<table>
<thead>
<tr>
<th>LABORATORY 1</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Data Sheet Laboratory 1</td>
<td>1.11</td>
</tr>
<tr>
<td>LABORATORY 2</td>
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<tr>
<td>Data Sheet Laboratory 2</td>
<td>2.3</td>
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<td>5.2</td>
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<td>6.1</td>
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<td>6.5</td>
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<td>Data Sheet Laboratory 9</td>
<td>9.3</td>
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<tr>
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<td>10.1</td>
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<tr>
<td>Data Sheet Laboratory 10</td>
<td>10.3</td>
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<td>11.1</td>
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<td>Data Sheet Laboratory 11</td>
<td>11.5</td>
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<td>LABORATORY 12</td>
<td>12.1</td>
</tr>
<tr>
<td>Data Sheet Laboratory 12</td>
<td>12.3</td>
</tr>
</tbody>
</table>
LABORATORY 1

METRIC SYSTEM, ANGLES AND GRAPHING

Equipment

1-meter measuring stick, 2-meter measuring stick, graph paper, 12 inch ruler and protractor.

Purpose

The purpose of this lab is to understand the metric system and how we analyze data.

Introduction

Many of the laboratory exercises in this manual involve taking measurements using the metric system, plotting data on a graph and measuring angles. Once you’ve learned a few rules, the process will be easy and convenient to use. The use of graphs eliminates trigonometric calculations and keeps the math very simple. Some common base units in the metric system are given in Table 1.1.

Systems of Measurement

Scientists need a standard frame of reference in order to compare results. While there are several standard units the major ones used by physicists are length, mass, and time. The official standards for the United States are kept in the National Bureau of Standards in Washington D.C. All other measurement devices such as for length are compared to the Washington D.C. standard. The Bureau’s name was changed to the National Institute of Standards and Technology in 1988. Although day to day commerce in the U.S. is conducted with the English system all scientific work is done using the metric system. The U.S. is gradually converting to the metric system as evidence by the common liter of soda.

The English System (also called the United States Customer System or British System.)
The English system used primarily in the United States was originally based on parts of the human body. For example a foot was the length or the King’s foot and the yard was the distance from the tip of his nose to the end of the fingers on an arm held straight out. Unfortunately, every time there was a new king the standard of measure changed a little.

The Metric System (part of the Systeme International “SI”)
This system was established by the French academy of Sciences in 1971. Instead of being based on body parts it uses nature, such as the distance from the equator to the North Pole. The SI has defined seven standard units. These are length, mass, time, electric current, temperature, amount of a substance and light intensity.
The standard unit of measure in the metric system can be visualized as a dollar made up of 100 cents with the cent being the smallest unit for a dollar. For convenience, the dollar can also be defined in larger terms such as the nickel, dime, and quarter. Instead of using cents, the meter is made up of 100 centimeters. One can also express the meter in larger units such as 10 decimeters or in smaller units such as 1,000 millimeters. Everything is based on the factor of 10. The next larger unit is 10 times bigger and the next smaller unit is 10 times smaller. The official standard of length is the kilometer which is equal to 1000 meters. The particular unit used by the scientist is determined by the work being done. The laboratory exercises for this class generally measure length in meters and most of the discussion of the metric systems uses the meter as an example unit.

<table>
<thead>
<tr>
<th>Physical quantity</th>
<th>Metric base unit</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance</td>
<td>Meter</td>
<td>m</td>
</tr>
<tr>
<td>Mass</td>
<td>Kilogram</td>
<td>kg</td>
</tr>
<tr>
<td>Time</td>
<td>Second</td>
<td>s</td>
</tr>
<tr>
<td>Volume (liquids and gases)</td>
<td>Liter</td>
<td>l</td>
</tr>
</tbody>
</table>

The metric system attaches prefixes to these base units. Some commonly used prefixes are shown below in Table 1.2. For example, kilo- means 1000. Thus, 1 kilometer equals 1000 meters. From the table we see that ‘milli’ means .001 (or 1/1000), thus 1 milligram equals 0.001 grams.
<table>
<thead>
<tr>
<th>Metric prefix</th>
<th>Symbol</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Giga</td>
<td>G</td>
<td>1,000,000,000 times the base unit</td>
</tr>
<tr>
<td>Mega</td>
<td>M</td>
<td>1,000,000 times the base unit</td>
</tr>
<tr>
<td>Kilo-</td>
<td>k</td>
<td>1000 times the base unit</td>
</tr>
<tr>
<td>Hecto-</td>
<td>h</td>
<td>100 times the base unit</td>
</tr>
<tr>
<td>Deka-</td>
<td>da</td>
<td>10 times the base unit</td>
</tr>
<tr>
<td>(Base unit)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deci-</td>
<td>d</td>
<td>0.1 times the base unit</td>
</tr>
<tr>
<td>Centi-</td>
<td>c</td>
<td>0.01 times the base unit</td>
</tr>
<tr>
<td>Milli-</td>
<td>m</td>
<td>0.001 times the base unit</td>
</tr>
<tr>
<td>Micro</td>
<td>µ</td>
<td>0.000001 times the base unit</td>
</tr>
<tr>
<td>Nano</td>
<td>n</td>
<td>0.000000001 times the base unit</td>
</tr>
</tbody>
</table>

Note that prefixes located on rows above the base unit have values greater than 1. Therefore a kilometer, hectometer, and dekameter are all greater than 1 meter. Prefixes on rows located below the base unit have values less than 1. Therefore, a decimeter, centimeter, and millimeter are all less than 1 meter.

**Converting Within the Metric System**

The key to understanding how to convert within the metric system is to remember a few simple rules:

1) Select a row that represents the unit that you want to convert from. For example, let's try the base unit, the meter. Then depending on what you want to convert the meter to:
2) for each row that you move up in Table 1.2, move the decimal point one place to the left.
3) for each row that you move down in Table 1.2, move the decimal point one place to the right.
4) If the number that you are given to convert does not have a decimal point, add “.0” to the end of the number (for example, change 95 to 95.0)

or

1) For each row that you move up in Table 1.2 divide the base or previous amount by 10.
2) For each row that you move down in Table 1.2 multiply the base or previous amount by 10.

