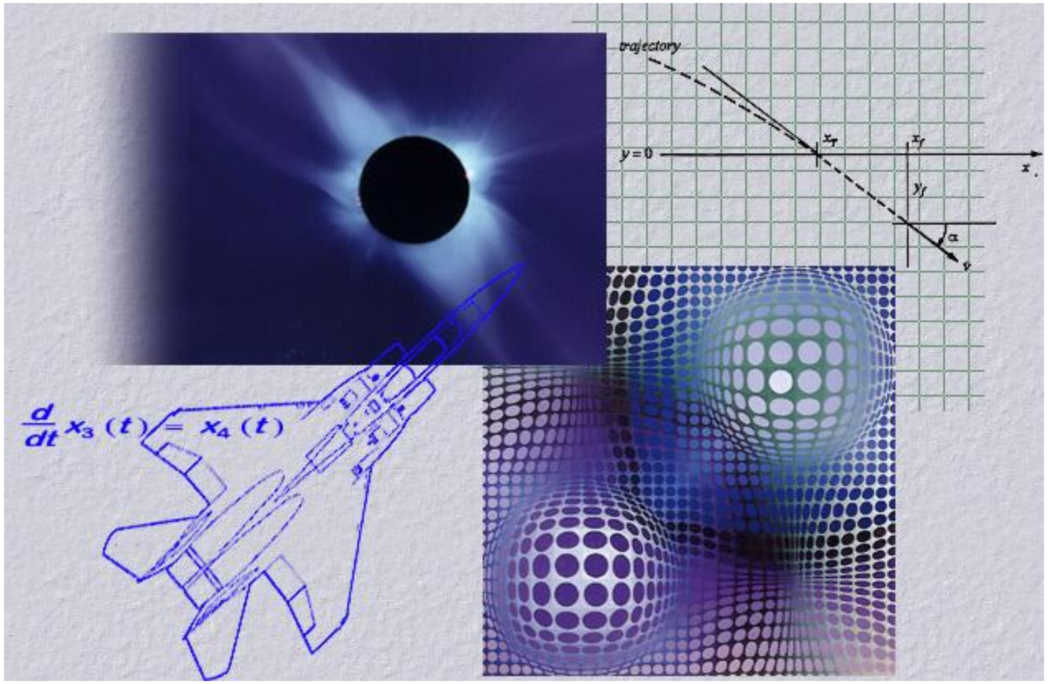
WHAT IS PHYSICS?

Physics is a branch of science that involves the study of the physical world: energy, matter, and how they are related.

Learning Physics will help you understand the physical world.



Once the physical world has been described, the Physics principles involved can be used to make predictions about a broad range of phenomena.

For example, the same Physics principles that are used to describe the interaction between two planets can also be used to describe the motion of a satellite orbiting the Earth.

Many of the inventions, appliances, tools, and buildings we live with today are made possible by the application of physics principles. Every time you take a step, catch a ball, open a door, whisper, or check your image in a mirror, you are unconsciously using your knowledge of Physics.

NAME	*SUBJECTS*	*EXAMPLES*
MECHANICS	motion and its causes	falling objects, friction, forces spinning objects
THERMODYNAMICS	heat and temperature	melting and freezing processes, engines, refrigerators
VIBRATIONS AND WAVES	specific types repetitive motion	springs, pendulums, sound
OPTICS	light	mirrors, lenses, color, astronomy
ELECTROMAGNETISM	electricity, magnetism and light	electrical charge, circuits, magnets
RELATIVITY	particles moving at any speed	particle collisions, particle accelerators, nuclear energy
QUANTUM MECHANICS	behavior of submicroscopic particles	atom and its parts

SCIENTIFIC METHOD

Making observations, doing experiments, and creating models or theories to try to explain your results or predict new answers form the essence of a scientific method.

All scientists, including physicists, obtain data, make predictions, and create compelling explanations that quantitatively describe many different phenomena.

Written, oral, and mathematical communication skills are vital to every scientist.

Scientific Methods

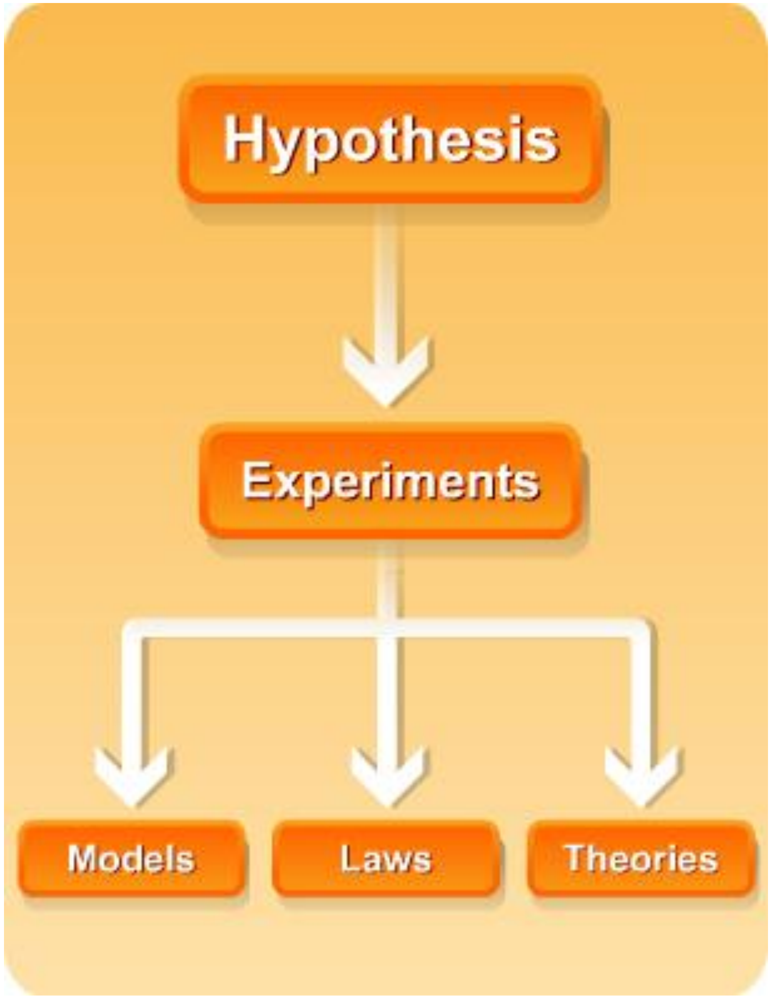
The experiments and results must be reproducible; that is, other scientists must be able to recreate the experiment and obtain similar data.

A scientist often works with an idea that can be worded as a hypothesis, which is an educated guess about how variables are related.

Scientific Methods

A hypothesis can be tested by conducting experiments, taking measurements, and identifying what variables are important and how they are related.

Based on the test results, scientists establish models, laws, and theories.



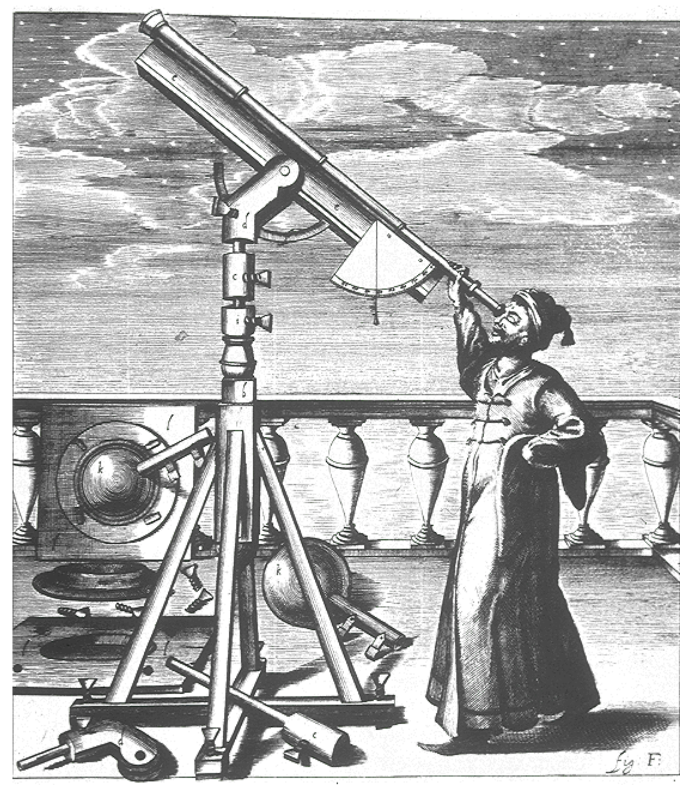
Scientific models are based on experimentation.

If new data do not fit a model, both new data and model are re-examined.

If the new data are born out by subsequent experiments, the theories have to change to reflect the new findings.

