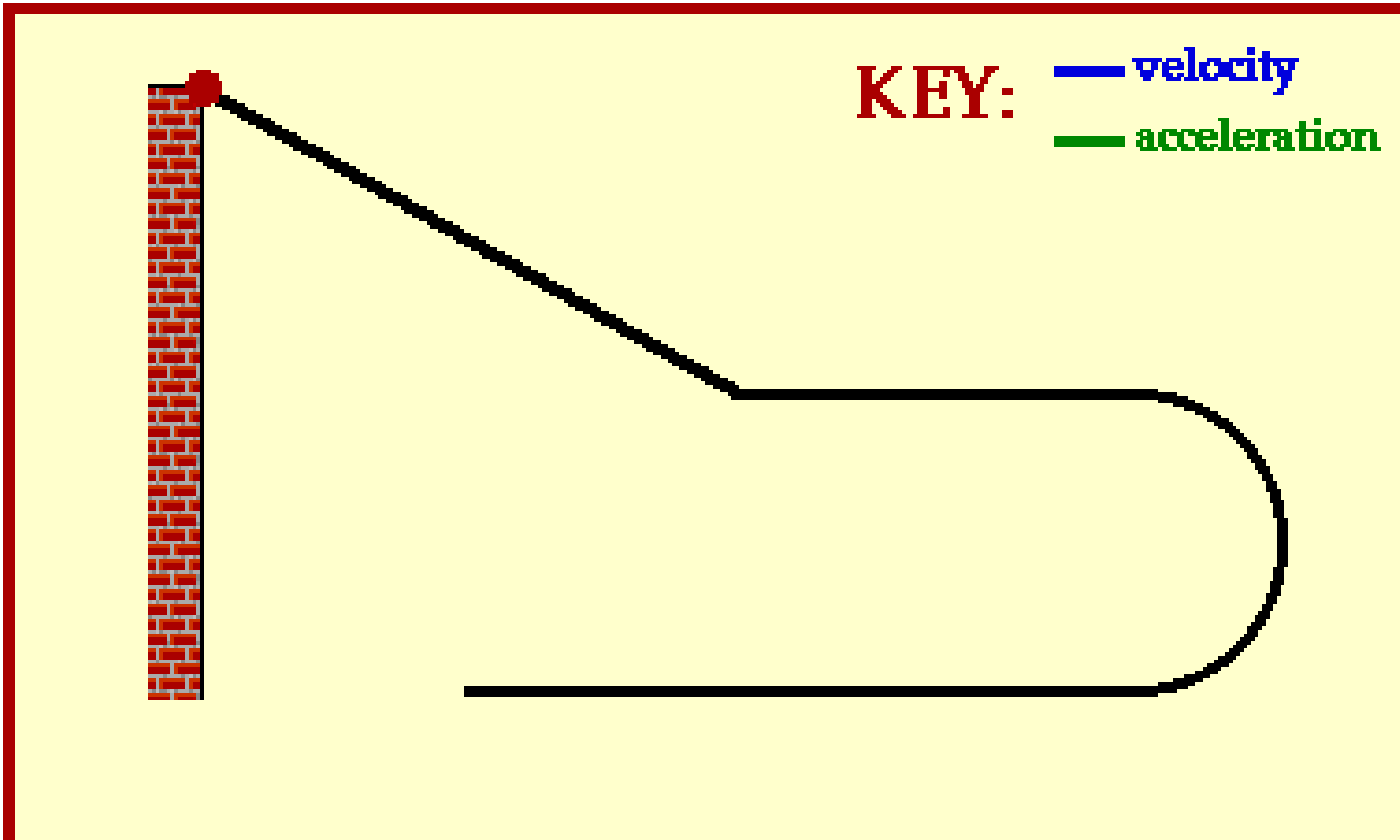
An air puck on an air table is attached to a spring. The puck is fired across the table at an initial velocity of 0.45 m/s right and the spring accelerates the air puck at an average acceleration of 1.0 m/s^2 left. What is the velocity of the air puck after 0.60s?

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*

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

Example 5:

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 9.81m/s2 down. Assume up is positive and down is negative.

What is the velocity of the ball after 0.50s and after 1.5s?

Solution:

Activity

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