**Moving up:** 1 meter = 0.1 dekameters = 0.01 hectometers = .001 kilometers

**Moving Down:** 1 meter = 10 decimeters = 100 centimeters = 1000 millimeters

**Example 1** Convert 43.9 kilometers to centimeters.
1. Refer to Table 1.2. To convert kilometers to centimeters, you have to go down five rows.
2. You must move the decimal point five places to the right. Note: after moving the decimal point one space to the right, we added 0’s as place-holders. Solution 43.9 kilometers = 4,390,000 centimeters
   Or
1. Going down each row requires that you multiply by 10 for each row.
2. 43.9 km = 439 hectometers = 4,390 dekameters = 43,900 meters = 439,000 decimeters = 4,390,000 centimeters.

**Example 2** Convert 5,425 milliseconds to seconds.
1. Since the given number does not have a decimal point, follow Rule #3 above and add “.0”
to the given number to get 5,425.0. This was not really necessary since we are moving the decimal point to the left.

2. Refer to Table 1.2 to see that to go from milliseconds to seconds (i.e., a base unit), you must go up three rows.

3. Thus, you must move the decimal point three places to the left. (See Rule #1 above)

4. 5,425.0 milliseconds = 5.425 seconds).

Or

1. Since there are 1000 milliseconds in 1 second
2. Divide 5,425 by 1000 = 5.425 or
3. Divide 5,425 by 10, and divide the result by 10 and divide the result by 10 again.

Angles and Graphing

To understand angles, it is necessary to first discuss two geometrical figures, the circle and triangle. Using a compass, a circle can easily be drawn on a piece of paper. The distance from the center of the circle to a point on the circle is called the radius (R). The diameter (D) is the distance between two opposite points on the circle that pass through the center. The distance around the circle is called the circumference (C) and is related to the radius R by the equation \( C = 2\pi R \) and to the diameter D by \( C = \pi D \) where \( \pi \) is 3.14.

An angle is the separation between two lines meeting at a point called the vertex point. The lines are called the sides of the angle. The separation of the lines is measured in degrees of arc, minutes and seconds and written as 15° 30’ 15” to distinguish angular measurement from temperature and time measurement.

For measuring angles a circle is divided into 360 equal parts called degrees of arc. Just as a ruler measures the length of a line, a protractor measures the size of an angle. A protractor is usually semicircular in shape. In this exercise measurement to the nearest degree will be sufficient.
Use a protractor to measure the angles below and record these as part of the pre-lab questions. Place the center point of the protractor on the vertex of the angle. Then align the left or right 0° with one of the sides of the angle and read the angle by finding the point at which the other line intersects the arc of the protractor. It may be necessary to extend the lines in order to measure the angles.

A triangle is a geometrical figure made up of three points not on the same line and three straight-line segments join the three points. The segments are the sides of the triangle and the points are the vertices of the three angles. The three sides of a triangle may be of different lengths and the three angles may be of various sizes. However, the sum of the angles in any triangle will always be 180°.
Drawing Angles and the Graph

Just as the protractor can be used to measure a given angle, it can be use in a reverse fashion to create an angle between two lines. Angles can be drawn on plain or graph paper. A graph is generally considered to be divided into four parts or quadrants with the center of the quadrant meeting points the origin. In many physics problems, only quadrant 1 is necessary.

To begin drawing angles, divide the graph paper by drawing the X-axis and the Y-axis as shown.

1) Place the center of the protractor at the origin of the graph the bottom of the protractor on the X-axis.
2) Locate an angle such as 45 degrees on the protractor.
3) Mark the 45° point on the paper.
4) Remove the protractor and draw a line from the origin to the point.
5) The line now makes a 45° angle with the X-axis.

To draw an angle between 0° and 90°, only quadrant 1 is required. For an angle between 90° and 180° quadrant 2 is needed and so forth for larger angles.

In future labs, the lines will be drawn from places on the graph other than the origin, but the procedure is very similar.

Drawing lines from data points

Another way of using a graph is to plot a series of points and then draw a line that connects the points. A data point on a graph is made up of the intersection of an X value and a Y value. In order to plot a point the first task is to assign a scale to the graph. For example, each square could represent ten centimeters. Next we must define the X-axis and the Y-axis. Assume that we want to plot data about shoe length and a person’s height to see if there is any type of relationship. Let the X-axis be the shoe length and the person’s height be the Y-axis.

To plot these three data points from the table:

1. Locate the point 2 squares from the origin on the X-axis and the point 13 squares from the origin on the Y-axis. Draw a line perpendicular to these points from each axis.
2. The intersection of the two lines represents the first data point. Put a dot on the graph at this point.
3. Locate the next data point by finding a point 2 ½ squares from the origin on the X axis and 16 squares on the Y axis. Draw line perpendicular to these points from each axis. The intersection of the two lines represents the second data point. Put a dot on the graph at this point.
4. Repeat the process for third data point.
5. Finally draw a line between the three points.
6. This line on the graph provides information about the relationship between shoe length and height. As you might expect, the taller a person the larger the shoe size.

*Interpretation of graph lines*

The lines below represent data points taken from three separate tests. Here the Test Score is plotted against the IQ of the students who took all three exams. What do the lines tell you about the difficulty of the tests?

**I.Q. verses Test Score**

What can we tell from the lines? Examine only one line at a time.

![Graph of I.Q. verses Test Score]

**Variable Relationships**

When both the X and Y data value increase or decrease at the same time, this is called a direct relationship. But when one goes up while the other goes down then the relationship is called inverse.

For example, if more hours of study results in a higher test score then the relationship between hours studied and test score is direct.

This would be an inverse relationship. If this were true then not studying at all should result in perfect 100% scores.
Examples of relationships are shown below:

**Proportions**

<table>
<thead>
<tr>
<th>Direct</th>
<th>Inverse</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y = X$</td>
<td>$Y = \frac{1}{X}$</td>
</tr>
<tr>
<td>$Y = 1$</td>
<td>$Y = \frac{1}{1}$</td>
</tr>
<tr>
<td>$Y = 2$</td>
<td>$Y = \frac{1}{2}$</td>
</tr>
<tr>
<td>$Y = 3$</td>
<td>$Y = \frac{1}{3}$</td>
</tr>
<tr>
<td>$Y = \frac{1}{X}$</td>
<td>$Y = \frac{1}{(1/2)} = 2$</td>
</tr>
</tbody>
</table>

The rates at which relationships change can vary greatly. For example, if you earn $1 per hour, then in 10 hours you will earn $10. This is a direct linear relationship. But if you earn $2 per hour, you will earn $20 in 10 hours. While each relationship is direct the second will have a line on the graph that is twice as steep.