In the nineteenth century, it was believed that linear markings on Mars showed channels.

As telescopes improved, scientists realized that there were no such markings.

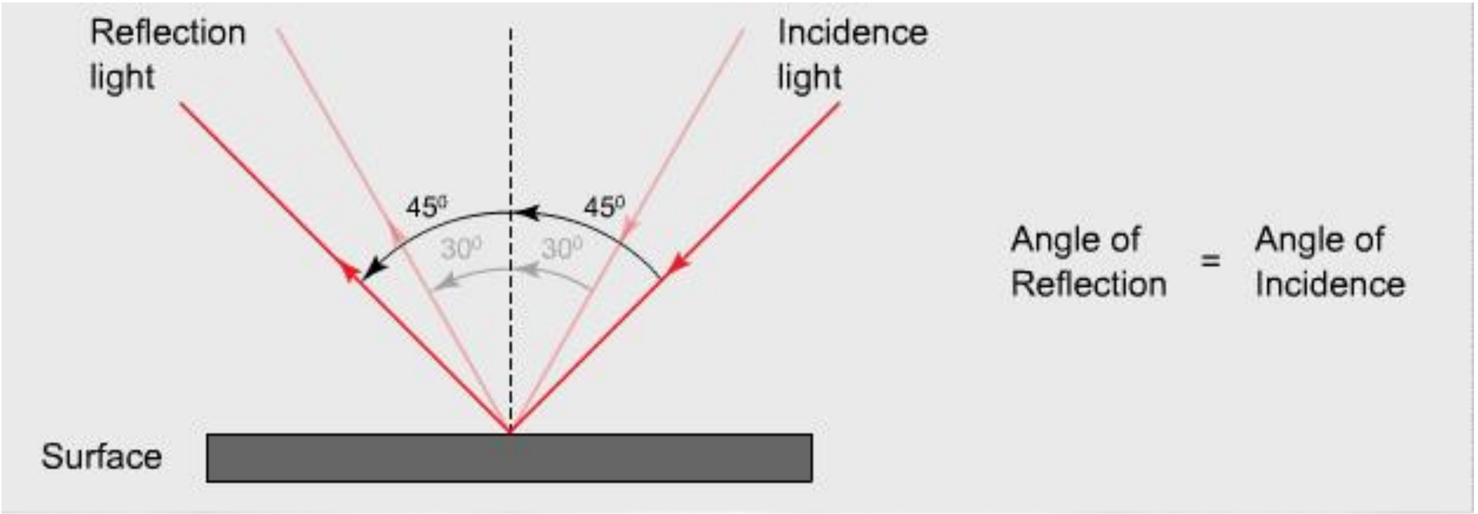


In recent times, again with better instruments, scientists have found features that suggest Mars once had running and standing water on its surface.

Each new discovery has raised new questions and areas for exploration.

Laws, and Theories

A scientific law is a rule of nature that sums up related observations to describe a pattern in nature.



The diagram above shows how a scientific law gets established. Notice that the laws do not explain why these phenomena happen, they simply describe them.

Laws, and Theories

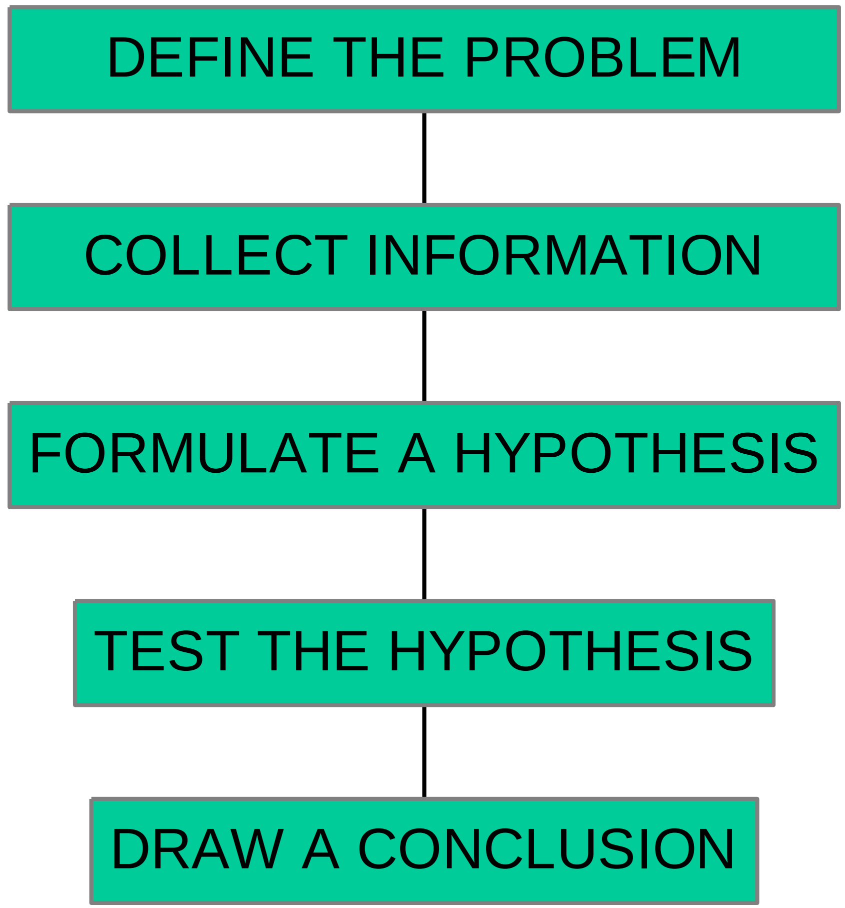
A scientific theory is an explanation based on many observations supported by experimental results.

A theory is the best available explanation of why things work as they do.

Laws and theories may be revised or discarded over time.

Theories are changed and modified as new experiments provide insight and new observations are made.

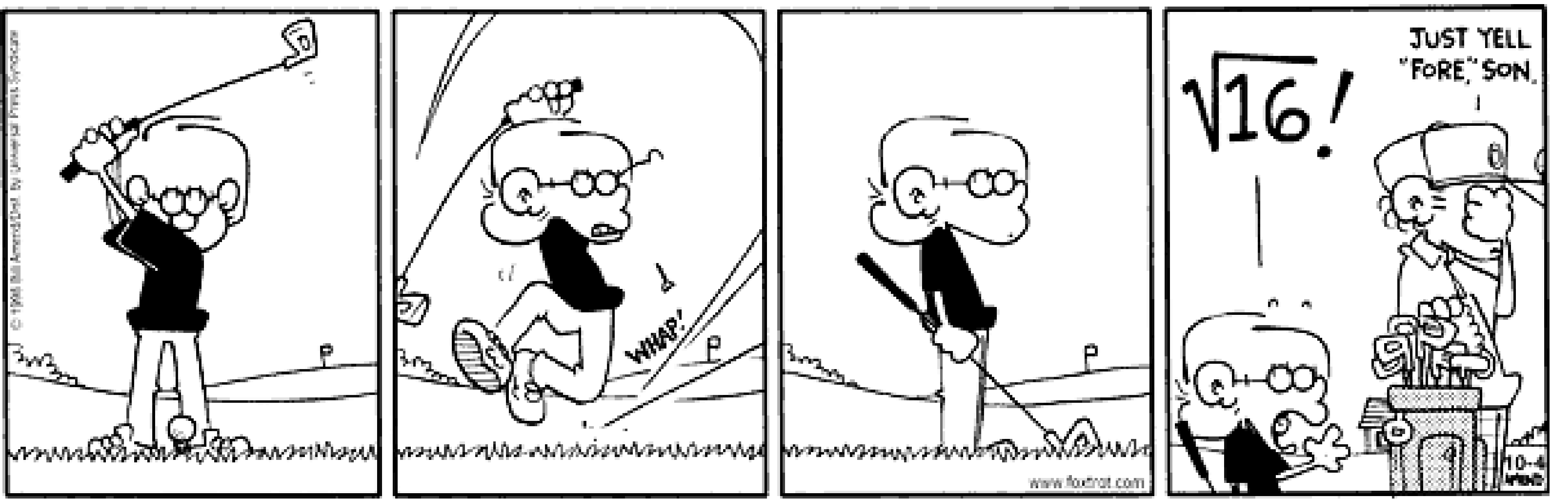
SCIENTIFIC METHOD



MATHEMATICS AND PHYSICS

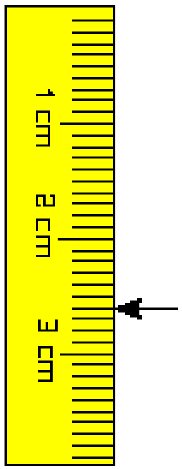
Physics uses mathematics as a powerful language.

In Physics, equations are important tools for modeling observations and for making predictions.

