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Introduction to Physics

The Journey

What is the most wonderful journey that humankind made for the last 10,000 years? Is it the land journey from the center of what is now Africa to all points of the world and led to the rise of human beings as the dominant species of the planet? Can it be Christopher Columbus' journey that led to the discovery of America? How about Neil Armstrong and Buzz Aldrin's epic journey to the moon? Can we also include Sergei Krikalev's 434 days in space?

While these journeys are a feat in their own right the best journey that man can ever make is the journey of DISCOVERY. The journey of discovery has led man from living in the cave and listening to the hum of birds for entertainment to tech savvy SMS addict complete with MP3 players and wearing synthetic clothes. You may ask where and how on earth did we do it? Well the answer is thanks to the people who didn't give up and continue to believe in the things they do and invent.

But the best journey that an individual can make is the journey of self-discovery where you discover and accepting simply what you are and making the best of it.

Motivation

What is the most common impression we have on this subject? Is this the subject that we dread because only the men of Einstein's caliber can succeed? How about the complex materials that we enjoy today and sometimes taking for granted like cars, cellular phones and televisions?

Many of us are having difficulty in physics because of our experience in High School. Where we find ourselves dumbfounded when the teacher discuss to us things like friction, motion vectors and in the end we wont know how we will make use of them.

How about the fact that the reason why we are having a hard time is because we HATE the fundamental subjects needed to survive physics. Physics is an advance science; before you got here you must already have basic skills and knowledge in the subjects of

- Algebra
- Plane Trigonometry
- General Science

The knowledge of these three subjects is like having a complete set of wheels in a tricycle. A degree of incompetence in any of these three subjects is like losing a wheel while driving a tricycle.

This program includes refresher modules for you to regain your composure in these three subjects. But you must also learn how to teach yourselves because life is not kind for people who only receive and do nothing about it.

People who their peers thought would never made it

If you think that this journey is somewhat filled with sharp stones and thorny bushes then what about the journeys taken by these two men.

Known as the wizard of Menlo Park for his record setting 1093 patents he made in his lifetime. He was deemed inattentive in class but the truth is he lacked encouragement and motivation both of which were developed with the help of his mother

This pillar of physics is said to be afflicted with dyslexia, a disorder in which it affected the way a person read even though the eyesight is good. He rose through the occasion by his desire to learn the invisible forces around him

I. Introduction

Science and technology:

The search for order and meaning of the world around us has taken place through science and technology[i].

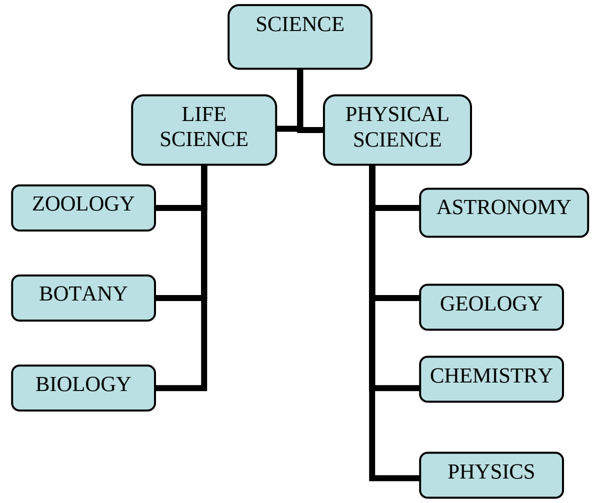
Science comes from the word *sciens* or *scientia*, which means having knowledge and the state of knowing. Science is broad because man has the desire to know and understand everything around him (or her).

On the other hand, technology comes from the word *technologia*, meaning the systematic method employed to facilitate human sustenance and comfort. In short, technology is the application of the knowledge gained from the studies of various branches of science.

Some people considered that with the vast knowledge gained from science, Man is beginning to unlock the mysteries of the universe that God is already irrelevant and Man's mastery of the world is assured. This is evident among the communists and other left wing believers. But according to the Catholic Church: *"Basic Scientific research, as well as applied research (technology) is a significant expression of man's dominion over creation. Science and technology are precious resources when placed at the service of man and promote his integral development for the benefit of all. By themselves however they cannot disclose the meaning of existence and human progress.[ii]"*

Branches of Science:

The study of science has branches into the study of *Life Sciences* (the study of living things) and *Physical Science* (the study of non-living things).[iii] The branches of Life Science are *ZOOLOGY*, *BOTANY* and *BIOLOGY* while the Branches of Physical Science are *ASTRONOMY*, *GEOLOGY*, *CHEMISTRY* and *PHYSICS*. (See fig 1 for the table for visual appreciation)



What is Physics?

Since Physics is our subject, we will then limit ourselves to its discussion. Physics is considered basic science because it deals with matter and energy and its transformation. It is about the nature of basic things such as *motion forces* and *energy*. These basics things are called *mechanics***.** Other than properties of mechanics Physics also deals with the properties of matter, heat, light, sound, magnetism, electricity, nuclear energy and structures.

The nature of Physics:

Physics is an *experimental science[iv]*. Physicists observed the phenomenon of nature and try to find the patterns and principles. Their findings are then summed up and formed into either theories or principles.

An idea is called a *principle* or *law* if its concept is firmly established. An example is Newton's law which will be discuss later.

A *theory* is an explanation of natural phenomenon based on observation and accepted fundamental principles. An example is the theory of biological evolution. *Theories are not regarded as absolute or final truth*. A new observation may necessitate in revision or rejection of a theory.

Physics in Health Science[v]*:*

Since Physics has a wide range of scope and applications it is not surprising that Physics has many applications in health science. These are some areas of health science that benefits from the knowledge of physics.

Athletics

Not all of us have an intuitive feeling for using our bodies efficiently. That's why athletes need coaches and trainer. This evolves in a branch of science called kinesiology – the study of motion. It is based on the relationships between *distance, time, velocity* and *acceleration* as well as the concepts of *force, work, energy and power*.

Nutrition and Exercise:

The knowledge of Physics can be appreciated when stored food energy is changed by work to heat, motion and other forms of energy.

Physical Therapy:

Patient that undergoes Physical therapy usually have weakened muscles or suffering with nerve disorders that make it very difficult to use their muscles. That's why a great deal of physical therapy takes place in water because it helps supports the person's weight. It helps the patient to do some movement without much muscular exertion. This is made possible by the principle of Archimedes.

Blood flow and respiration:

Liquid and gasses can be moved by application of pressure. Pressure is created by a pumping heart to help move the blood inside our body. Also air is circulated inside the body by pumping lungs.

Hearing:

Hearing is a perception of sound. And sound is an example of a wave phenomenon. Sound wave is converted to electrical impulses, which are transmitted to brain for interpretation.

Ultrasound Scanners:

Another application of wave phenomenon involves ultrasound scanning. Ultrasound wave involves using ultrasound waves to create images inside the body without resorting to exploratory surgery.

Nervous System:

The nervous system is the body's electrical system. The brain sends out electrical pulses along the nervous system to control the muscles that allow our body to move and also to control the different internal organs needed to support our body. The understanding of the body's electrical system resulted in the recording of the heart's condition by electrocardiogram which is the electrical impulses that control the beating of the heart.

Vision:

The application of principles regarding optics is best appreciated by appreciating the gift of vision we have since birth. The eye lenses are like glass lenses which adjust the focus of light and like hearing; light is converted to electrical impulse or signals to the brain for interpretation.

X-Rays and radiotherapy:

Everyone knows that X-rays are used by doctor to diagnose different illness or bone fracture inside our body. The reason why X-ray machine can do this is because of the principles of radiation. If increase in dosage, radiation is used to kill cancerous tumors specially those that can't be remove through surgery. This is a delicate procedure because any mistake can damage healthy cells and muscles.

Solving Physics Problems:

If in solving complex algebraic problems can be done using "**M**y **D**ear **A**unt **S**ally" or Multiplication, Division, Addition in that exact order, Physics problems can be solve by saying "**I SEE**" or **Identify**, **Set up**, **Execute** and **Evaluate**.

In solving physics questions, *identifying the relevant concept* is the first step. Of course our discussions will focus on the relevant concepts and it's up to the student to understand them. Only by understanding these concepts can you correctly identify the relevant concept for a given problem.

Once you correctly identify the relevant concept in a given problem you can know *set up the problem*. It can be done by drawing the right model and setting up the right equations needed to solve the problem.