**Experimental Error**

Finally, when we experience data we must judge if the data is valid. We judge this data via the method of percent discrepancy. The smaller the discrepancy, the better the chance the data represents reality. The percent discrepancy is given by:

$$\%\text{ Discrepancy} = \left(\frac{\text{True Value} - \text{Experimental Value}}{\text{True Value}}\right) \times 100\%$$  

Equation 1.1
Laboratory Procedures

Procedure 1 Testing Your Knowledge

To test your knowledge of the metric system, perform the calculations in Table 1.3 of data sheet.

Procedure 2 Metric Measurements

1. Use a metric ruler to take the measurements listed in Table 1.4 of data sheet.
2. Complete Table 1.3 on data sheet.

Procedure 3 Angles

1. Using graph paper and a protractor draw and label the lines for the following angles.
   a. 15°  b. 45°  c. 90°  d. 120°

Procedure 4 Metric Measurements and Graphing

1) Measure and graph shoe length (y-axis) as a function of height (x-axis) using the following guidelines for each member of your group and borrow some data from another group

   a) Record the shoe size and height for a person in centimeters and record the data in Table 1.5.

   b) Scale and label your axes properly:
      i)  Scale your x-axis and y-axis so that almost the entire sheet of graph paper is used.
      ii) You may choose different scales for the x-axis and the y-axis.
      iii) Axes do not have to begin at zero.
      iv) Label the y-axis “shoe length (cm)” ; label your x-axis “height (cm)”.

   c) Title your graph. Titles are usually of the form “y-axis (unit) vs. x-axis (unit)”. In this case, a good choice of title would be “Shoe length (cm) vs. height (cm)”.

   d) Draw a straight line that fits through your data. This “best-fit” line does not have to go through every point. It is the line that best represents the trend shown by your data. There should be about the same number of points above and below the line. Turn in the graph with our completed data sheet.

2) Measure and graph a person’s span (y-axis) and height (x-axis) in centimeters using a procedure similar to that in 4A above. Record the data in the Table 1.6. The span is the distance between a person’s outstretched hands. This is also called a fathom. Find the difference between the span and height for your group and borrow some data from another group. Also compute the average difference ignoring the (+) and (-) signs. What can you conclude from your measurements?

3) Now consider the average shoe length to be 30 cm. This is your True Value. Find the average value of the shoe length for the group of students you measured. This is your Experimental Value. Using Equation 1.1, find the percent discrepancy for your shoe data.
Put the calculations in Table 1.7.
Data Sheet Laboratory 1

Name: __________________________ Partner(s): _______________________

Table 1.3 Procedure 1 Testing Your Knowledge

1. 5,289 meters = ___________ kilometers
2. 5,289 centimeters = _________ meters
3. 1,205 millimeters = _________ centimeters
4. 35,111 grams = ____________ decigrams
5. 254 milliseconds = _________ seconds

Table 1.4 Procedure 2 Metric Measurement

1. Use a metric ruler to take the following measurements:
   a. The length of this sheet of paper to the nearest millimeter is ____________ mm.
   b. The width of this sheet of paper to the nearest millimeter is ____________ mm.

2. Observe your fellow students in terms of how tall they look and how big their shoes look. Based on your observations, write a statement (hypothesis) about how a person’s height relates to their shoe size in the space below.

3. Now take the following measurements and record the data in Table 1.5
   a. Measure your shoe length (heel to toe) and height to the nearest tenth of a centimeter.
   b. Measure the shoe length of your partner and height to the nearest tenth of a centimeter
   c. Measure the shoe length and height of six other students.

Table 1.5 Procedure 4.1 Metric Measurements & graphing of shoe size and height

<table>
<thead>
<tr>
<th>Person’s Name</th>
<th>Shoe Length (cm)</th>
<th>Height (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 1.6 Procedure 4.2 Metric Measurements and graphing of span and height

<table>
<thead>
<tr>
<th>Student Names</th>
<th>Span in cm</th>
<th>Height in cm</th>
<th>Diff = Span - Height</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Average difference = ____________ cm

Table 1.7 Procedure 4.3 Average Shoe Length and the Percent Discrepancy

Average Shoe Length = ____________

Percent Discrepancy = ____________

Questions

1. Was the hypothesis that you stated in procedure 2 generally supported by the data in Table 1.5? Explain your conclusion.

2. Does the best fit line on your graph indicate a direct or inverse relationship? Explain.

3. What does percent discrepancy tell you about the variety of the shoe lengths? Explain.
LABORATORY 2
DENSITY

Equipment

Mass balance, 250-ml graduated cylinders, 400-ml beaker, beaker of ice and water, rock samples (pumice and granite).

Pre-lab Exercise

Devise a method for measuring the volume of an irregularly shaped solid object (e.g., a rock).

Purpose

The purpose of this lab is to measure the density of water and rocks.

Introduction

Density is a measure of buoyancy. Objects that are denser than water will sink in water, whereas objects that are less dense than water will float in water. Mathematically, density is defined as the ratio of mass to volume. In other words,

\[
\text{Density} = \frac{\text{Mass}}{\text{Volume}} \quad \text{Equation 2.1}
\]

Density and mass are directly related: If mass increases, density increases (assuming that volume remains constant). Density and volume are inversely related: If volume increases, density decreases (assuming that mass remains constant).

Procedure 1 Density of Water

1. Zero the balance by pressing the tare button.
2. Weigh a clean, dry, empty graduated cylinder on the balance.
3. Fill the graduated cylinder with 200 ml of water.
4. Weigh the filled cylinder.
5. Record data in Table 2.1. Be sure to include units.
6. Calculate density from Equation 2.1; record result in Table 2.2.
7. Determine the experimental error of your density calculation. Experimental error is calculated as shown in Laboratory 1. The accepted value for the density of water is 1.00 g/ml (i.e., 1.00 g/cm²). Show calculations and final result in Table 2.2.