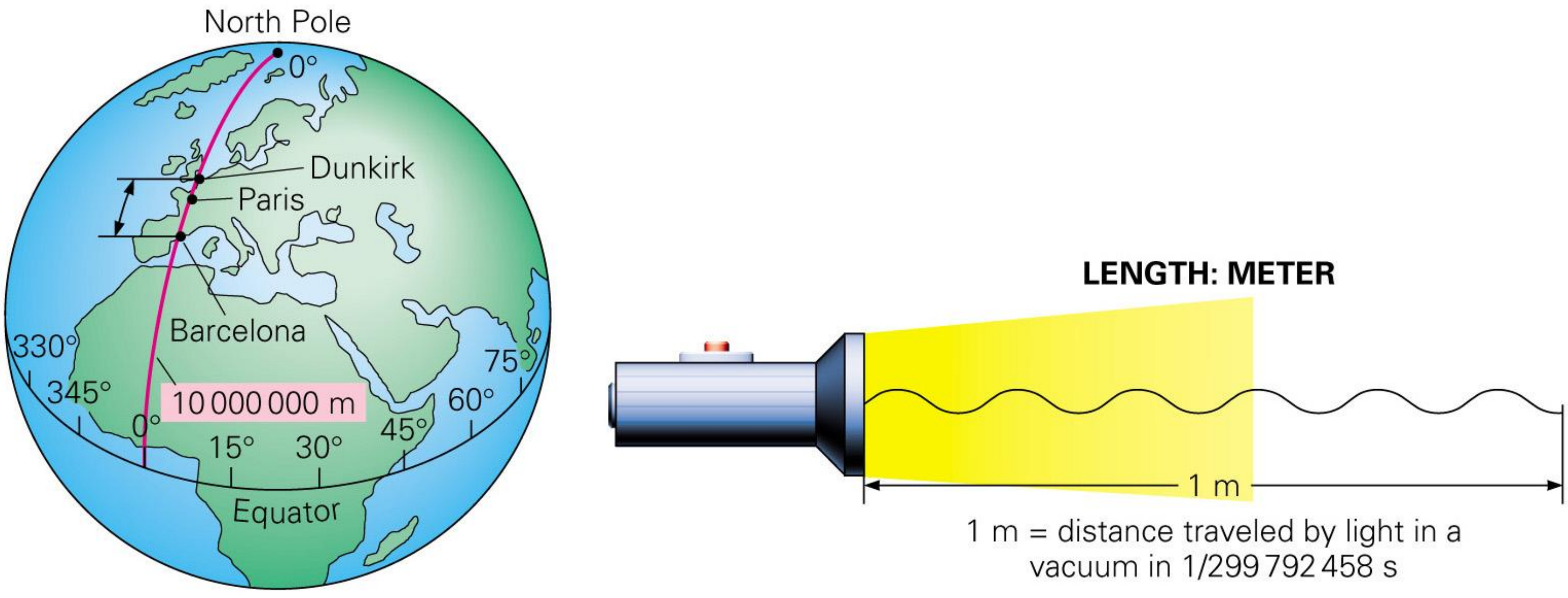


UNITS, STANDARDS AND THE SI SYSTEM

The base units that will be used in this course are: meter, kilogram, second



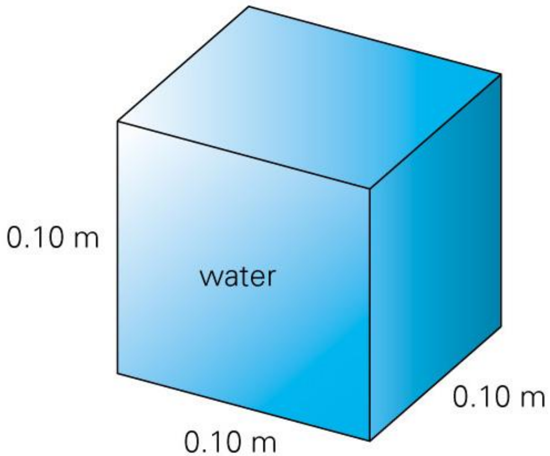
A Meter Stick Ruled in 1 mm Graduations



(a) (b)

The SI length standard: the meter

meter (m): One meter is equal to the path length traveled by light in vacuum during a time interval of 1/299,792,458 of a second.

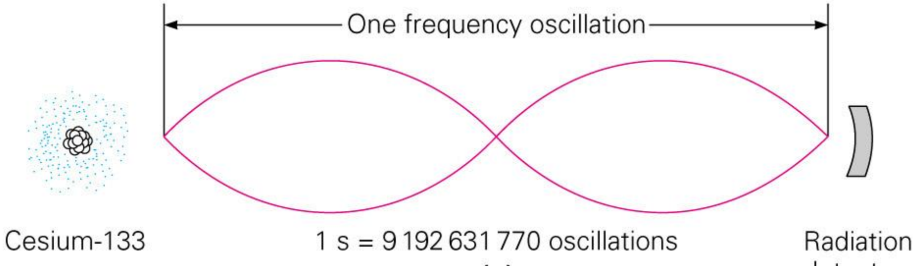


(a)


(b)

The SI mass standard: the kilogram

kilogram (kg): One kilogram is the mass of a Platinum-Iridium cylinder kept at the International Bureau of Weights and Measures in Paris.



(a)


(b)

The SI time standard: the second

second (s): One second is the time occupied by 9,192,631,770 vibrations of the light (of a specified wavelength) emitted by a Cesium-133 atom.

All physical quantities are expressed in terms of base units. For example, velocity is usually given in units of m/s.

All other units are derived units and may be expressed as a combination of base units. For example: A Newton is a unit of force: 1 N = 1 kg.m/s^2

SI PREFIXES

Multiple	Prefix	Symbol	Multiple	Prefix	Symbol
10^{-1}	deci	d	10	deca	da
10^{-2}	centi	c	10^{2}	hecto	h
10^{-3}	milli	m	10^{3}	kilo	k
10^{-6}	micro	μ	10^{6}	mega	M
10^{-9}	nano	n	10^{9}	giga	G
10^{-12}	pico	p	10^{12}	tera	T
10^{-15}	femto	f	10^{15}	peta	P
10^{-18}	atto	a	10^{18}	exa	E

MATHEMATICAL NOTATION

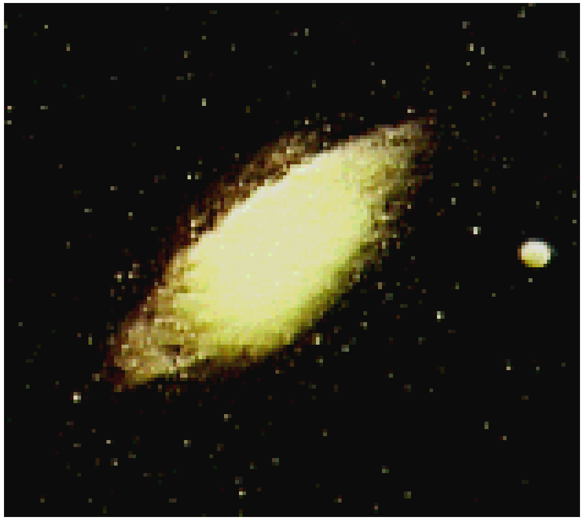
Many mathematical symbols will be used throughout this course:

- **=** denotes equality of two quantities
- **∝** denotes a proportionality
- **<** means is less than and
- **>** means greater than
- **≈** two quantities are approximately equal to each other
- **Δx** (read as “delta x”) indicates the change in the quantity *x*
- **Σ** represents a sum of several quantities, also called summation (sum of…)

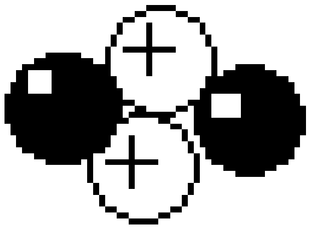
Why Use Scientific Notation?

Scientific Notation was developed in order to easily represent numbers that are either very large or very small. Here are two examples of large and small numbers. They are expressed in decimal form instead of scientific notation to help illustrate the problem:

The Andromeda Galaxy (the closest one to our Milky Way galaxy) contains at least 200,000,000,000 stars.



On the other hand, the weight of an alpha particle, which is emitted in the radioactive decay of Plutonium-239, is 0.000,000,000,000,000,000,000,000,006,645 kilograms.



As you can see, it could get tedious writing out those numbers repeatedly. So, a system was developed to help represent these numbers in a way that was easy to read and understand: Scientific Notation.

What is Scientific Notation?

Using one of the above examples, the number of stars in the Adromeda Galaxy can be written as: 2.0×10^{11}

How Does Scientific Notation Work?

As we said above, the exponent refers to the number of zeros that follow the 1. So:

$10^1 = 10$;
$10^2 = 100$;
$10^3 = 1{,}000$,
and so on.