After setting up the right equations you will then *execute the problem*. In this step "YOU DO THE MATH!" This part really needs your skills that were learned in your previous mathematics.

After executing the needed mathematical solutions you must evaluate your answer. This is an important precautionary measure because any mistake that you overlook will be held against you.

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[i] College Physics; Asuncion C.M. Del Rosario 2004
[ii] Catechism of the Catholic Church; Libreria Editrice Vaticana 1994
[iii] College Physics; Asuncion C.M. Del Rosario 2004
[iv] University Physics 11th ed.; Young and Freedman 2004
[v] Physics with health science applications; Paul Peter Urone

Measurements

Motivation:

When you try to buy rice or a piece of cloth the retail is in terms of measurements. Usually we would purchase rice in terms of weight and lines are purchased in terms of yards.

Physics usually measures things as part of experiments in order to quantify something. Sometimes when we travel we measure the distance from manila to province in terms of kilometers and travel from one point to another in Manila in terms of hours.

What is Measurement?

Measurement maybe defined as comparison of the amount of the amount of an object with a standard (measuring scale) to find out how many times the object is larger or smaller[i].

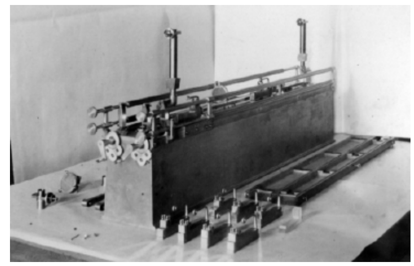
Systems of Measurements:

There are two systems of measurement commonly used at present, namely the S.I (from the French word System Internationale) or *Metric* and the *English* system. The *metric system* is the most widely used measuring system in the world. It was first set up in France at the height of the French revolution in 1791. The English system is used by the United States and a few other countries but they are already in the process of converting their standards to the metric system. Since the Philippines always use the metric system we will then limit our discussion to it with occasional reference to the English system.

The single and most advantage of metric system from the English system is that its unit can be expressed in multiples of 10.

The metric system was first derived by the French Academy of Science at the height of the French Revolution in 1791. It was set to standardize the different unit of measurements in the country.

Trivia:
The original standard meter was recalibrated in 1960 by using wave-length of the orange-red light emitted by the atoms of Krypton (^{86}Kr) in a glow discharge tube. The accepted standard of the meter derived from this experiment was only longer by less than half a millimeter![ii]


Replica of the original meter standard.

Variations of the Metric system:

The metric system has two variations: The MKS or Meter-Kilogram-Second and the CGS or Centimeter-Gram-Second. As for the English system it is expressed in FPS or Foot-Pound-Second.

All measurement units in Physics are expressed in the *fundamental qualities of mass (M), length (L), time (t), temperature (T) and electric charge (Q).*

The basic metric units in the MKS system are *meter (m)* for length, *Kilogram (Kg)* for mass, *second (s)* for time and *Liter (l)* for volume. In the CGS system the basic units are *centimeter (cm)* for length, *gram (g)* for mass, and *second (s)* for time.

Other common subdivision of these basic units are named by the used of prefixes.

Ex:
The equivalent of 1000 meters (1000m) is 1 kilometer (1km).

Table 1: Prefixes

Tera (T)	Trillions (10^{12}) 1,000,000,000,000
Giga (G)	Billions (10^{9}) 1,000,000,000
Mega (M)	Millions (10^{6}) 1,000,000
Kilo (K)	Thousands (10^{3}) 1,000
Hecto (h)	hundreds (10^{2}) 100
Deka (D)	Tens (10^{1}) 10
base	Unit (ones) 1
Deci (d)	Tenths (10^{-1}) 0.1
Centi (c)	Hundredth (10^{-2}) 0.01
Milli (m)	Thousandths (10^{-3}) 0.001
Micro (*ɥ*)	Millionths (10^{-6}) 0.000001
Nano (n)	Billionths (10^{-9}) 0.000000001
Pico (p)	Trillionth (10^{-12}) 0.000000000001

From the table above we can see that larger units can be derived by multiplying the base by multiples of 10 and smaller units are obtained by dividing the base also by the multiple of 10.

Ex:

Convert 1 meter into centimeter

Identify: From table 1, 1 meter is the larger unit because it's the base

Set up: Since meter is larger, we will then divide the meter by the factor of the centi
1 m / .01

Execute and Evaluate:
1 m / (.01/1m) = 100cm

Ex:

Convert 150cm into meter

Identify: From Table 1, centimeter is smaller than meter

Set up: Since 150 centimeter is smaller than 1 meter, we will then multiply 150 by the factor of the centi 0.01
150 cm * (1m/.01cm)

Execute and Evaluate:
150 cm * (1m/.01cm) = 1.5 m

Table 2: unit symbols

Metric (SI)	**English**
Acre………a	Feet……..ft
Centimeter……cm	Gallon…….gal
Cubic Centimeter….cc	Inch……in
Kilogram………..kg	Mile…….mi
Liter…………..l	Ounces……….oz
Meter……….m	Pint………….pt
Millimeter………..mm	Pound………lb
Milliliter………….ml	
Metric ton……….MT	

Table 3: Equivalent of certain units

Length	**Mass**
1 km = 1000m	1 kg = 1000g
1 hm = 100 m	1 hg = 100g
1 Dm = 10 m	1 Dg = 10 g
1 dm = 0.1 m	1 dg = 0.1 g
1 cm = .01 m	1 cg = 0.01 g
1 mm = .001 m	1 mg = 0.001

Table 4: Metric – English system equivalent

Length	**Mass**
1 m = 3.28 ft = 39.37 in	1 kg = 2.2 lb
1 in = 2.54 cm	1 MT = 100 g
1 km = .62 mi	1 Long Ton = 2,200 lb
1 cm = .375 in	1 lb = 454 g
1yd = 3ft = 36in = 91.44 cm	1 oz = 28 g
1 ft = 12 in = 30.48 cm	1 lb = 16 oz

Exercises:

Find the distance in a.) meters and b.) miles, if the distance between Manila and Bataan is 130 kms.

In McDonald's there is a hamburger called "Quarter Pounder". How much is it in ounces, Oz?

A box and its contents weighs 4,200 g, how much is it in a.) kilograms and b.) pounds

A man is 5'9" tall. What is his height in centimeter?

IMPORTANT!!!!

In solving problems, **the units must be consistent** and should be expressed in one system of measure only. Also remember **never to add or subtract units that are not in the same units of measure**.

Significant Figures:

Measurements have uncertainties. For example let us try to measure the height of the CLDH Admin Bldg. Since we do not have a very long measuring tape and it would also be very dangerous to climb up and drop the tape we will then have to measure it by trigonometry. To come up with a probable answer (from our calculations) we need a technique to represent our answer.

Significant figures are figures or digits of measurement that you are sure of plus the estimated digit.

The following are rules for determining the numbers of significant figures:

1. *All non-zero digits are significant*
   Example:
   4.6 contains 2 significant figures
   129.72 contains 5 significant figures

2. *All zeroes between non-zero digits are significant*
   Example:
   20.08 contains 4 significant figures
   8700.09 contains 6 significant figures

3. *All Zeroes to the right of a decimal point and to the right of a non-zero digit are significant.*
   Example:
   2.00 contains 3 significant figures
   167.0750 contains 7 significant figures

4. *All zeroes to the left of an expressed decimal point and to the right of a non-zero digit are significant*
   Example:
   2500.0 contains 5 significant figures
   81000.0 contains 6 significant figures

5. *All zeroes to the left of an understood (or implied) decimal point but to the right of a non-zero digit are not significant.*
   Example:
   63,000 contains 2 significant figures
   72,300 contains 3 significant figures

6. *All zeroes to the left of a non-zero digit but to the right of the decimal point are not significant.*
   Example:
   0.0074 contains 2 significant digits
   0.000358 contains 3 significant digits

Rounding of Numbers:

When some physical quantities such as volume and area are obtained by mathematical computations the level of accuracy and precision must be preserved. In order to do that non significant digits should be drop off. Rounded off numbers are easier to compute and remember.

Hint:
In rounding off numbers to a certain number of significant figures, retain the number of digits specified starting from the left. If the first digit to be dropped is 4 or less than 4 the preceding digit is not changed, however if the digit to be dropped is 5 of greater than 5, the preceding digit is raised by 1.