Procedure 2 Density of Ice

Observe the beaker filled with a mixture of water and ice. Based on your observations, answer the questions listed in Table 2.3.
Procedure 3 Density of Rocks

1. Now take a look at the granite and pumice rock. Put them in the 250-ml beaker which is filled with 150 ml of water. Which one floats? sinks? The rock that float is less dense than water. Record your results in Table 2.4 and state which is less dense than water.

2. Now put the granite rock in the water, record the level of the water in beaker. Do the same for the pumice. Now subtract 150 ml from each level. This will be the volume for each rock. Report results in Table 2.5.

3. Now weigh each rock and calculate the density of pumice and granite. Record all measurements in Table 2.6. Show all work and include all units.
### Data Sheet Laboratory 2

Name: ___________________________  Partner(s): __________________

#### Table 2.1 Procedure 1 Density of Water

<table>
<thead>
<tr>
<th>Number and Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass of empty cylinder</td>
</tr>
<tr>
<td>Mass of cylinder plus water</td>
</tr>
<tr>
<td>Mass of water</td>
</tr>
<tr>
<td>Volume of water</td>
</tr>
<tr>
<td>Density of water (experimental value)</td>
</tr>
</tbody>
</table>

#### Table 2.2 Procedure 1 Experimental Error of the Density of Water

#### Table 2.3 Procedure 2 Density of Ice

The ice is (floating, sinking). Therefore, the ice is (more dense, less dense) than the water.  
*Circle correct answers.*

#### Table 2.4 Procedure 3.1 Estimate of Density of Pumice and Granite

#### Table 2.5 Procedure 3.2 Volumes of Granite

<table>
<thead>
<tr>
<th>Granite: Level in Beaker</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Original Level</td>
<td>150-ml</td>
</tr>
<tr>
<td>Volume</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pumice: Level in Beaker</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Original Level</td>
<td>150-ml</td>
</tr>
<tr>
<td>Volume</td>
<td></td>
</tr>
</tbody>
</table>
Table 2.6 Procedure 3.3 Density Calculation for Pumice and Granite

<table>
<thead>
<tr>
<th></th>
<th>Pumice</th>
<th>Granite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volume</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Questions

1. The mass of water does not change as it freezes. What must happen to the volume in order to explain your observations in Procedure 2? Volume (increases, decreases). Circle your answer.

2. Are your density calculations (Table 2.6) consistent with the estimates shown in Table 2.4? If not, resolve any discrepancies.

3. How does the density of an object change with size? For example, if you compare a big chunk of iron with a tiny piece of iron, which would have the greater density (big piece, small piece, both the same)? Circle your answer. Explain your answer in terms of mass and volume.
LABORATORY 3
MOTION AND FORCE

Equipment
Air track, glider, level, stopwatch, graph paper.

Pre-lab Exercise
1) At the beginning of a trip, your car is moving at 50 miles per hour. Give examples of velocities at the end of your trip that represent positive acceleration, negative acceleration, and zero acceleration.

2) Give an example of a unit of each of the following: velocity and acceleration.

3) What have you observed in a crash between a large truck and a small car?

Purpose
To study the relationship between velocity and acceleration and how we use this to determine the force of an object.

Introduction
A moving object has constant velocity if it covers equal distances in equal time. For example, if a car is moving at a constant velocity of 40 miles per hour, it covers 40 miles every hour. An object whose velocity is changing (increasing or decreasing) is said to be accelerating. For example, if a car's velocity changes from 40 to 50 miles per hour, it is accelerating. And when multiply the acceleration by the mass of the object you receive the force the object exerts in a particular direction. Equations for velocity, acceleration, and force are given below.

\[
\text{Average Velocity} = \frac{\text{Distance}}{\text{Time}} \quad \text{Equation 3.1}
\]

\[
\text{Average Velocity} = \frac{\text{Initial Velocity} + \text{Final Velocity}}{2} \quad \text{Equation 3.2}
\]

\[
\text{Average Acceleration} = \frac{\text{Final Velocity} - \text{Initial Velocity}}{\text{Time}} \quad \text{Equation 3.3}
\]

\[
\text{Force} = \text{mass} \times \text{acceleration} \quad \text{Equation 3.4}
\]

Equation 3.1 states that if the final velocity is greater than the initial velocity, the acceleration has a positive sign ("positive acceleration"). On the other hand, if the final velocity is less than the initial velocity, the acceleration has a negative sign ("negative acceleration" or "deceleration"). Thus, positive acceleration corresponds to an increase in velocity, whereas negative acceleration (or deceleration) corresponds to a decrease in velocity.

Notes on Equations: (1) For the purpose of this lab, "velocity" and "speed" are used interchangeably, but be aware this is not strictly correct. (2) Equation 3.2 assumes uniform acceleration.
Procedure 1 Data Collection

The purpose of this procedure is to prove or disprove the statement:

"A glider on an air track has constant velocity."

You will be asked to design and conduct an experiment to determine whether the velocity of a glider on an air track changes over five continuous laps of motion. Record your data in Table 3.1. Include units.

Procedure 2 Graphs and Calculations

1. On a sheet of graph paper, graph velocity (y-axis) as a function of lap number (x-axis) according to the graphing guidelines of Lab 1. Draw a best-fit line to your data. Turn in the graph with your completed Data Sheet.

2. Calculate the glider's average velocity during the five continuous laps of motion. Show calculations and final results in Table 3.2. Include units.

3. Calculate the glider's average acceleration during the five continuous laps of motion. Show calculations and final results in Table 3.3. Include units.

4. Then weigh the glider to find the glider's mass. Take this mass and multiply the mass by the acceleration from the acceleration in part 2.4. Include the mass and the calculations in Table 3.4. Include units.

5. Finally, watch the demonstration conducted by the instructor of collisions between the different mass gliders. And record your results in Table 3.5.
Data Sheet Laboratory 3

Name: __________________________ Partner(s): __________________________

Table 3.1 Procedure 1 Data Collection

<table>
<thead>
<tr>
<th>Lap</th>
<th>Distance</th>
<th>Time</th>
<th>Average Velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
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<td>3</td>
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<td></td>
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<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3.2 Procedure 2.2 Velocity Calculation

Table 3.3 Procedure 2.3 Acceleration Calculation

Table 3.4 Procedure 2.4 Force Calculation
Table 3.5 Procedure 2.5 Instructor Demonstration Observations

Questions

1. During the five continuous laps of motion, the glider's velocity (increased, decreased, remained the same). This implies the glider experienced (positive, negative, zero) acceleration. Circle your answers.