Similarly, $10^0 = 1$, since the zero exponent means that no zeros follow the 1.

Negative exponents indicate negative powers of 10,

So:

$10^{-1} = 1/10$;

$10^{-2} = 1/100$;

$10^{-3} = 1/1{,}000$,

and so on.

Write the following numbers in scientific notation:

1. **156.90 =**

2. **12 000 =**

3. **0.0345 =**

4. **0.008 90 =**

Expand the following numbers:

5. $1.23 x 10^{6}$ =

6. $2.5 x 10^{-3}$ =

7. $1.54 x 10^{4}$ =

8. $5.67 x 10^{-1}$ =

USE 01 PHYSICS SKILLS W.S. – SCI NOTATION

Solve the following and put your answer in scientific notation:

9. $$\frac{6.6x10^{-8}}{3.3x10^{-4}} =$$

10. $$\frac{7.4x10^{10}}{3.7x10^{3}} =$$

11. $$\frac{2.5x10^{8}}{7.5x10^{2}} =$$

12. $(2.67x10^{-3}) - (9.5\ x10^{-4}) =$

13. $(1.56 \times 10^{-7}) + (2.43 \times 10^{-8}) =$

14. $(2.5 \times 10^{-6}) \times (3.0 \times 10^{-7}) =$

15. $(1.2 \times 10^{-9}) \times (1.2 \times 10^{7}) =$

16. $(2.3 \times 10^{4}) + (2.0 \times 10^{-3}) =$

ORDER OF OPERATIONS

Equations are used throughout the study of physics. These equations consist of operations such as addition, subtraction, multiplication, division, and trigonometric functions. When solving equations, it is important to follow an order in which the operations are performed.

For example, what number is equal to $3 + 4 \times 2 - 5$?

Order of Operations:

1. Perform all operations within grouping symbols, such as parentheses.

2. Evaluate all exponential expressions.

3. Evaluate all trigonometric functions.

4. Perform all multiplication and division in the order they occur from left to right.

5. Perform all addition and subtraction in the order they occur from left to right.

PLEASE EXTERMINATE MY DEAR AUNT SALLY

GUIDED PRACTICE

Find the value of each of the following expressions:

1. 8.0 x 4.0 – 9.0 =

2. $\frac{-100}{10}+25$ **=**

3. $\frac{8}{2}(4)$ **=**

4. $\frac{75-25}{5}+10$ **=**

5. $\dfrac{5+2}{8-1}$ **=**

6. -2(5 - 3) + 8 =

7. $\dfrac{48}{4.0(6.0)} - 10.0$ **=**

8. $\dfrac{\dfrac{2.0(3.0)}{8.0} - 12}{6.0}$ **=**

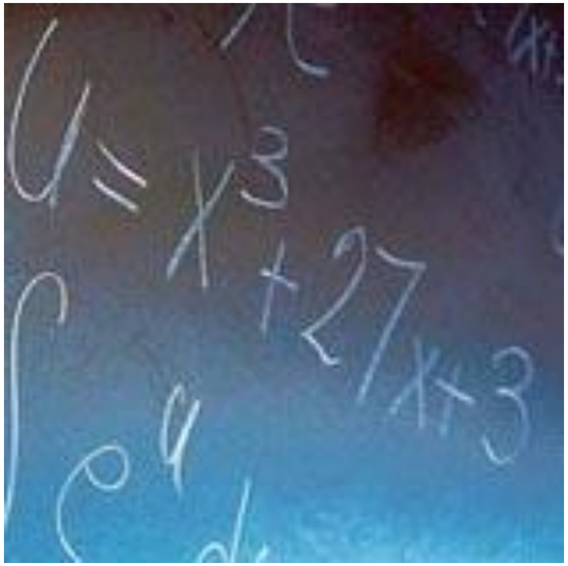
PART I. SOLVING EQUATIONS

BASIC ALGEBRA:

adding ⟷ subtracting

multiplying ⟷ dividing

squared ⟷ square root



SOLVING EQUATIONS – *USE 02 PHYSICS W.S. - EQUATIONS*

Solve the following equations for the quantity indicated.

1. $x = vt$ **Solve for *v***

2. $F = ma$ **Solve for *m***

3. $F = ma$ **Solve for *a***

4. $F_T - F_g = ma$ **Solve for *a***

5. $F_T - F_g = ma$ Solve for F_T

6. $F_T - F_g = ma$ Solve for F_g

7. $v = \dfrac{x}{t}$

Solve for *t*

8. $y = \dfrac{1}{2}at^2$

Solve for *t*

9. $x = v_o t + \frac{1}{2}at^2$ **Solve for v_o**

10. $v = \sqrt{2ax}$ **Solve for x**

11. $$a = \frac{v_f - v_o}{t}$$ **Solve for *t***

12. $$a = \frac{v_f - v_o}{t}$$ **Solve for v_f**

13. $KE = \frac{1}{2}mv^2$ **Solve for *v***

14. $KE = \frac{1}{2}mv^2$ **Solve for *m***

15. $F = \frac{Gm_1 m_2}{r^2}$ **Solve for *r***

16. $F = \frac{Gm_1 m_2}{r^2}$ **Solve for m_2**

17. $T = 2\pi\sqrt{\frac{L}{g}}$ **Solve for *L***

18. $T = 2\pi\sqrt{\frac{L}{g}}$ **Solve for *g***

PART III. FACTOR-LABEL METHOD FOR CONVERTING UNITS

Change 25 *km/h* to *m/s*

$$\left(\frac{25\ \text{km}}{\text{h}}\right)\left(\frac{1000\ \text{m}}{1\ \text{km}}\right)\left(\frac{1\ \text{h}}{3600\ \text{s}}\right) = \mathbf{6.94\ m/s}$$

What is the conversion factor to convert *km/h* to *m/s?*

DIVIDE BY 3.6

What is the conversion factor to convert *m/s* to *km/h?*

MULTIPLY BY 3.6

USE 03 PHYISCS SKILLS W.S. – UNIT CONVERSION

1. Convert 28 km to cm.

2. Convert 45 kg to mg.

3. Convert 85 cm/min to m/s.

4. 8.8×10^{-8} m to mm

5. Convert the speed of light, $3x10^8$ m/s, to km/day.

6. Convert 450 m/s to km/h.

7. Convert 150 km/h to m/s

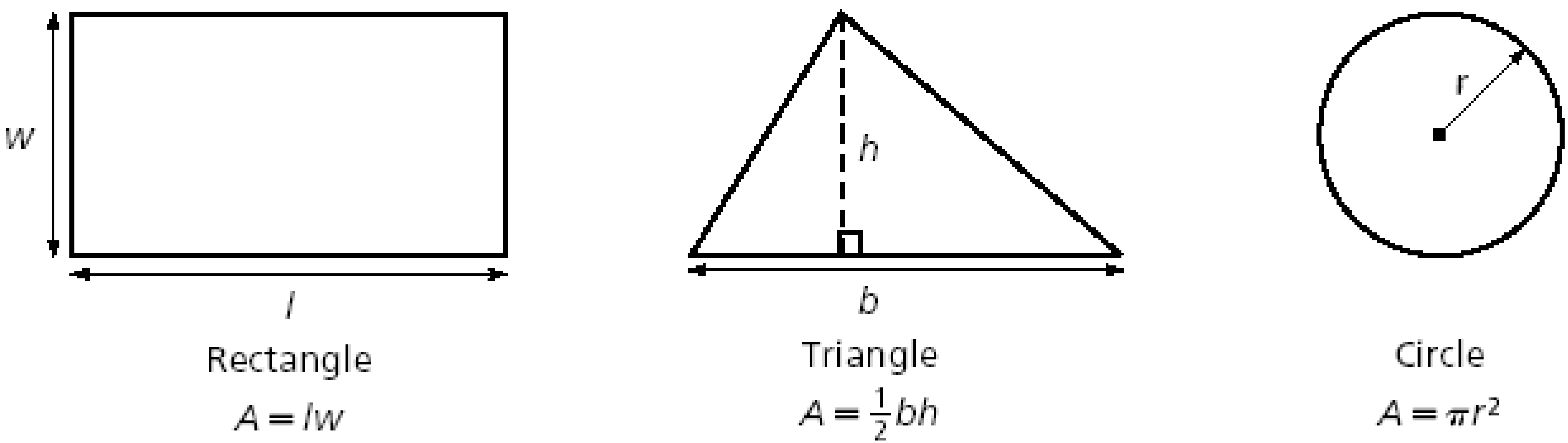
8. How many seconds are in a year?