Example:

Number	2 fig	3 fig	4 fig
1.4275	1.4	1.43	1.428
8.2550	8.3	8.26	8.255
4.6654	4.7	4.67	4.665

Example:

Add:	6.752 m	
	5.34 m	
	48.4 m	Least accurate measurement It is accurate to the tenth of a meter
	60.492 m	60.5, the final answer is rounded to the tenth of a meter

Multiplication and Division:

In multiplying or dividing, the number of significant figures in the final answer is equal to the least number of significant figures in any original factor.

Example:

21.43 in x 2.31 in = 49.5033 in^2 = 49.5 in^2

36.5 m / 3.414 m = 10.69 = 10.7

Scientific Notation:

A convenient way of writing very large or very small numbers is by means of scientific notation expressed by the formula Y x 10^n where Y is the number of significant figures desired and n is the positive or negative exponent (*n* is positive for very large numbers and negative for very small numbers)

To write a number in scientific notation, first determine Y by moving the decimal point and putting it after the first non-zero digit. Then count the number of places the decimal point has been moved and write it as the exponent n. If the decimal point has been moved to the right, *n* is negative and if moved to the left, *n* is positive.

Examples:

Write the following in scientific notation with three significant figures.

a. 28759305 = 2.88×10^7
b. 0.00000152 = 1.52×10^{-6}

In adding or subtracting numbers written in scientific notation, first change all the numbers to a common power (exponent) before performing the indicated operations

Example:

Add:	1.87×10^4	1.87×10^4	
	2.63×10^3	0.263×10^4	
	3.72×10^5	37.2×10^4	
		39.33×10^4	Final ans

	33.95×10^3	33.95×10^3
	$- 235 \times 10^2$	$- 23.5 \times 10^3$
		10.45×10^3

In multiplying or dividing numbers written in scientific notation, simply multiply or divide the values of Y's respectively and then find the algebraic sum of the exponents.

Example:

a. $(3.76 \times 10^5)(1.75 \times 10^4) = 6.58 \times 10^9$

b. $(1.25 \times 103)(1.64 \times 10^2) = 2.05 \times 10^5$

c. $(2.05 \times 105) / (1.25 \times 10^2) = 1.64 \times 10^3$

Assignment#1

Answer the following:

1. How important is measurement in Physics?
2. convert each of the following length measurements to its equivalent in a. meters, b. feet, c. yard
   i. 1.1 cm
   ii. 76.2 km
   iii. 2.5 km
   iv. 0.123 Mn (Megameter)
   v. 500 nm (nanometer)
3. A building is 65 ft high. How High is this in:
   Meters and Centimeter
4. Change 7,200 seconds to a. minutes and b. hours

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[i] College Physics; C.M Del Rosario 2004
[ii] University Physics; Young and Freedman 2004

Experiment #1 Score:

SIGNIFICANT FIGURES

Name: Group Mates:
Date Performed:

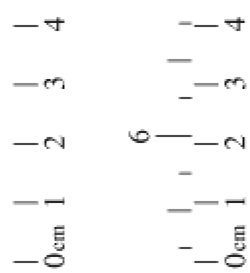
Objectives:

- To develop skills in measuring using the vernier calipers
- To apply the rules for significant figures in experimental computations
- To perform simple algebraic operations following the rules of significant figures

Theory:

The previous lessons (see P. 5) have elaborated the significance of measurement in Physics. It is from measurements of quantities where one deduces or confirms basic physical laws. Remember that the process of deducing or confirming conclusions from measured quantities is an important process of all sciences ranging from physical, behavioral or social.

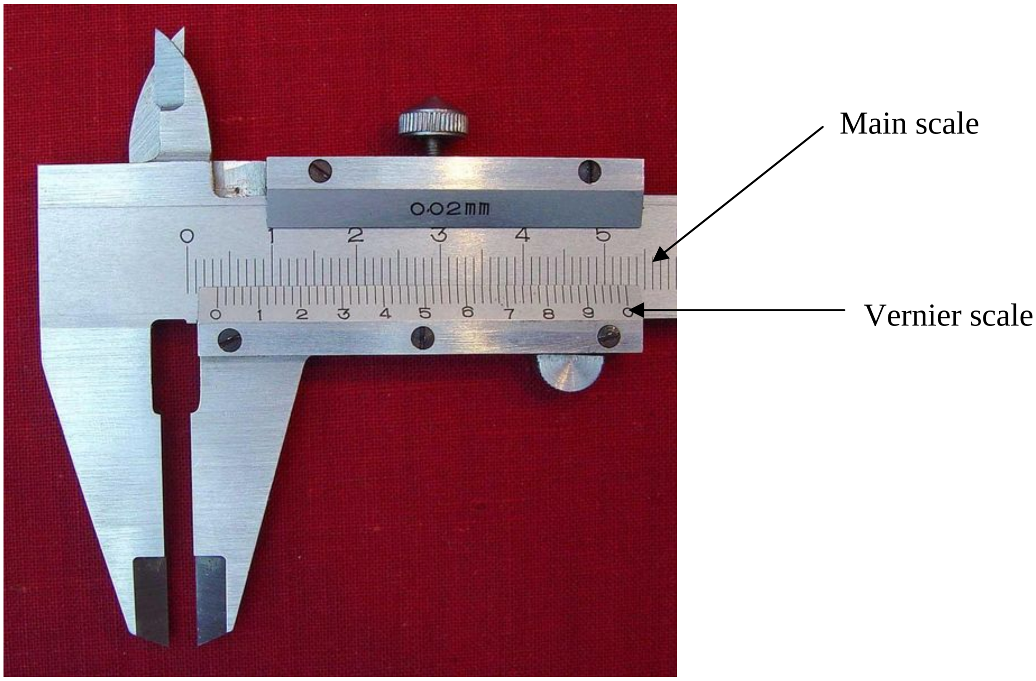
Reading measurements involves reading some form of scale – either in metric or English.



The ruler above shows us both the inch-centimeter that we usually see in commercially available rulers. In the following page a true to scale ruler is available. (note: when printing that page be sure to disable the “shrink to fit” in the printer options

The Vernier Caliper:

Vernier calipers can measure internal dimensions (using the uppermost jaws in the picture at right), external dimensions using the pictured lower jaws, and depending on the manufacturer, depth measurements by the use of a probe that is attached to the movable head and slides along the centre of the body. This probe is slender and can get into deep grooves that may prove difficult for other measuring tools.



The vernier caliper consist of a fixed part with a main engraved scale and a movable jaw with an engraved vernier scale. The mail scale is calibrated in inches on the upper part and millimeter on the lower part. The lower calibration has a maximum of 200 divisions with each division equal to one mm. The vernier scale usually has 10 major divisions. The least count of the caliper is the smallest value that can be read directly from a vernier scale. For example if the least count indicated on the caliper is 0.05mm and its vernier scale has 20 divisions, each division corresponds to a 0.05mm. This means that the vernier scale divides one division on the main scale into 20 subdivisions. When the jaws are closed the zero line or index of the vernier scale coincides with the division that the vernier scale has moved is determined by noting which vernier division coincides with a main scale division.

How to use the vernier caliper:

The vernier caliper measures lengths, outer and inner diameters, and internal depths with the use of its jaws or calipers, inner calipers and depth gauge respectively. To measure the width of a small rectangular block, open the movable jaws and place between the outside jaws the block to be measured. Close the jaws on the object and do the following steps to get the reading:

1. Observe where the zero line or index of the vernier scale falls on the main scale.

2. Note the line on the vernier scale that coincides on the main scale.

APPARATUS/MATERIALS:

1 peso coin, ID card, Ruler, Vernier Caliper

PROCEDURE:

A. Volume and Surface area of a coin

1. Measure the diameter (*D*) and the thickness or height (*H*) of a coin using a ruler.
2. Calculate the volume (*V*) and the area (*A*) of the coin using the rules of significant figures for multiplication.
   Surface Area (*A*) = Πr^2
   Volume of a cylinder = $\Pi r^2 H$
   Where r is the radius of the cylinder
3. Repeat step I and two using vernier caliper and tabulate the result

B. Perimeter and Thickness of an ID card

1. Measure the thickness (T) of three identical ID cards using a vernier caliper. Divide the reading by three to get the thickness of one ID card.
2. Repeat the above procedure using a vernier caliper. Tabulate results.
3. Measure the length (L) and width (W) of an ID card using a ruler.
4. Calculate the perimeter of the card by adding twice the length and twice the width using the rules of significant figures for multiplication
   Perimeter of an ID card = 2L + 2W

DATA SHEET:

A. Surface area and Volume of Coin

Instrument	L (cm)	W (cm)	T (cm)	V (cm^3)
Ruler				
Vernier Caliper				

B. Perimeter and Thickness of an ID card

	L (cm)	W (cm)	T (cm)	P (cm)
Ruler				
Vernier Caliper				

SAMPLE COMPUTATIONS:

QUESTIONS:

1. Indicate the number of significant figures in the following:

a. 20 Students	e. 7.805 m
b. 24 hours/day	f. 100,480 cm
c. 330 kg	g. 0.00064 m^3
d. 6.083 sec	h. 0.1005 L

2. Perform the indicated operations for the following measured values

   a. 4.065 cm x 3.81 cm =

   b. 378.23 m – 41 m =

   c. 0.005 mm + .012 mm + 1.27 cm =

   d. 9.70 x 10^8 m/s ÷ 1.25 s =

3. Solve the following problems

   a. A rectangular paperboard measures 6 cm long, 4.3 cm wide and 1.75 mm thick. Find the volume of the paperboard

   b. Determine the volume of a drum that has a radius of 0.80 m and a height of 125 cm.