2. If you noted any change in velocity, what do you think caused this to happen?

3. What was the sign of the acceleration that you calculated in Procedure 2.3 (Table 3.2)? Is this consistent with the best-fit line on your graph? Explain.

4. What occurred in the instructor demonstration? Does this seem reasonable in what you have observed car crashes in the past?
LABORATORY 4
FORCES AND THE FORCE TABLE

Equipment

Force table, with four pulleys, string, four weight hangers, set of slotted weights, protractor, ruler, level, graph paper.

Pre-lab Exercise

1) Define vector and scalar quantities.
2) What graphical procedure is used to add vectors?
3) Is speed a scalar or vector quantity?

Purpose

The purpose of this lab is to determine the resultant force $\mathbf{R}$ experimentally using the force table and graphically by drawing forces on graph paper using the head to tail method.

Introduction

Ideally, the resultant force should be the same with either method. How close the numbers agree will be an indication of your accuracy in conducting the experiment. Forces can be graphically represented by arrows and drawn on graph paper. The length of a force vector is proportional to its magnitude and the arrow points in the direction of the force.

Graphical Method

In the head to tail method, draw the vector representing the first force $\mathbf{F}_1$ to scale. Then draw the vector for the second force $\mathbf{F}_2$ in the correct direction beginning at the head of the first vector. The resultant vector $\mathbf{R}$ can be found by drawing it from the tail of the first vector to the head of the second vector. From the graph, one can measure the resultant vector $\mathbf{R}$ and determine its magnitude and direction.
Experimental Method

A force table is a device that permits one to determine indirectly, the resultant force of several vectors. It is done indirectly; because one finds the equilibrant force \( E \) rather than the resultant force \( R \). The resultant force \( R \) has the same magnitude as the equilibrant force \( E \) but is in the opposite direction. Remember this when you determine the resultant force’s direction from the scale on the rim of the force table.

![Equilibrant force \( E \) and Resultant force \( R \)](image)

Procedure 1 Determining Resultant Vectors

If the force table is not set up, assemble it and attach pulleys, strings and the appropriate number of weight hangers for each set of forces. Be sure the safety pin is in the hole in the center of the table and that the ring is around the pin. Next perform the following exercises. Also, we will only using the masses as we are on Earth and the acceleration due to gravity on each mass is the same, therefore we will dealing using \( M \) instead of \( F \) for the resultant.

Experimental Resultant 1 - Place the pulleys and weights for two masses: \( M_1 = 200 \) grams in a direction of \( 0^\circ \) and \( M_2 = 200 \) grams in a direction of \( 90^\circ \). Next grab the equilibrant force string and pull it while moving either to the left or right until you determine the approximate direction that the resultant mass will be in and place a pulley at that point. Next place weights on the resultant weight hanger to balance the other two mass. It will be necessary to adjust the position of the resultant pulley and the amount of weight until a good balance is achieved. Record the resultant mass in the Data Table. Determine the direction of the resultant force as measured from \( 0^\circ \) and also record it in Table 4.1.

Graphical Resultant 1 (See next page on instructions for drawing vectors.) Draw the forces \( M_1 \) and \( M_2 \) to scale and direction on the graph paper. First draw \( M_1 \) and then draw \( M_2 \). Next transpose \( M_2 \) so that its tail is connected to the head of \( M_1 \) but still retains its original direction. Finally, draw a vector from the tail of \( M_1 \) and connect it to the head of \( M_2 \). Now using the same scale that was used to draw the known vectors, measure the resultant \( R \) to determine its magnitude. Use a Protractor to measure its direction and record this information in the Data Table. How do the results from the two methods compare.

Repeat the Experimental and Graphical procedures for other Resultant forces 2 and 3 as listed in the data table.
How to Draw Vectors on Graph Paper

Assume that you want to add the following two vectors by drawing them on graph paper using the head to tail method.

\[ M_1 = 200g \text{ at an angle of } \theta = 20^\circ \text{ and } M_2 = 200g \text{ at an angle of } \theta = 60^\circ \]

1. Examine the graph paper and count the number of big squares and the number of small squares within each large square.

2. Using the magnitude of your vectors determine the scale to be used for the graph. For example: if the largest mass is 200 grams, let each large square be equal to 20 grams. Thus, the vector will be 10 squares long. Since there are more vertical squares than horizontal squares on the 8 ½” by 11” paper it many be necessary to rotate the paper. Usually the scale is based on the largest vector.

3. If the vectors are between 0° and 90° use the first quadrant of the coordinate system. Start at the lower left hand corner of the graph paper and label the vertical and horizontal axis with the scale chosen in step 2. If the vectors are between 90° and 180° use the first and second quadrants of the coordinate system. If any quadrant besides the first are also used the origin of the graph can not be at the lower left hand corner but needs to be placed somewhere on the graph. The exact point will depend on the scale and magnitude of the vectors. Ideally you want to be able to fit everything one sheet of paper. Sometime this cannot be done and two pieces of graph paper will have to be taped together. Always try to make the graph as large as possible and remain on one sheet of paper. The larger your drawings the better the accuracy of the addition.

4. Draw each of the vectors on the graph paper. For the above example, we would use only the first quadrant since no force is in a direction of more than 90°.

   a. With the protractor at the origin measure the necessary angle for the first vector. In this case it will be \( \theta = 20^\circ \). Draw a long line to represent this angle.

   b. Next using the scale selected (20 grams per large square) measure the distance along this line. This can be easily done using a ruler. Measure how many centimeters 200 grams represents on the horizontal or vertical axis and transfer this length to the line a \( 20^\circ \). Put an arrow head at the end of the line. This is now the vector for force \( F_1 \).

   c. Next repeat steps (a) and (b) for the force \( F_2 \) at 60°. Since both forces in this example are the same magnitude, both vectors will be the same length.
5. Now **move** one of the vectors so that the head of one touches the tail of the other and retains its original direction angle. While either vector can be moved it is best to move the second. **The first vector usually remains fixed.** If there are more than two forces, the second vector is moved such that its tail connects with the first vectors head. Then the third vector is moved such that its tail connects with the second vectors head, etc.