USE 04 PHYISCS SKILLS W.S. – GEOMETRY/TRIG

BASIC GEOMETRY

Area

Area, *A*, is the number of square units needed to cover a surface. Some common shapes and the formulas for calculating the area of each shape are shown below:



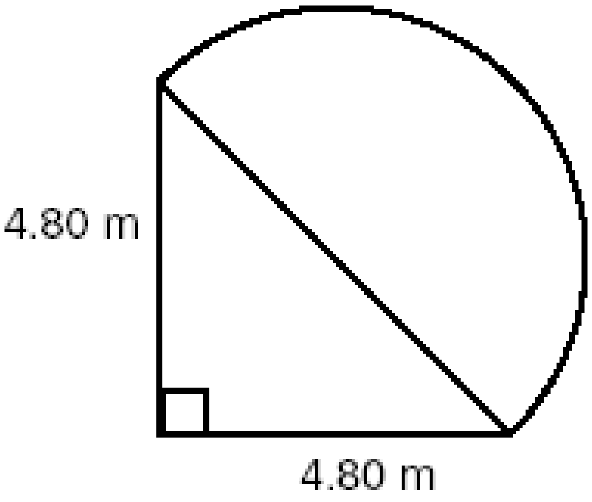
USE 04 PHYISCS SKILLS W.S. – GEOMETRY/TRIG

Find the area of each of the following shapes described below.

1. A rectangular driveway that is 3.05 m wide and 64.0 m long

2. Circle with r = 8.00 cm

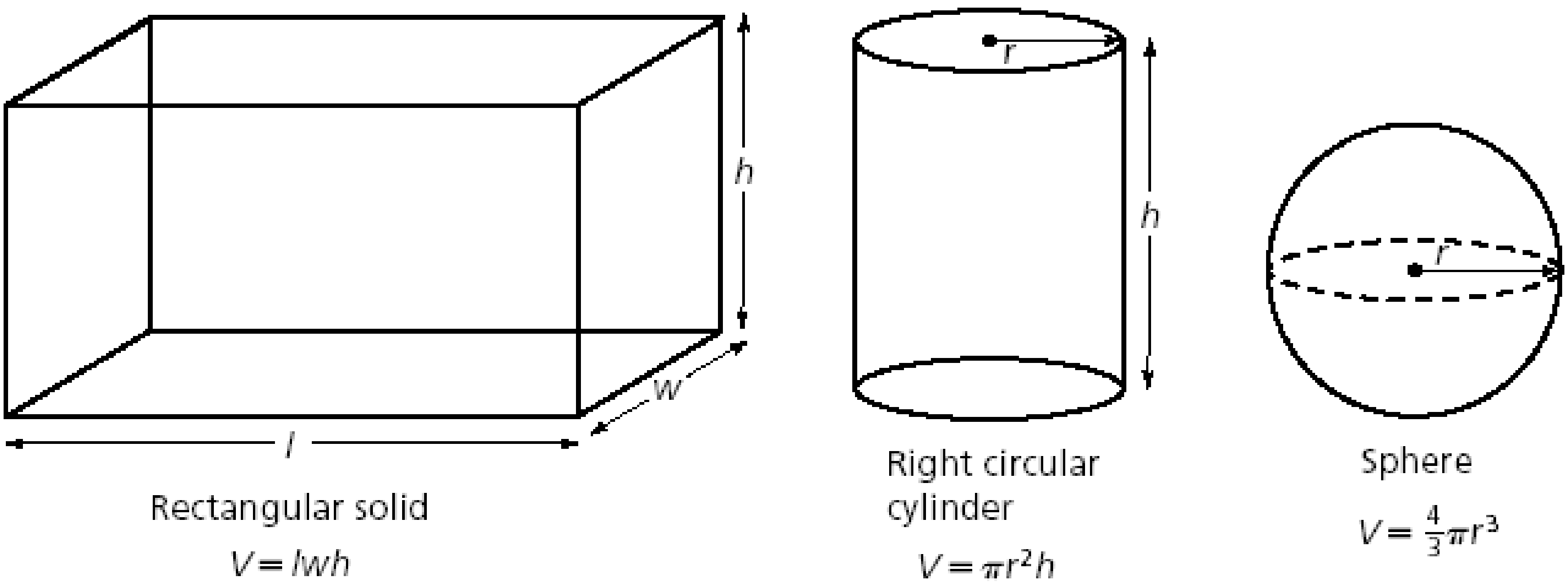
3. A shape formed by the figure below



USE 04 PHYISCS SKILLS W.S. – GEOMETRY/TRIG

Volume

The volume, V, of a three-dimensional object is the amount of space it occupies. The units for volume are length units cubed, such as m^3 or cm^3. Some common formulas for volume are shown below:



Find the volume of the shape:

4. A physics laboratory workbook with
***l* = 27.7 cm, *w* =21.6 cm, and *h*= 3.7 cm**

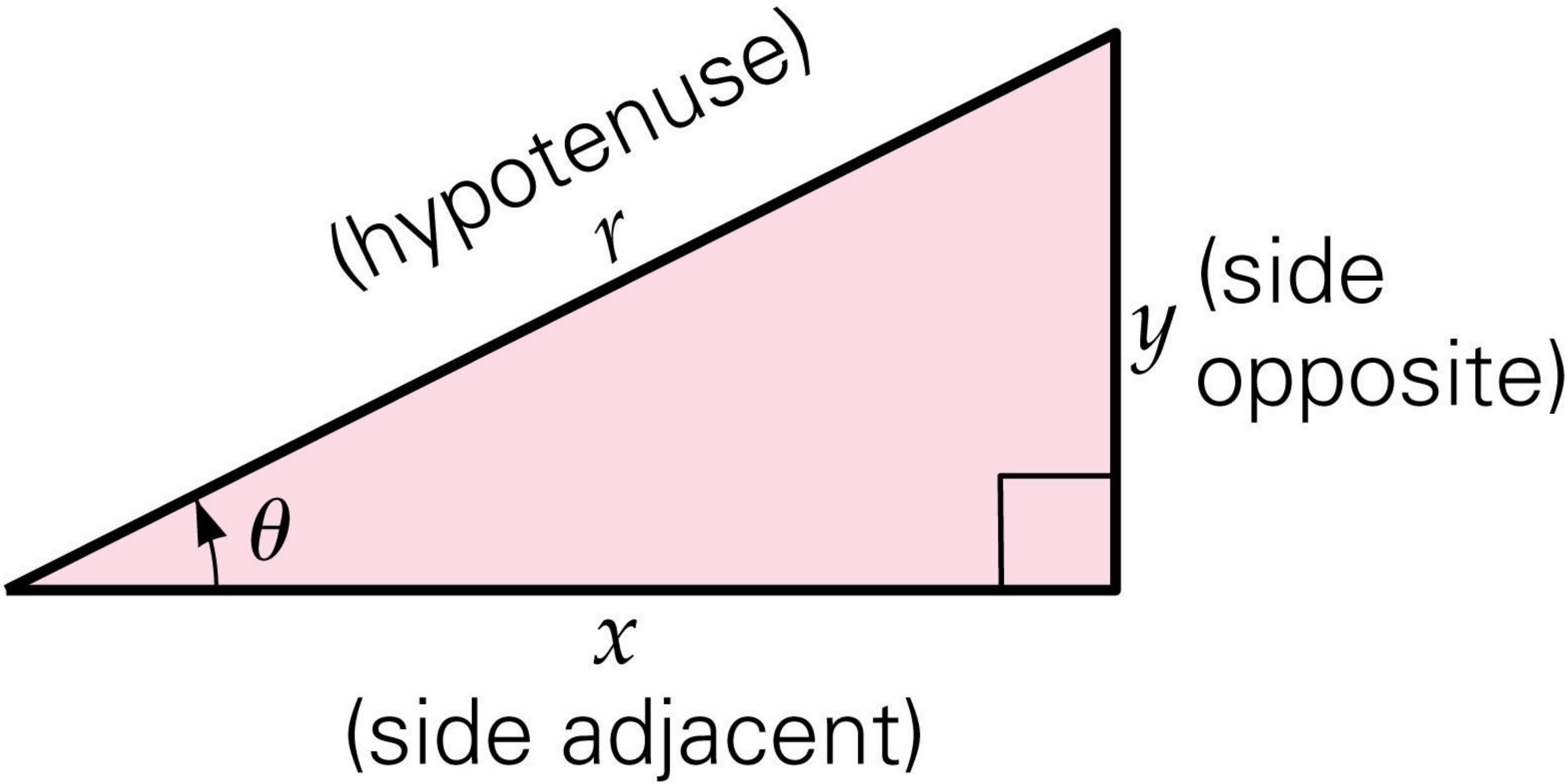
5. A plastic jewel case for a computer CD-ROM with *l*= 14.1 cm, *w*= 12.4 cm, and *h*= 1.0 mm