Experimental Error[i]

Theory

In the previous experiment we have seen that measuring physical quantities are almost always affected by factors giving rise to variations in reading. In short, measuring has a certain degree of uncertainty which affects the results of computations. These variations are well known to us as *errors*. An error that tends to make an observation too high is called a *positive error* and the one that makes it too low is *negative error.* Experimental errors are generally classified as **systematic** and **random** errors

Systematic Errors

A systematic error is one that always produces an error of the same sign, e.g., one that would make all observations too low. Systematic errors maybe due to personal, instrumental or external factors.

a. Personal errors
   Personal errors may arise from a personal bias of the observer in recording an observation or the particular method of consulting or taking data. This includes mistakes in mathematical computations. Personal errors can be eliminated by observing proper caution and disregarding personal biases in taking measurements.

b. Instrumental errors

   An instrumental error is produced by faulty or inaccurate apparatus and improperly calibrated measuring instruments.

c. External errors

   External errors are usually caused by external conditions such as temperatures, atmospheric pressure, wind and humidity. External errors can be reduced by refining the experiment procedures and introducing more accurate and calibrated instruments as well as the introduction of coefficient variables.

Random errors

Random errors most often result from limitations in the equipment or techniques used to make a measurement. Suppose, for example, that you wanted to collect 25 mL of a solution. You could use a beaker, a graduated cylinder, or a buret. Volume measurements made with a 50-mL beaker are accurate to within 5 mL. In other words, you would be as likely to obtain 20 mL of solution (5 mL too little) as 30 mL (5 mL too much). You could decrease the amount of error by using a graduated cylinder, which is capable of measurements to within 1 mL. The error could be decreased even further by using a buret, which is capable of delivering a volume to within 1 drop, or 0.05 mL.

Random errors can be minimized by taking large numbers of observations. One may apply *descriptive measures of statistics* to arrive at a certain definitive conclusions about the magnitude of errors.

There are two major classes of descriptive errors. One class measures the *Central Tendency* or location and the other measures the *dispersion or variability* among the observed values. The concepts of these two classes of errors are described in the following paragraph.

Central Tendency

Is a value which the observations tend to cluster and which typifies their magnitude. The arithmetic mean or average, median and mode are descriptive measures under this class.

a. Arithmetic mean

   The arithmetic mean is what is commonly called the average: When the word "mean" is used without a modifier, it can be assumed that it refers to the arithmetic mean. The mean is the sum of all the scores divided by the number of scores. This is mathematically expressed as:

$$\bar{x} = \frac{x_1 + x_2 + x_3 + ... + x_N}{N} = \frac{1}{N}\sum_{i=1}^{N} x_1$$

b. Deviation

The deviation of any observation (x_1) of a set of observations from the mean value of the set is:

$$d_1 = x_1 - \bar{x}$$

c. Mean Absolute Deviation or Average Deviation

The mean absolute deviation is the sum of the absolute values of the deviation divided by the number of observations. It can be thought of as the average “scattering” of measured values from the mean value. The average deviation is a measure of the dispersion of the experimental measurements about the mean (i.e., it is a measure of precision). The average deviation $\bar{d}$ is written as:

$$\bar{d} = \frac{|d_1| + |d_2| + |d_3| + ... + |d_N|}{N} = \frac{1}{N}\sum_{i=1}^{N} |d_i|$$

The absolute value of the deviation $|d_1|$ which is equal to $|d_i| = |x_i - \bar{x}|$ is just the value of d_1 without taking into account its algebraic sign.

d. Variance σ^2

The Variance of a set of observations is the average of the squares of the deviations. This is a technique to avoid the problem of negative deviations and absolute values it is given as:

$$\sigma^2 = \frac{1}{N}\sum_{i=1}^{N} (d_i)^2$$

e. Standard Deviation σ

The positive square root of the variance is called the standard deviation σ It is also called the root mean equation or simply the root mean square. The standard deviation is used to described the precision of the mean of the set of measurements

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N} (d_i)^2}$$

The experimental value $E_x = \bar{x} \pm \sigma$. This value gives us the best estimate of the quantity measured

f. Numerical Error

Numerical errors is defined as the difference between the experimental value and the standard variables

g. Percentage error

This is defined as the absolute value of the difference between the experimental values and the true values multiplied by 100%

$$\%error = \frac{|StdValue - ExpValue|}{StdValue} * 100$$

[i] Laboratory Manual in College Physics, Susan Fontanilla, DLSU Press

Experiment #2 Score:

EXPERIMENTAL ERRORS

Name: Group Mates:
Date Performed:

Objectives:

- Identify the types of experimental errors and its sources and explain how these errors can be reproduced
- Interpret data with the use of statistical methods of dealing with errors

Theory:

Previously we have discussed various types of errors and we have also learned that it is also possible to have errors because the environment can also affect the way we conduct our experiments. But in situation where several variables are independent of one another we have to conduct several experiments in order to determine the magnitude of its error statistically. This activity will exercise you to conduct experiments where errors are deliberately made in order for you to appreciate how a proper experiments yields credible results.

APPARATUS/MATERIALS:

Sliding rack, meter stick, marble, carbon paper, bond papers

PROCEDURE:

1. Drop a plumb from the lip of the ramp to the floor and mark the position. This is the reference for the horizontal position

2. Place the marble at the highest position and release from rest. Observe where this would land and mark this as *C*. This will give you an idea of the approximate range on the table and place a carbon paper face down on top of the paper.

3. Measure the height h, the vertical distance *y*, and the horizontal x as shown below.

4. Starting from rest, release the ball ten times.

5. Measure the distances (X_n) of each of the markings made by the marble as it drops on the carbon paper and bond paper from the starting point marked. Record the distances as X_1, X_2, X_3, …, X_{10}.

6. Repeat step 4 and 5 for another 10 trials using a new bond paper, and still another for ten more trials.

7. Compute for the individual deviation, average deviation, standard deviation and the arithmetic mean.

8. Compute the theoretical range which is given as $X_{theo} = 2\sqrt{hy}$

DATA SHEET:

Trial #	X in cm	Deviation (d) in cm		d^2 in cm^2
		positive	negative	

Arithmetic mean:	h = ______ *cm* y = ______ *cm* $X_{theo} = 2\sqrt{hy} =$ ______ cm
Average Deviation:	Percentage error:

$\bar{x} \pm \sigma =$ _________ cm

QUESTIONS:

1. Classify the following as to whether they are *personal*, *instrumental* or *external* errors

   ______________________ a. incorrect calibration of scale
   ______________________ b. bias of observer
   ______________________ c. expansion of scale due to temperature changes
   ______________________ d. parallax
   ______________________ e. pointer friction
   ______________________ f. estimation of fractional parts of scale division
   ______________________ g. displaced zero of scale

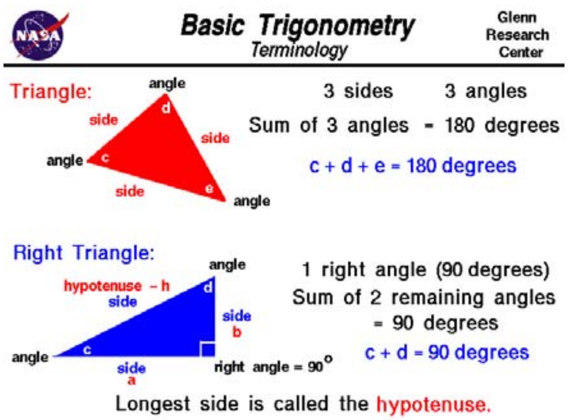
2. Discuss the significance of the term $\bar{x} \pm \sigma$ in the experiment.