6. Finally, draw the **resultant vector**. It goes from the **origin** to the head of the last vector added. In this case it would be vector two for force $F_2$.
   
   a. Use the protractor to measure the angle of this resultant line and record the answer.
   
   b. Next use the ruler to **measure the length of the resultant vector** in centimeters and measure this distance along the horizontal or vertical axis scale and determine how many grams it represents. Record you answer.
Data Sheet Laboratory 4

Name: ____________________  Partner(s): ____________________

Table 4.1 Data Table

<table>
<thead>
<tr>
<th></th>
<th>Forces</th>
<th>Experimental Resultant</th>
<th>Graphical Resultant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resultant 1</td>
<td>$M_1 = 200 \text{ g}$ $\theta = 0^\circ$</td>
<td>$R = \theta =$</td>
<td>$R = \theta =$</td>
</tr>
<tr>
<td></td>
<td>$M_2 = 200 \text{ g}$ $\theta = 90^\circ$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resultant 2</td>
<td>$M_1 = 150 \text{ g}$ $\theta = 20^\circ$</td>
<td>$R = \theta =$</td>
<td>$R = \theta =$</td>
</tr>
<tr>
<td></td>
<td>$M_2 = 200 \text{ g}$ $\theta = 80^\circ$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resultant 3</td>
<td>$M_1 = 200 \text{ g}$ $\theta = 0^\circ$</td>
<td>$R = \theta =$</td>
<td>$R = \theta =$</td>
</tr>
<tr>
<td></td>
<td>$M_2 = 100 \text{ g}$ $\theta = 180^\circ$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Remember to measure the direction of the resultant vector from zero degrees on the force table. Also, give the graphical resultants directions measured from zero degrees with respect to the other vectors.
Questions

1. Which method of determining the resultant do you feel was more accurate? Discuss your choice.

2. What are possible sources of error with the experimental method?

3. If an airplane is flying directly East at 200 mph and a cross wind from the North at 100 mph pushes on the airplane, what direction will the plane travel and how fast? Show work.

4. Discuss how the forces were acting in the Resultant 3 exercise.
LABORATORY 5

HEAT AND TEMPERATURE


Equipment

One 400-ml beaker, beaker tongs, two smaller beakers, stirrer, crushed ice, bunsen burner, lighter, thermometer, graph paper, food coloring, sugar cubes.

Pre-lab Exercise (Physiological Experience of Heat)

Gather three large pots or bowls that can hold sufficient water to cover your submerged hand. Fill one with iced water. Fill the second with tap water at room temperature. Fill the third with very hot water (but not so hot as to burn you).

Place one hand in the hot water and the other hand in the cold water for several minutes, then quickly place them both in the lukewarm water. When both hands are initially placed in the lukewarm water, do they both feel that the water is at the same temperature? Or does one feel that the water is hotter? Describe your observations.

Purpose

To study the interaction between the heat an object receives and the temperature it displays.

Procedure 1 Phase Changes of Water

1. The fictional data in Table 6.1 show how the temperature changes as ice (original temperature = -30°C) is gradually heated to steam (final temperature = 140°C). On a sheet of graph paper, plot temperature (y-axis) as a function of the amount of heat added by using time as the x-axis. Turn in the graph with your completed Data Sheet.

Table 5.1 Fictional Data on Phase Changes of Water

<table>
<thead>
<tr>
<th>Time (minutes)</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-30</td>
</tr>
<tr>
<td>1</td>
<td>-20</td>
</tr>
<tr>
<td>2</td>
<td>-10</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>7</td>
<td>20</td>
</tr>
<tr>
<td>8</td>
<td>30</td>
</tr>
<tr>
<td>9</td>
<td>40</td>
</tr>
<tr>
<td>10</td>
<td>50</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time (minutes)</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>60</td>
</tr>
<tr>
<td>12</td>
<td>70</td>
</tr>
<tr>
<td>13</td>
<td>80</td>
</tr>
<tr>
<td>14</td>
<td>90</td>
</tr>
<tr>
<td>15</td>
<td>100</td>
</tr>
<tr>
<td>16</td>
<td>100</td>
</tr>
<tr>
<td>17</td>
<td>100</td>
</tr>
<tr>
<td>18</td>
<td>110</td>
</tr>
<tr>
<td>19</td>
<td>120</td>
</tr>
<tr>
<td>20</td>
<td>130</td>
</tr>
<tr>
<td>21</td>
<td>140</td>
</tr>
</tbody>
</table>
2. Fill the 300-ml beaker to the 200-ml mark with crushed ice and then up to the 300-ml with cold water. Suspend a thermometer in the center of the beaker. Record the initial temperature on the first row of Table 6.2. Heat the beaker on a high flame, and stir constantly. Record the temperature every minute on the appropriate row of Table 6.2 and note the state of the water. Stop recording data after the water has been boiling for at least three minutes. This may take more or less time than the 15 minutes listed in Table 5.2; use the blank lines (or attach an additional sheet) as necessary.

**Procedure 2 Food Coloring Experiment**

This activity requires two small beakers; one filled with very hot water and one filled with very cold water. Use the water from Procedure 1.2 above as your very hot water. To obtain very cold water, add ice to tap water and wait for the ice to melt before proceeding. Gently add a drop of food coloring to each beaker. Describe your observations in Table 5.3 of data sheet.

**Procedure 3 Sugar Cube Experiment**

This activity again requires two beakers; one filled with very hot water and one filled with very cold water. You may use the colored water from Procedure 2, or you may prepare fresh samples if you prefer. Carefully place a sugar cube into each beaker and observe what happens. Describe your observations in Table 5.4 of data sheet.

**Procedure 4 Temperature of Objects**

1. Touch various objects in the laboratory, such as metal, plastic and wood. Do they feel as if they are all at the same temperature? Detail your observations in Table 5.5 of data sheet.