6. **A salad crouton cube whose side measures 7.00 mm**

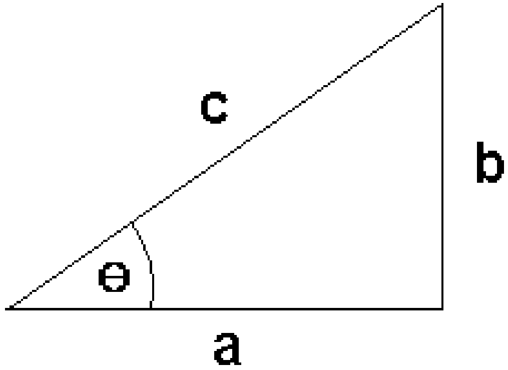
7. A cylindrical juice glass with:
diameter = 6.5 cm and *h*= 11.0 cm

8. A basketball with diameter = 22 cm

TRIGONOMETRY



SOH CAH TOA



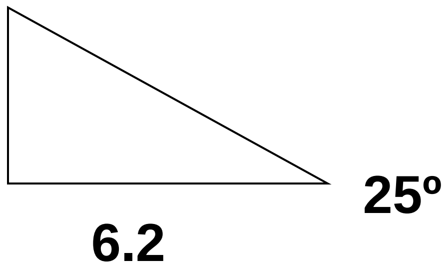
$$\sin\theta = \frac{opp}{hyp} = \frac{b}{c}$$

$$\cos\theta = \frac{adj}{hyp} = \frac{a}{c}$$

$$c^2 = a^2 + b^2$$

$$\tan\theta = \frac{opp}{adj} = \frac{b}{a}$$

1.



$$\cos 25^\circ = \frac{6.2}{c}$$

$$c = \frac{6.2}{\cos 25^\circ}$$ **= 6.84**

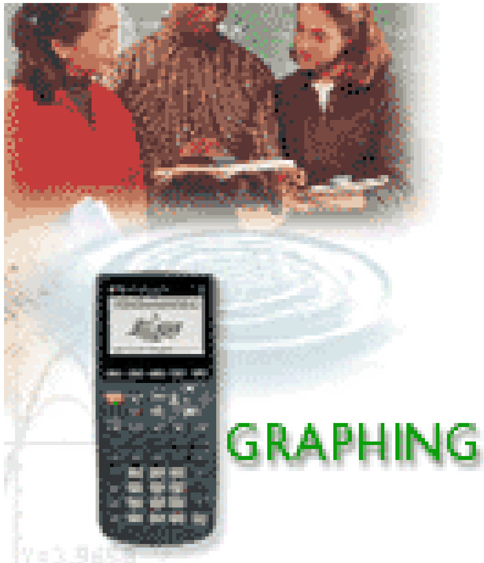
$$c^2 = a^2 + b^2$$

$$a^2 = c^2 - b^2$$

$$a = \sqrt{c^2 - b^2} = \sqrt{(6.84)^2 - (6.2)^2}$$ **= 2.89**

B = 180º - (90º+25º)**= 65º**

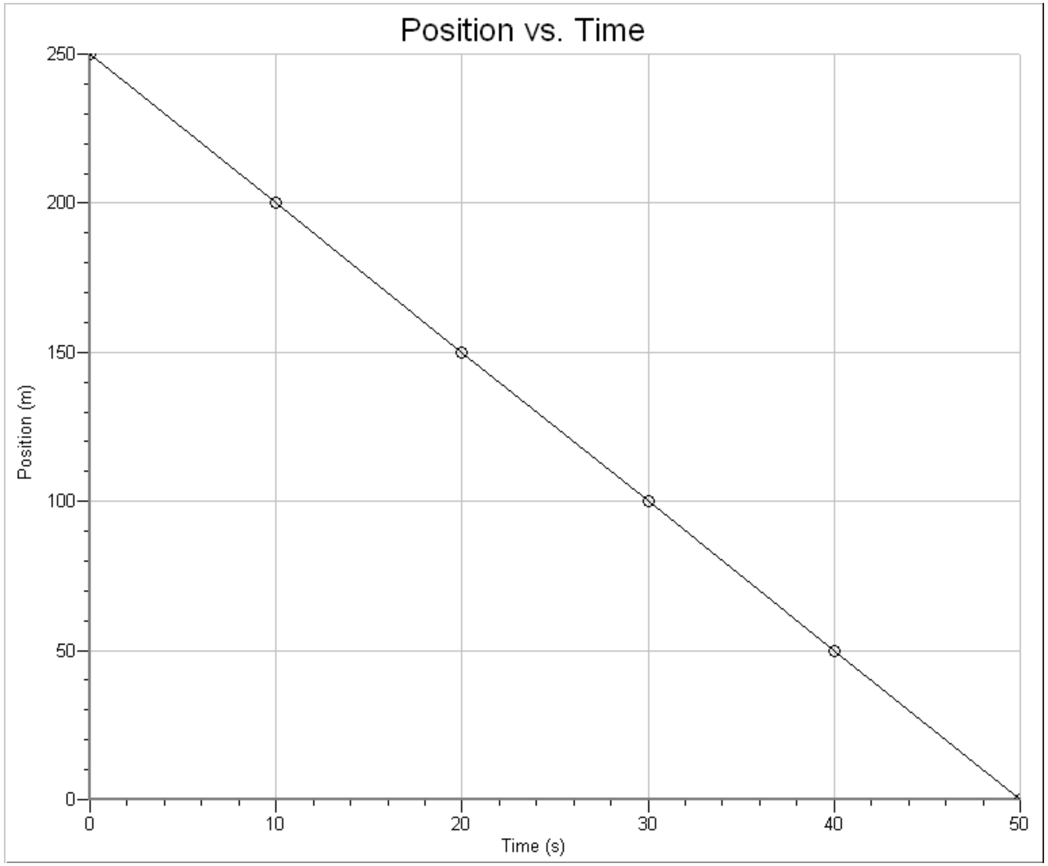
c = 6.84
a = 2.89
A = 65º



GRAPHING TECHNIQUES

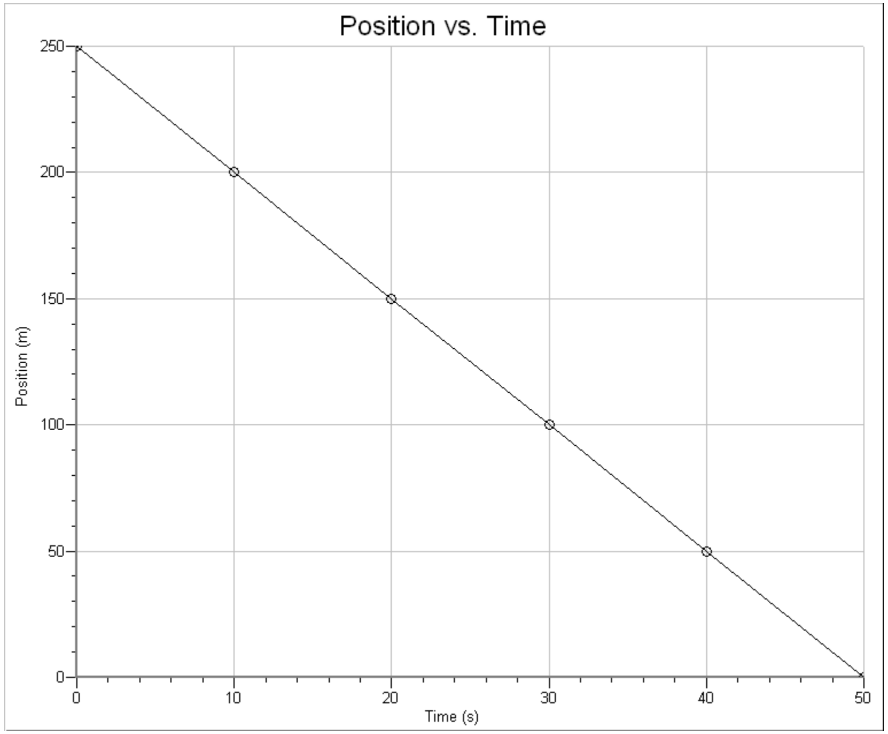
Frequently an investigation will involve finding out how changing one quantity affects the value of another.