3. An experiment was carried out to determine the specific heat of water under standard conditions. If the experiment arrived at a value of 1.1 cal/*g*C^0, what expression should be used to compare the two, percentage error or percentage difference? Show the computation.

Vector Analysis

Motivation:

During your High School years have you ever wondered where in the world you will use trigonometry.



How about hearing the late Ernie Baron during his stint as the weather man in TV Patrol when he described the probable directions that a storm would take?

During your countless travels have you ever wondered if the sign that said “TARLAC: 125kms” really means that the bus will travel it by hugging the road or does map makers simply drew a straight line from that point where you see the sign to Tarlac Plazuela?

In this topic you will begin to learn something about vectors. The mastery of vectors will take you somewhere especially in the field of engineering for without the basic knowledge of it there would be no buildings, airplanes and even prosthesis.

Theoretical Background:

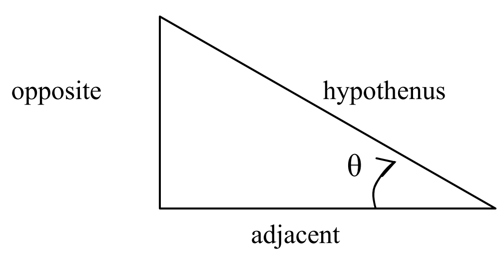
Before we continue to our lesson proper let us have a review of some mathematical lessons that we have previously learned.

In algebra, we have learned that the symbol |*a*| is used to denote the distance between *a* and *0*, and it is called the **absolute value of *a***. Take note on the number line below.

<number line to be drawn>

If you move the point, a, to the left of 0, a negative number should be noted. But since we are determining the distance between two points a negative distance is somewhat unacceptable in physics. In addition, since experiments in physics always deals with negative errors, mathematically the improper use of the negative values is very disastrous in our activities. Thus, absolute value has gained importance in the study of physics.

Another thing that we should remember is the basic trigonometric principles and formulas. From the drawings in your left, the basics of a triangle are drawn for you. The following formulas are listed for you to know.



$$Sin\theta = \frac{opposite}{hypothenus}$$

$$Cos\theta = \frac{adjacent}{hypothenus}$$

$$Tan\theta = \frac{opposite}{adjacent}$$

Scalar Quantity:[i]

A scalar quantity is one that is completely described by its **size** or **magnitude** only. Examples are 5 km, 10 kg and 15 liters. Calculations of scalar quantities involve ordinary arithmetic operations.

Examples:

15 kg + 3 kg = 18 kg
20 kms + 3 kms = 23 kms
23 kg + 6 s = !!!!! (cannot be!)

Vector Quantity:[ii]

A vector quantity is a quantity that is completely described by its **magnitude** (or size) as well as its **direction**. When vector quantities are written, an arrow is placed over the symbol such as:

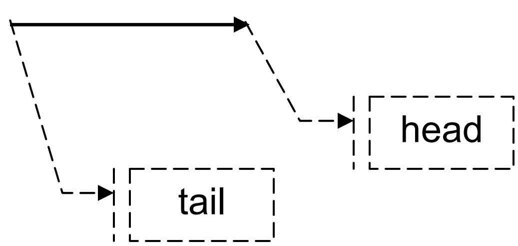
$$\vec{\mathbf{A}}$$

Operations with vectors:[iii]

Vectors can be added graphically and analytically. Vectors that add together are called component vectors while the sum of vectors is called resultant.

Graphical Methods of Vector Addition:

A graphical method of finding the magnitude and direction of vector can be made from a diagram constructed to scale and measuring the resultant vector.



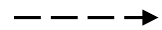
A. Same Direction

Two vectors are added by placing them head to tail and drawing them to scale. To find the magnitude of the resultant, the same scale used to construct the two vectors measures its length.

Example:

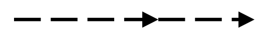
Find the sum of (or Resultant of) the two vectors A = 500m east and B = 400m east

Solution: draw the vectors to scale



A = 500m east

B = 400m east



500m 400m

Resultant, R = 900m east

B. Opposite Direction

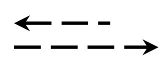
The method of head and tail will also apply.

Example: Find the resultant of two vectors A = 20 m west and B = 30 m east

Solutions: draw the vectors to scale

A = 20m west

B = 30m east

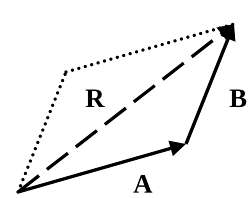


Total resultant is 10m east.

Why?

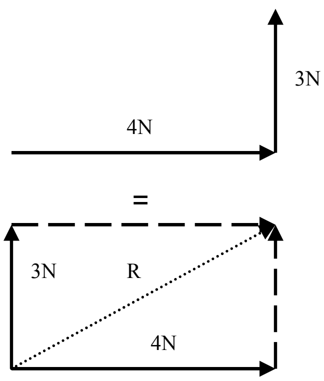
C. Parallelogram Method

In this method the resultant R of the two vectors (A and B) acting at an angle between 0^0 and 180^0 upon a given point is equal to the diagonal of a parallelogram of which the two vectors are the sides.



Example: Find the resultant R of two forces 4N (Newton) and 3N (Newton) acting on a point 0 at an angle of a. 90^0 and 60^0 with each other.

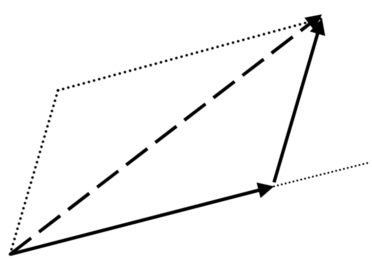
A. For the angle of 90^0



The resultant R is determined by measuring by ruler. This can be check by Pythagorean Theorem since the vector 3m and 4m are right angle.

$$
\begin{aligned}
R &= \sqrt{3^2} + \sqrt{4^2} \\
&= \sqrt{9} + \sqrt{16} \\
&= \sqrt{25} \\
&= 5
\end{aligned}
$$

B. For the angle of 60^0



By measuring it accurately by ruler, R is 6.1cm. The Resultant can also be found by using the Distance Formula.

Example: Find the resultant R of the following vectors: A = 10m, 60^0 N of W; B = 20m 50^0 N of E; C = 10m, E and D = 15m, S of W

Exercise #2

SOLVE GRAPHICALLY:

After walking 11 km due north from Magic Star[tm] Mall, a man walks 4 km due east.

a. Find the total Distance walked by the man
b. Find the total displacement from the starting point

Two force of 62 N each act concurrently on a point P. find the magnitude of the resultant force when the angle between the forces is as follows:

a. 30^0 b. 60^0 c. 90^0

An off-roader drives 1.00 km north and then 2.00 km east on a hilly field in Capas. How far and in what direction is he from the starting point?

A ferry boat heads due west at 16 m/s across a river that flows due north at 9 m/s

a. Find the resultant velocity (speed and direction) of the ferry boat.
b. If the river is 136 m wide, how long does it take for the ferry boat to reach the other side of the river?
HINT: distance = velocity * time
c. How far downstream is the ferry boat when it reaches the other side of the river?

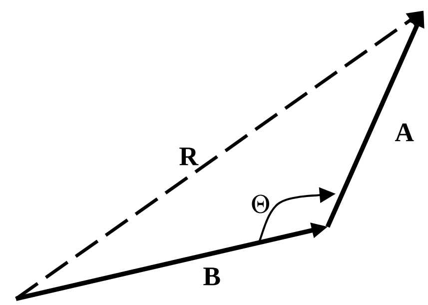
Analytical Methods of Vector Addition:

A. Trigonometric method
The resultant R of two vectors A and B as shown in the figure can be calculated through the use of the **Law of Sines** and the **Law of Cosines** of trigonometry.