2. The laboratory is held at a constant temperature over long periods of time. Therefore, objects in the laboratory should all be at approximately the same temperature. How can you reconcile this statement with your observations in Procedure 4.1 above? Explain your reasoning in Table 5.5.
Data Sheet Laboratory 5 ____________

Name: __________________________ Partner(s): ______________________

Table 5.2 Procedure 1 Phase Changes of Water

<table>
<thead>
<tr>
<th>Time (minutes)</th>
<th>Temperature (°C)</th>
<th>Notes on the state of the water</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>Mainly ice; some liquid water</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
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<tr>
<td>4</td>
<td></td>
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<td>6</td>
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<td>10</td>
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<tr>
<td>11</td>
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</tr>
<tr>
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<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5.3 Procedure 2 Food Coloring Experiment

Observations:

Table 5.4 Procedure 3 Sugar Cube Experiment

Observations:

Table 5.5 Procedure 4 Temperature of Objects

Revised - 8/5/2014 5.2
Observations (Procedure 4.1):

Explanation (Procedure 4.2):

Questions

1. If your graph in Procedure 1 was not a straight line, explain why not. (What physical processes caused the "steps" in your graph?)

2. Is it possible to add heat energy to an object without increasing its temperature? Give an example.

3. Were the data that you collected in Procedure 1 consistent with the fictional data provided? Explain.

4. Which do you think have greater kinetic energy- molecules in hot water or molecules in cold water? Support your statements with the results of Procedures 2 and 3.
LABORATORY 6
CHEMISTRY

Equipment
Five unknown carbohydrate samples, two unknown protein/ amino acid samples, hot water bath, test tubes, Benedict’s test, Barfoed’s test, Seliwanoff’s test, Iodine test, Biuret’s test, safety goggles, Bunsen burner, burner ring and stand, Bunsen beaker, beaker bad, test tubes, test tube holders, test tube cleaning brush, five graduated cylinders, lab aprons, and latex gloves.

Pre-lab Exercise
1) What are the three types of carbohydrates? What foods do you eat these in daily?
2) What test is used to determine the difference between sucrose and starch?
3) What are sources of proteins that helps with hair and nail growth?
4) What is a chemical formula and what does it tell about the elements in a substance.

Purpose
The purpose of this lab is to see different chemical reactions with everyday substances, carbohydrates and proteins.

Introduction
We deal with these substances daily. You will use different tests to determine which of 7 unknowns are these substances.
Carbohydrates are sugars that are present in pastas, breads, and desserts that we eat daily. They provide energy to our cells. Carbohydrates are divided into three groups called monosaccharides, disaccharides, and polysaccharides. Monosaccharides are located mostly in fruits and vegetables with the most important being glucose and fructose. Disaccharides are located mostly in "sweet" types of foods with the most important being sucrose and lactose. Lactose is the sugar in milk. Starch is the most important polysaccharide and is located in breads. The chemical formulation for a monosaccharide is C_n(H_2O), with n being the number of molecules from 3 to 7. The chemical formulation for disaccharides is C_{n+1}(H_2O)_n.

Proteins and amino acids are the basic building blocks of your body. They are present in meat, fish, beans and rice. Amino acids are present in different structures of our cells especially our DNA. Proteins build up our hair and nails.
Your first task in this lab is to determine which of the unknowns are fructose, glucose, lactose, sucrose, or starch. Finally, you must determine which are proteins or amino acids. This is a step-by-step process of elimination to discover the truth.

Caution! Be very careful and follow the instructions. Please wear your safety glasses, latex gloves and apron. These chemicals will stain skin and clothes.
**Procedure**

1) **Set-up:**
   a. Prepare a boiling water bath. Start by putting the beaker pad on the ring stand and the Bunsen Beaker on the pad.
   b. Place 400 ml of water in the beaker and place on the pad.
   c. Next place the Bunsen burner under the pad, turn on the gas and light the burner. Adjust the flame for maximum heat. (As the water boils away it will be necessary to occasionally add water in order to keep the water level at about the 400 ml mark.)
   d. Put on the latex gloves, apron and safety goggles provided for you. People with long hair should tie up their hair with the rubber bands provided.
   e. When asked to dispose of any samples in steps 2-6, you should pour the sample down the drain with the water running.

2) **Benedict’s Test:**
   a. Label the test tubes as A, B, C, D, & E.
   b. For each of the unknown carbohydrate samples, measure out 1 mL of each using different a graduated cylinder and pour into a different test tube. Always put unknown “A” into test tube “A”, “B” into test tube “B” and so on.
   c. Next clean the five graduated cylinders.
   d. Then using a graduated cylinder, pour 5 mL of the blue Benedicts reagent into each test tube.
   e. Place the five test tubes in the boiling water bath using the test tube holders and leave for 3 minutes.
   f. Remove the test tubes from the water bath and inspect each for a reddish-orange color indicating a positive test. This implies the presence of 1) glucose, 2) fructose, or 3) lactose.
   g. Record the positive samples by placing a P in the appropriate cell in Table 6.1 and an N for samples with a negative test.
   h. Dispose of all the samples as instructed above. Clean the test tubes using soap and a brush for the next step.

3) **Barfoed’s Test:**
   a. Now make new samples for the unknowns that were positive for the Benedict’s test. If unknown “A” was positive, you will pour unknown “A” into test tube “A” and so on. Pour a fresh 1 mL of each positive unknown into different test tubes using different graduated cylinders. Next clean the graduated cylinders.
   b. Now add 5 mL of the Barfoed’s reagent to each test tube using a clean graduated cylinder.
   c. Place each test tube in the boiling water bath for 10 minutes. A reddish-orange color forms for a positive result in the bottom of the test tube. This indicates either glucose or fructose is present.
   d. Record the positive samples by placing a P in the appropriate cell in Table 6.1 and an N for samples with a negative test. If you have a negative result you should be able to identify this unknown. What is it? Write the name in the appropriate cell of Table 6.2.
   e. Dispose of all the samples in this test as instructed above. Clean the test tubes for the next step.
4) **Seliwanoff’s Test:**
   a. Now make new samples for the unknowns that were positive for the Barfoed’s test by pouring a fresh 1 mL into two correctly labeled test tubes as in the previous step.
   b. Add 4 mL of Seliwanoff’s reagent to each.
   c. Place these in the boiling water bath for 5 minutes.
   d. The first test tube exhibiting a dark red color is fructose (So keep an eye on the samples during this test).
   e. The second test tube exhibiting the dark red color is glucose.
   f. Print fructose or glucose in the appropriate cell in Table 6.1 for each of the unknowns.
   g. Dispose of these two samples as instructed and clean the test tubes.
   h. Turn off your hot water bath and let it cool down.