The quantity that is deliberately manipulated is called the *independent variable*.
The quantity that changes as a result of the independent variable is called the *dependent variable.*



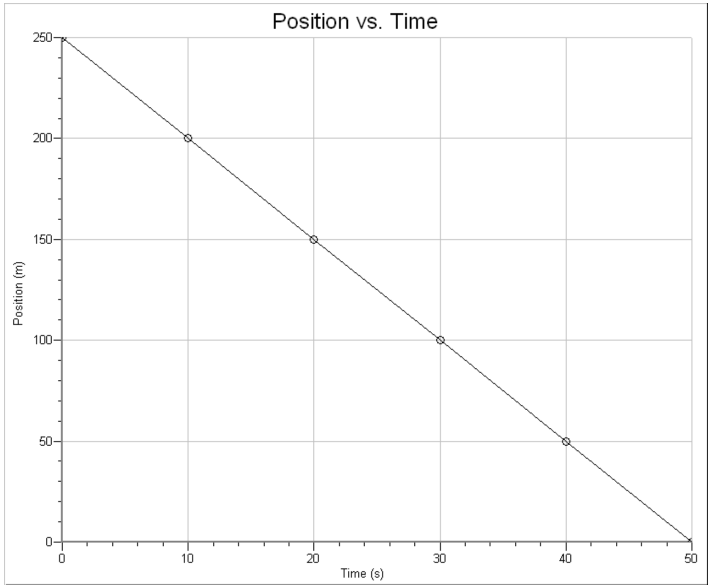
1. **Identify the independent and dependent variables:**

Time = independent
Position = dependent



2. **Choose your scale carefully: 5 cm = 1 unit**

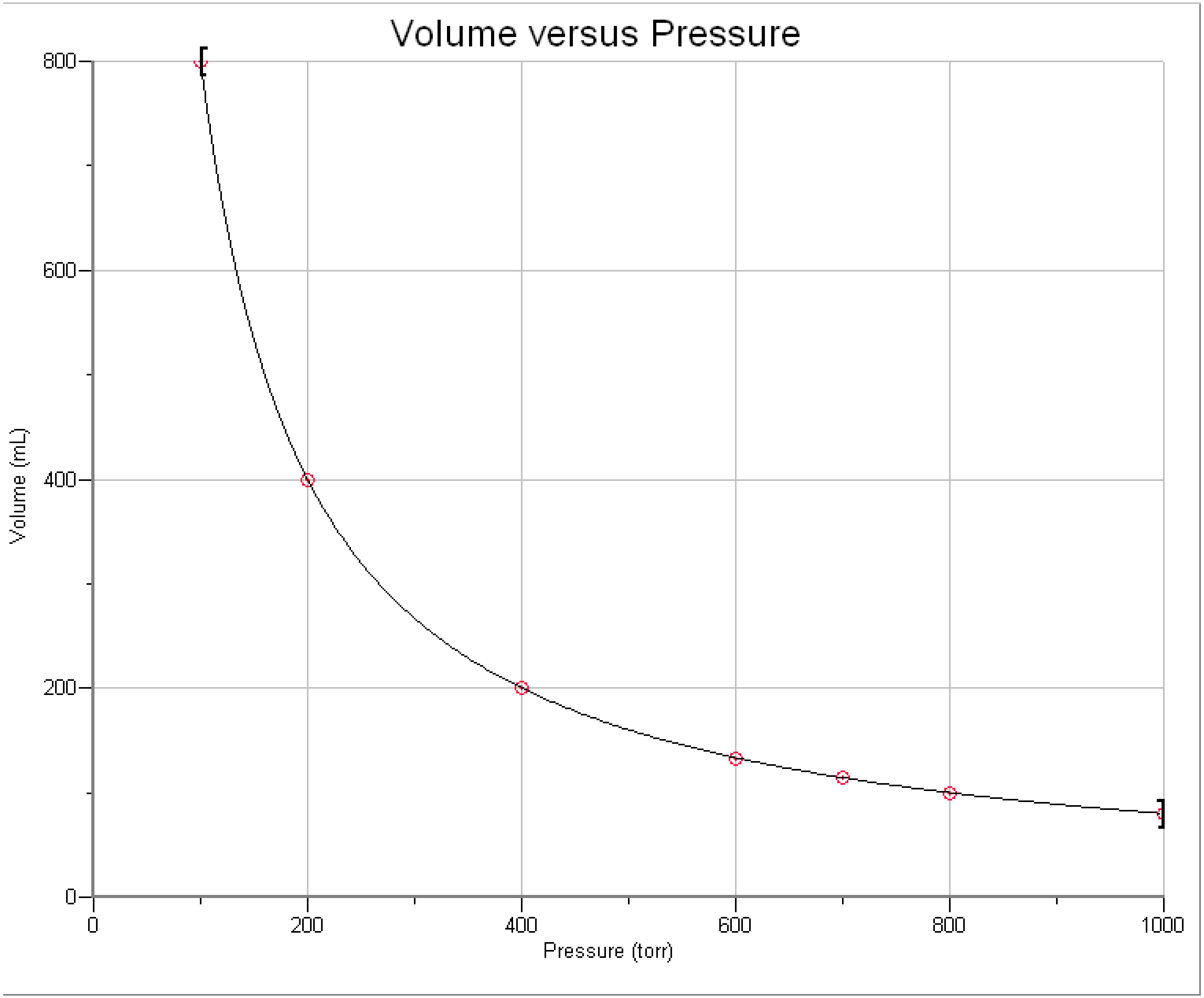
3. **Plot the independent variable on the horizontal (*x*) axis and the dependent variable on the vertical (*y*) axis.**



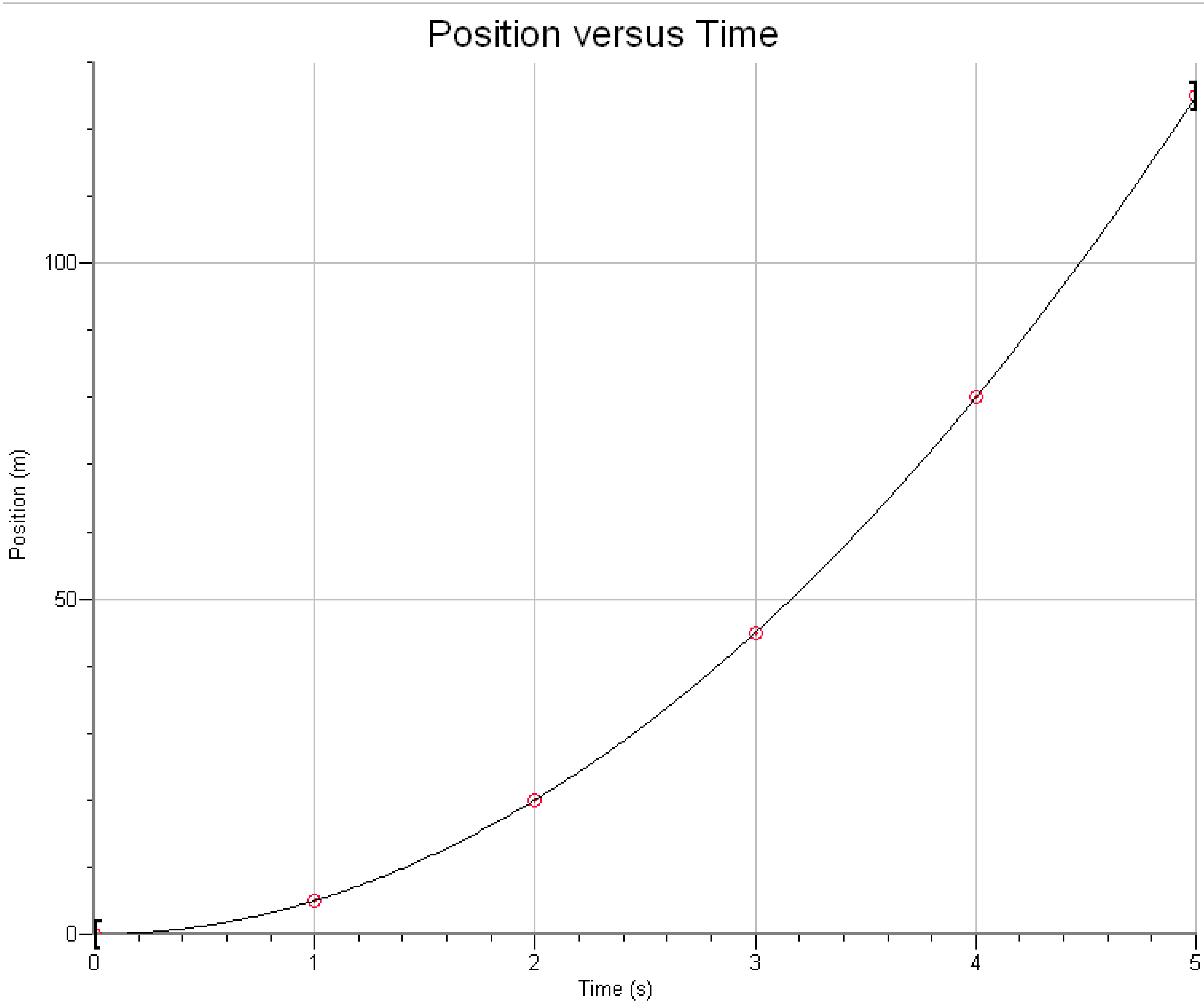
4. If the data points appear to lie roughly in a straight line, draw the best straight line you can with a ruler and a sharp pencil.