The **Law of Cosines**

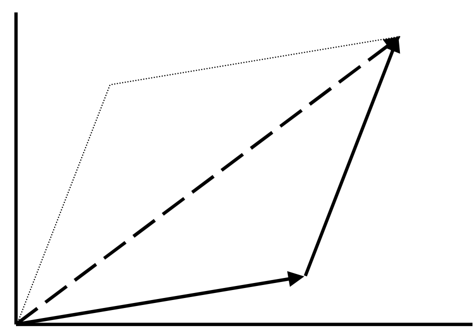
$R^2 = A^2 + B^2 - 2AB\ \text{Cos}\Theta$

$R = \sqrt{A^2 + B^2 - 2AB\ \text{Cos}\Theta}$



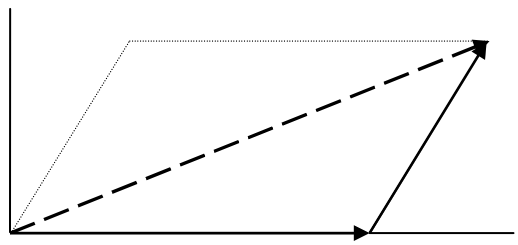
The **Law of sine**

$$\frac{\text{Sine } r}{R} = \frac{\text{Sin } a}{A} = \frac{\text{Sin } b}{B}$$



Example:

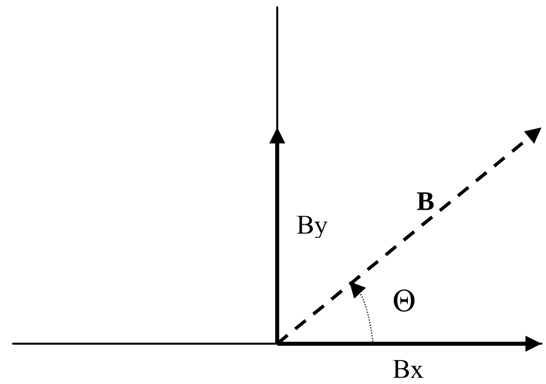
Find the magnitude and direction of the resultant R of two vectors, A = 4 N and B = 3 N at an angle of 60^0 with each other.



Solution:

B. Component Method.[iv]

Based on our experienced in measuring using scale diagram, the accuracy offered to us is very limited. Another method that we can use is the component method. *This works if we have vector that we knew its magnitude and direction.* For example consider vector **B.**



From the figure we can see that

$$\frac{Ax}{A} = \text{Cos }\Theta \quad \text{and} \quad \frac{Ay}{A} = \text{Sin }\Theta$$

$$Ax = A \text{ Cos }\Theta \qquad Ay = A \text{ Sin }\Theta$$

Note: Θ is measured from the + X axis towards the + Y axis.

If Θ is measured from + Y Axis

$Ax = A \text{ Sin }\Theta$; $Ay = A \text{ Cos }\Theta$

Example: Three CLDH students where brought to the center of a large flat field. Each is given a meter stick, a compass, a calculator, a shovel and (in a different order for each contestant) the following displacement.

72.4m, 32.0^0 east of north
57.3m, 36.0^0 south of west
17.8m straight south

The three displacements lead to a place where the keys to a brand new NISSAN X-TRAIL are buried. Two contestants start measuring immediately but the winner first calculates where to go. What does she calculates?

Solution:

Exercise # 3

SOLVE EACH PROBLEM ANALYTICALLY

After walking 11 km due north from Magic Star^{tm} Mall, a man walks 4 km due east.

c. Find the total Distance walked by the man
d. Find the total displacement from the starting point

Two force of 62 N each act concurrently on a point P. find the magnitude of the resultant force when the angle between the forces is as follows:

a. 30^0 b. 60^0 c. 90^0

An off-roader drives 1.00 km north and then 2.00 km east on a hilly field in Capas. How far and in what direction is he from the starting point?

A ferry boat heads due west at 16 m/s across a river that flows due north at 9 m/s

a. Find the resultant velocity (speed and direction) of the ferry boat.
b. If the river is 136 m wide, how long does it take for the ferry boat to reach the other side of the river?
HINT: distance = velocity * time
c. How far downstream is the ferry boat when it reaches the other side of the river?

Assignment # 2 (Pass in graphing paper)

SOLVE GRAPHICALLY:

A plane flies due north at 225 km/hr. A wind blows it due east at 55 km/hr. Find the magnitude and direction of the plane's resultant velocity.

A PAGASA weather team releases a weather balloon. The balloon's buoyancy accelerates it straight up 15 m/s^2. The wind accelerates it horizontally at 6.5 m/s^2. What is the magnitude and direction (with reference to the horizontal) of the resultant acceleration?

After a PAF fighter plane takes off, it travels 150 km south, 20 km west and 14.5 kms up. How far is it from that take off point?

SOLVE ANALYTICALLY:

A force of 25 N is applied along the handle of a gurney, which is pushed along the hospital corridor. Find the horizontal and vertical component of this force when the handle is held at a. 30^0 b. 40^0 and c. 60^0

From the shore, navy patrol boat travels 45^0 south of east for 60 km, and then turns 60^0 south of west for another 36 km before reaching a sinking ship. Give the shortest route (magnitude and direction) that the boat could have taken to reach the sinking ship?

Your Physics professor drives 3.25 km north, then 4.75 km west and then 1.5 kms, 45^0 north of west to visit his girlfriend. Show the resultant displacement by method of components and compare it with your graphical solution.

---

[i] College Physics, Asuncion CM Del Rosario
[ii] College Physics, Asuncion CM Del Rosario
[iii] University Physics, Young and Freedman
College Physics, Asuncion CM Del Rosario
[iv] University Physics, Young and Freedman

GRAPHS and EQUATIONS[i]

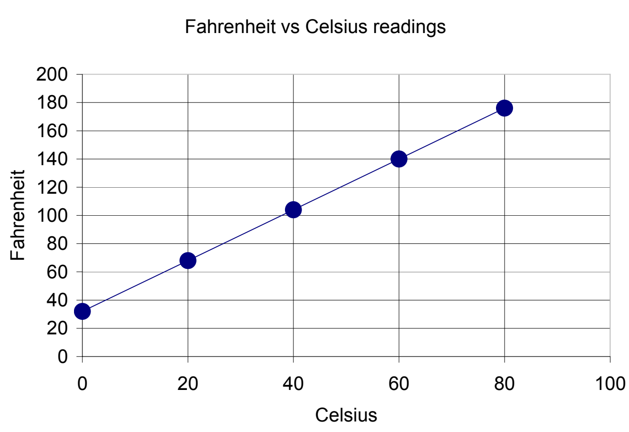
A graphical presentation is often used as an effective tool to show explicitly how one variable varies with one another. By plotting the numerical results of an experiment and observing the shape of the resulting graph, a relationship between two quantities can be established. The shape of the graph gives us a clue to the relationship of the variables involved. Some of the common ones are as follows.

- A straight-line graph indicates linear or direct relationship between two quantities.
- A hyperbolic graph indicates an inverse relationship
- A parabolic graph tells us of a specific kind of linear or direct relationship.

The specific equation relating the two variables of the graph can only be formulated when the graph is linearized. We will see how this can be done in the succeeding discussion.

A. Straight Line Graphs

Graph #1 shows a straight line graph that does not pass through the origin. This graph definitely shows linear relationship



Graph #1

Data of Graph #1

Celsius	Fahrenheit
0	32
20	68
40	104
60	140
80	178

Graph #1 shows the relationship between Celsius and Fahrenheit. We know for sure that the temperature of the air is the same for a given moment but can be read differently. Thus the direct relationship can be clearly established between Celsius and Fahrenheit.

The general equation for a linear graph is the same with the equation of the line, which is

$$y = mx + b \quad \text{- eqn 1}$$

Where *m* and *b* are constants. *m* is the slope and b is the y-intercept. The Y-intercept is the value of y when x is zero.

Let us take $y = 68^0$, $x = 20^0$ and $b = 32^0$ the slope can be obtained using Eqn 1.

- eqn 2

Substituting the value of the slope obtained in eqn 2 to eqn 1 and considering that the Y axis is ^{0}F and the x axis is ^{0}C the equation relating Fahrenheit to Celsius is therefore:

- eqn 3

This is the conversion of Celsius to Fahrenheit.

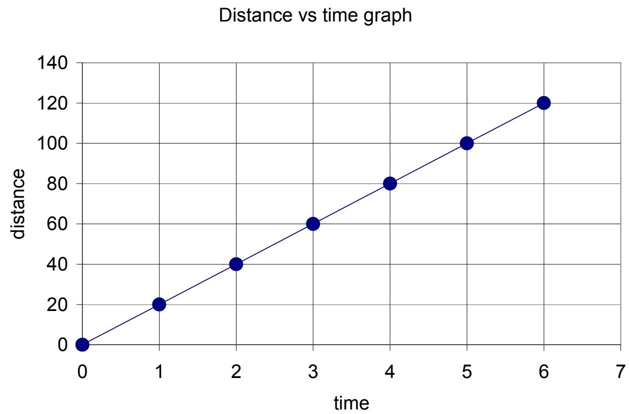
A linear graph can be *extrapolated* to determine other values of Celsius to Fahrenheit. Extrapolations can be done graphically or by manipulating eqn 3.

Direct Proportionality.

Graph #2 shows a straight line passing through the origin. The zero values for both variables simultaneously occur. When time is doubled the distance is also doubled. In this case we can say that distance is directly proportional. The equation relating to them is

$$y = kx \text{ or } k = \frac{y}{x} \quad \text{eqn 4}$$

Where k is the constant of proportionality. This equation shows that the quotient of the two variables is always equal to a constant.



Graph #2

Data of Graph #2

Distance	Time
0	0
20	1
40	2
60	3
80	4
100	5
150	6

The constant of proportionality is also a representation of the slope of the line.

B. Parabolic Graphs

If the graph shown has a curve like drawn in graph #3 that is either a parabolic or a hyperbolic graph.

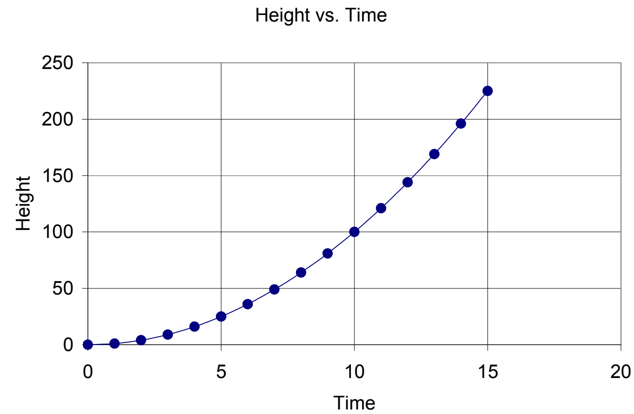
We can say that this graph is parabolic if it satisfies the following equation

$$y = kx^2, y = kx^3, \ldots, y = kx^n \quad \text{- eqn 5}$$

Rewriting eqn 5

$$\frac{y}{x^n} = k$$

The ratio of y and x^n is a constant. To verify the actual relationship, one has to linearize the graph by plotting y vs. x^n where n = 2,3,4,…



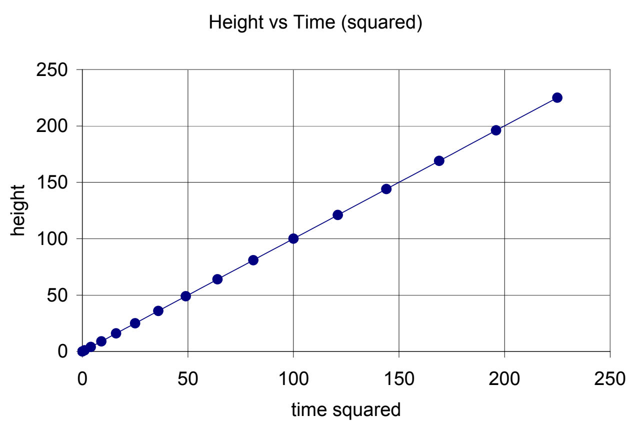
Graph #3

Data:

Ht	Time
0	0
1	1
2	4
3	9
4	16
5	25
6	36
7	49
8	64
9	81
10	100
11	121
12	144
13	169
14	196
15	225

The value of n determines the specific equation relating x and y. By inspection, squaring the time in the data yields a direct square relationship between height and time to verify the relationship let us plot the height vs the square of time

Height	Time	$Time^2$
0	0	0
1	1	1
2	4	16
3	9	81
4	16	256
5	25	625
6	36	1296
7	49	2401
8	64	4096
9	81	6561
10	100	10000
11	121	14641
12	144	20736
13	169	28561
14	196	38416
15	225	50625



Graph #4: Linearize Version of Graph 3

In general, if one quantity (y) varies directly with the square of another quantity (x^2) we write y α x^2. In this case n = 2, thus the equation that correctly expresses the relationship of height (h) and time (t) in the data is

$$\frac{h}{t^2} = k \text{ (constant)} \rightarrow h = kt^2$$

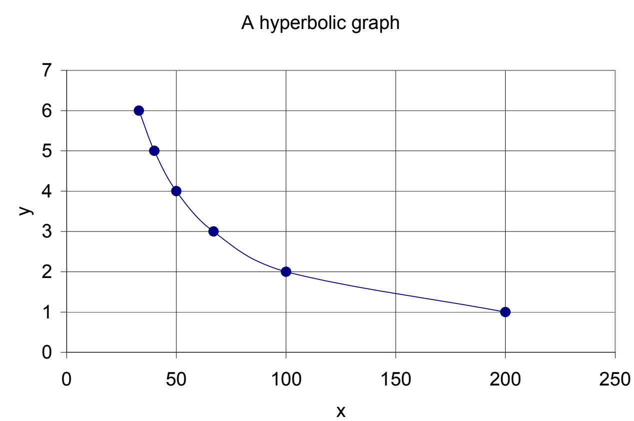
Thus we can say that height is "directly proportional to the square of time"

C. Hyperbolic Graph

If linearization is not possible by raising x to the nth power then the graph is hyperbolic. The quantities of hyperbolic graph can be obtained by obeying the following equations:

$$y = \frac{k}{x}, y = \frac{k}{x^2}, y = \frac{k}{x^3} \ldots y = \frac{k}{x^n} \quad \text{- eqn 6}$$

A hyperbolic graph indicates inverse relationship between two quantities i.e. y α $\frac{1}{x^n}$. The specific equation can be derive by determining the values on n. For n = 1 the equation is $y = \frac{k}{x}$. A hyperbolic graph was shown below



Graph #5

Inverse proportionality

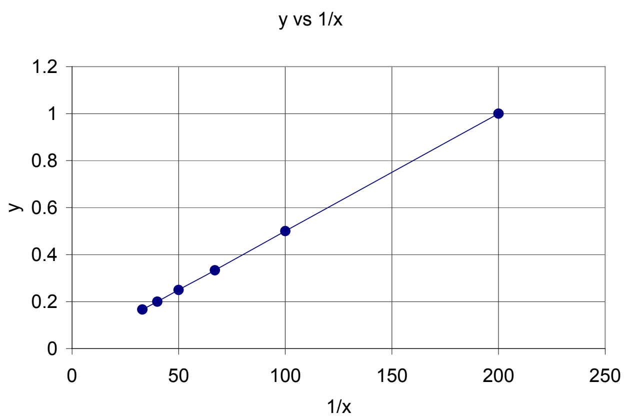
Graph #5 shows a hyperbolic graph. To linearize it, try n = 1 such that y = 1/x. Plotting y vs. 1/x yields a straight line graph as shown in Graph #6. Hence y is directly proportional to 1/x or y is inversely proportional to x. In equation form:

$$y = \frac{k}{x} \text{ or } k = xy \quad \text{- eqn 7}$$

where k is a constant which is equal to the slope of y vs. 1/x graph.