5. Title your graph.

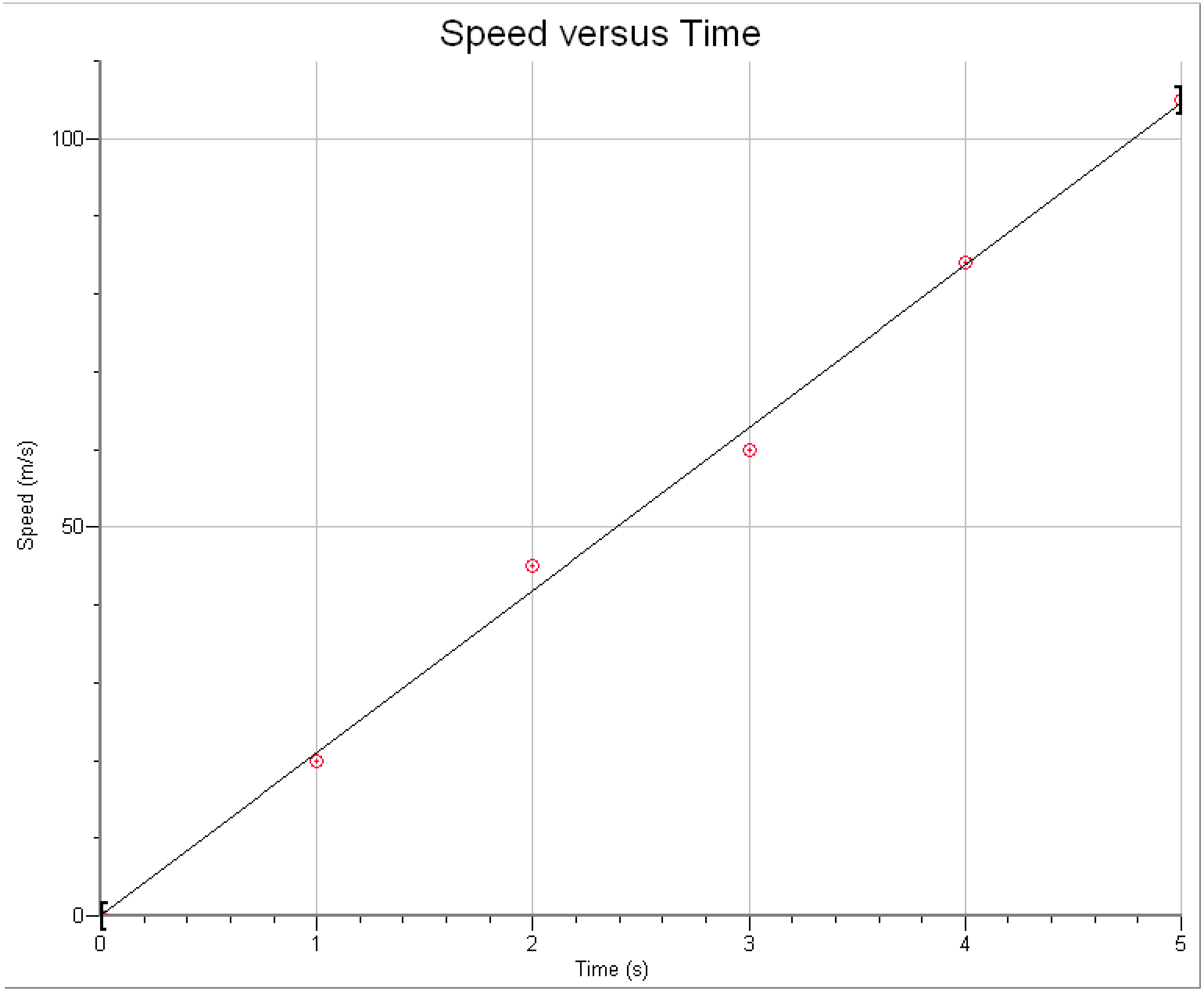
6. Label each axis with the name of the variable and the unit.



Volume versus Pressure
Volume (mL)
Pressure (torr)
0
200
400
600
800
1000

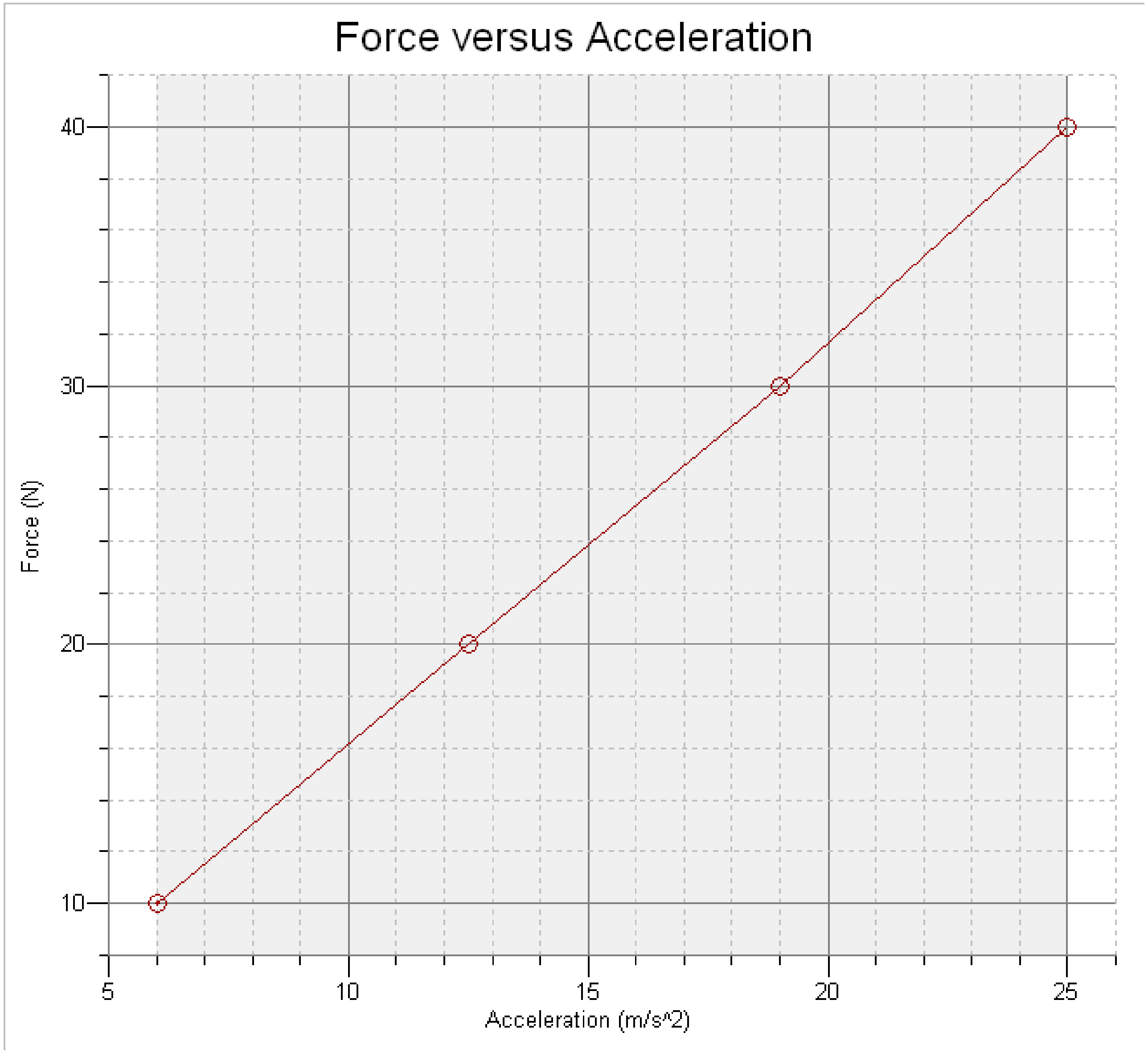


Position versus Time
Position (m)
100
50
0
0
1
2
3
4
5
Time (s)



Speed versus Time
100
50
0
Speed (m/s)
0
1
2
3
4
5
Time (s)

1. **Suppose you recorded the following data during a study of the relationship of force and acceleration. Prepare a graph showing these data.**



a. Describe the relationship between force and acceleration as shown by the graph.

Acceleration is directly proportional to force

b. What is the slope of the graph?

$$slope = \frac{\Delta y}{\Delta x} = \frac{40-10}{25-6} = \frac{30\ \text{kg}\times\text{m/s}^2}{19\ \text{m/s}^2} = \mathbf{1.57\ kg}$$

c. What physical quantity does the slope represent?

The slope represents the mass.