Data of Graph #6

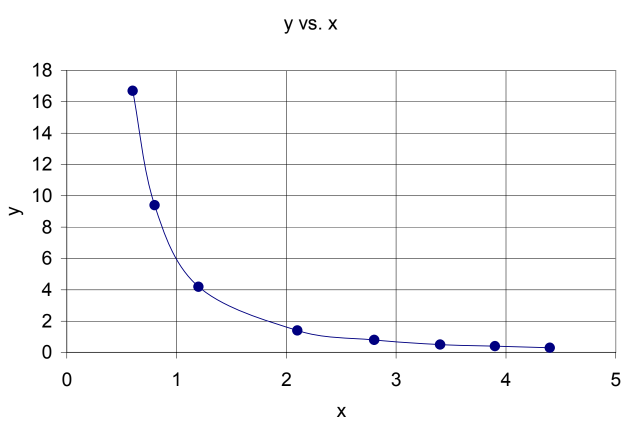
y	x	1/x
200	1	1
100	2	0.5
67	3	0.333333
50	4	0.25
40	5	0.2
33	6	0.166667



Graph #6: Linearize version of Graph #5

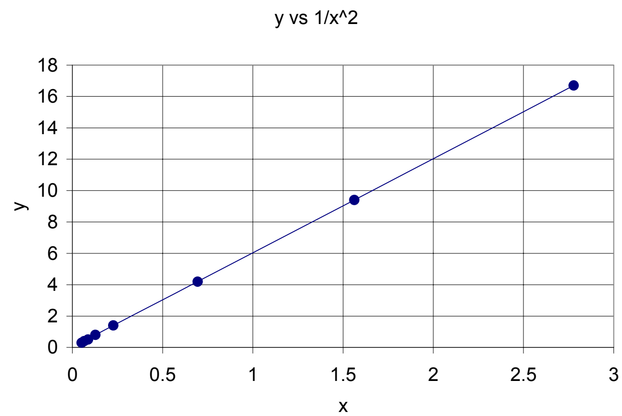
Inverse Square Proportionality

Sometimes, plotting y and 1/x will not yield a staright line but plotting y vs. $1/x^2$ will yield one. This relationship is called inverse square proportionality. The Variable (y) is inversely proportional to the square of x. Graph #7 illustrates such a case.



Graph #7 A hyperbolic graph

The linearized graph is shown below. This can only be done if n =2 such that $y = \frac{k}{x^2}$



Graph #8 A linearized version of Graph #7

D. Methods of least Squares

The method of least squares is a statistical way of determining the best-fitting curve for a given set of data. If the set of data given does not yield any of the given relationships above then this it the best way to plot the result.

The method of least squares usually yields a straight line whose slope and whose y-intercepts can be solved by applying the following equations

The Slope (m) is:

$$m = \frac{n\left\{\sum_{i-1}^{n}(x_i y_i)\right\} - \sum_{i=1}^{n}(x_i)\sum_{i=1}^{n} y_i}{n\left\{\sum_{i=1}^{n} x_i x_i\right\} - \sum_{i=1}^{n}(x_i)\sum_{i=1}^{n} x_i} \qquad \text{Eqn 8}$$

The y-intercept is:

$$b = \frac{\left\{\sum_{i-1}^{n}(x_i y_i)\right\}\sum(y_{i)}) - \sum_{i=1}^{n}(x_i)\sum_{i=1}^{n}(y_i x_i)}{n\left\{\sum_{i=1}^{n} x_i x_i\right\} - \sum_{i=1}^{n}(x_i)\sum_{i=1}^{n} x_i}$$

Eqn 9

Where n represents the number of samples. After determining the slope (m) and the y-intercept, the equation for the best line is determined by:

$$Y = mx + b$$

It is important that experimental data be plotted correctly for accurate graphical interpretation. To achieve this, the rules enumerated below can be of help. MS Excel users have all the tools they would need and select the appropriate command.

Rules for Drawing Graphs on Rectangular Coordinate Paper

1. **Determination of Coordinates**

   Determine which of the quantities to be graphed is the dependent variable and which one is the independent variable. The independent variable is the quantity, which controls or causes a change in the other quantity (dependent variables) Whenever it is increased or decreased. By convention, plot the independent variable along the X-axis and dependent variable on the y-axis.

2. **Labeling the axes**

   Label each axis with the name of the quantity being plotted and it's corresponding unit. Abbreviate all units in standard form.

3. **Choosing the Scale**

   Choose scales that are easy to plot and read. In general, choose scales for the coordinate axes so that the curve extends over most of the graph sheet. The scale on the X and Y axes can also be different.

4. **Location of Points**

   Encircle each points plotted on the graph to indicate that the value lies anywhere close to that same point. Draw the curve up to the circle on one side.

5. **Drawing the Curve**

   When the points are plotted, draw a smooth line connecting the points; ignore any points that are obviously erratic. "Smooth" suggests that the line does not have to pass exactly through each point but connects the general areas of significance

6. **Title of the Graph**

   At an open space near the top of the paper, state the Title of the graph in the form of the dependent variable (y) vs. independent variable (x).

[i] Laboratory Manual In College Physics V1. Susan Fontanilla, 2004

Experiment #3 Score:

GRAPHS AND EQUATIONS

Name: Group Mates:
Date Performed:

Objectives:

- To apply the rules in plotting the numerical results of an experiment
- To linearize parabolic and hyperbolic graphs which will verify the actual relationship between two physical quantities.
- To interprete the graphs and determine the relationship between two physical quantities
- Formulate an equation relating two or three quantities based on the data and the graphs.

Theory:

From the previous lessons that we have we have determined that a straight-line graph is the most indicative of the relationship between variables. The reason for which is that parabolic and hyperbolic graphs must still be linearize in order to create a clear relationship for equations. By establishing a clear relationships between variables it is very possible to derive an equation for a given set of problem in an experiment.

APPARATUS/MATERIALS:

Graphing papers (coordinate papers would be better), pencil and pen and Ruler

EXERCISES:

1. The following data were obtained in an experiment relating time (t) (the independent variable) to the speed (v) of an accelerated object.

t (s)	0.5	1.0	1.5	2.0	2.5	3.0
v (m/s)	10	15	20	25	30	35

Plot these data on rectangular coordinate paper

a. Determine the slope of the graph
b. What physical quantity does the slope represent?
c. Determine the Y-Intercept
d. What is the equation of the Curve?

2. The heating effect of an electric current in a rheostat is found to vary directly with the square of the current. What type of graph is obtained when the heat is plotted as a function of the current? How could the variables be adjusted so that a linear relation would be obtained?

3. The current in a variable resistor to which a given voltage is applied is found to vary inversely with the resistance. What is the shape of the current resistance curve? How could these variables be changed in order for a straight line graph to be obtained?

Do the following for exercises 4 to 8

4. The data below shows the electric field (E) due to a point charge varies with distance (r)

Distance (r) in meters	1	2	3	4	5	6	7	8	9
Electric field E in N/C	81	20.3	9	5.06	3.24	2.25	1.65	1.27	1.00

5. The following values represent a particle with an x-coordinate that varies in time

Time (t) in seconds	0	1	2	3	4	5	6	7
Distance (x) in meters	200	195	160	65	-120	-425	-880	-1515

6. The following values represent the motion of a particle with a y-corrdinate that varies with time

Time in Seconds	0	1	2	3	4	5	6	7	8
Distance (y) in meters	0	15	20	15	0	-25	-60	-105	-160

7. Potential energy (Us) as a function of x – coordinate for the mass-spring system

x-coordinate (m)	-5	-4	-3	-2	-1	0	1	2	3	4	5
Us in joules	375	240	135	60	15	0	15	60	135	240	375

8. The values below are unknown variables x and y with a characteristic behavior

X	-10	-1	1	2	4	5	10	20	35	40
Y	10	100	-100	-50	-25	-20	-10	-5	-2.88	-2.5

9. Determine the equation, which will represent the best line for the following set of data and plot the graph of the equation

   Method of least square

	x	y	xx	xy
1	0	4.6	0	0
2	1	7.1	1	7.1
3	2	9.5	4	19.1
4	3	11.5	9	34.5
5	4	13.7	16	54.8
6	5	15.9	25	79.8
7	6	18.6	36	111.6
8	7	20.9	49	146.3
9	8	23.5	64	188.0
10	9	25.4	81	228.6

n = ______ number of sample $\sum_{i=1}^{n}(x_i)$ = ________ $\sum_{i=1}^{n}(y_i)=$ ________

$\sum_{i=1}^{n}(x_i x_i)=$ ________ $\sum_{i=1}^{n}(x_i y_i)=$ ________

The slope is:

$$m=\frac{n\left\{\sum_{i-1}^{n}(x_i y_i)\right\}-\sum_{i=1}^{n}(x_i)\sum_{i=1}^{n}y_i}{n\left\{\sum_{i=1}^{n}x_i x_i\right\}-\sum_{i=1}^{n}(x_i)\sum_{i=1}^{n}x_i}$$ = ________________________________ = __________

The Y-intercept is:

$$b=\frac{\left\{\sum_{i-1}^{n}(x_i y_i)\right\}\sum(y_{i)})-\sum_{i=1}^{n}(x_i)\sum_{i=1}^{n}(y_i x_i)}{n\left\{\sum_{i=1}^{n}x_i x_i\right\}-\sum_{i=1}^{n}(x_i)\sum_{i=1}^{n}x_i}$$ = ____________________________ = ________

The equation of the best line from the data is: y = mx + b = ___x + ____