5) **Iodine Test:**
   a. Using the unknown sample(s) that tested negative for the Benedict’s test, pour 2 mL of the unknowns into two clean test tubes labeled correctly.
   b. Next add a drop of iodine solution to each. A positive test for Starch should produce a blue-black color. The negative sample is sucrose.
   c. Dispose of the samples as instructed.
   d. Record each of the test results in Table 1 by writing sucrose or starch in the cell indicating the test and unknown letter.
   e. Make your determination of which unknown is glucose, fructose, lactose, sucrose, or starch and write the name of the unknown in Table 6.2. Clean the test tubes.

6) **Biuret’s Test:** (This is the second part of the lab.)
   a. Reuse the test tubes that were labeled as “A” and “B” in step 2. Be sure these test tubes have been washed.
   b. Take each of the amino acids/protein unknown samples labeled “A” and “B” and pour 2 mL of each in separate test tubes using different graduated cylinders. (These are different samples of “A” and “B” than were used in the first part of this lab.)
   c. Pour unknown “A” into test tube “A” and unknown “B” in to test tube “B”. This test involves two strong acids **SO HANDLE EACH WITH CARE**.
   d. Using a different clean graduated cylinder, add 2 mL of the NaOH solution to each test tube and mix by moving the test tube in a SLOW swirling motion. Be careful not spill or splash anything on you.
   e. Next add 5 drops of CuSO₄ and mix with the same SLOW swirling motion. Wait a few minutes for a reaction to occur. A purple color indicates an amino acid. A yellow tinge or blue, color indicates a protein.
   f. Report the results in Table 6.3 by writing the name of the unknown “A” and “B” in the space provided. Dispose of the samples and clean the test tubes.

*Wash any dirty test tubes, clean up your lab table and put supplies back in their original containers or place before leaving the lab.*
Testing for Carbohydrates

5 Unknowns

Benedict's Test

Positive

Glucose
Fructose
Lactose

Negative

2 unknowns

Iodine Test

Positive

Starch
Blue-black

Negative

Sucrose

Seliwanoff's Test

Positive

1st Fructose

Negative

2nd Glucose
Data Sheet Laboratory 6

Name: _____________________  Partner(s): _____________________

### Table 6.1 Carbohydrate Unknowns

<table>
<thead>
<tr>
<th>Unknown</th>
<th>Benedict</th>
<th>Barfoed</th>
<th>Seliwanoff</th>
<th>Iodine</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 6.2 Carbohydrate Results

<table>
<thead>
<tr>
<th>Unknown</th>
<th>Name of Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td></td>
</tr>
</tbody>
</table>

### Table 6.3 Amino Acid/Protein Results

<table>
<thead>
<tr>
<th>Unknown</th>
<th>Name of Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
</tr>
</tbody>
</table>
Questions

1. Disaccharides are the combination of two different monosaccharides. Fructose and glucose combine to make sucrose and their molecular number is n=6. What is the chemical formula for each?

2. If you were a CSI (Crime Scene Investigator), and you found a sample of blood at the scene, how would you tell if your suspect preformed the crime? You have a suspect that happens to be diabetic and you know that Diabetics have too much glucose because their pancreas does not produce enough insulin to process the glucose. Explain you deductive process in detail.
LABORATORY 7

TOPOGRAPHIC MAPS

Equipment

Persimmon Creek, NC topographic map, hand lens, rulers, One Earth Globe

Pre-lab Exercise

Go to the following website:

Answer these questions:
1) What location do you see in the map?
2) Does the map have many contour lines (lines that show a change in elevation)?
3) What occurs when you change the scale on the left hand side of the map?

Purpose

The purpose of this lab is to study topographic maps and learn how they model three dimensions through a two dimensional model.

Introduction

The topographic map shows a bird’s eye view of the location of hills, valleys, rivers, streams, lakes, the steepness of slopes and other features natural and man-made.

Topographic maps are quadrangle maps generally prepared by the United States Geological Survey (USGS). A quadrangle map is a rectangular area of the earth’s surface.

MAP SCALES, LATITUDE AND LONGITUDE, ADDITIONAL INFORMATION ON TOPOGRAPHIC MAPS

MAP SCALES

A topographic map is a scale model representing a part of the earth’s surface.

The **scale** of a map is how much smaller the map is than the real world it represents. They are expressed in three different ways.

A **fractional scale** expresses how much smaller the map is as a fraction such as 1/24,000 or 1:24,000. This means that the map is 1/24,000 the size of the real world and that any unit distance on the map is 24,000 times larger in reality. For example, 1 centimeter (inch, foot) on the map equals 24,000 centimeters (inches, feet) on the ground. The standard sizes are 1:24,000, 1:62,500, and 1:250,000 although other scales are sometimes used.
A **verbal scale** is a simpler way of stating the difference between the map distance and ground distance. For example, “one inch equals one mile”. A verbal scale may not be precise but is close enough for rough estimates.

A **graphic scale** is a line or bar drawn showing miles, feet and kilometers so that with a ruler the distance on the map can be scaled out.

**Figure 7.1 Conversion Table**

<table>
<thead>
<tr>
<th>A. English Units of Linear Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 inches = 1 foot</td>
</tr>
<tr>
<td>3 feet = 1 yard</td>
</tr>
<tr>
<td>1 mile = 1,760 yards, 5,280 feet, 63,360 inches</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B. Metric Units of Linear Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 millimeters = 1 centimeter</td>
</tr>
<tr>
<td>100 centimeters = 1 meter</td>
</tr>
<tr>
<td>1,000 meters = 1 kilometer</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>C. Conversion of English Units to Metric Units</th>
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<tbody>
<tr>
<td>symbol</td>
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<tr>
<td>in.</td>
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<tr>
<td>ft.</td>
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<tr>
<td>yd.</td>
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<td>mi.</td>
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</table>

<table>
<thead>
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<th>D. Conversion of Metric Units to English Units</th>
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</thead>
<tbody>
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<td>symbol</td>
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<td>cm</td>
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<tr>
<td>m</td>
</tr>
<tr>
<td>m</td>
</tr>
<tr>
<td>km</td>
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</tbody>
</table>

**LATITUDE AND LONGITUDE**

Every topographic map can be located precisely on the earth’s surface by the international grid system of latitude and longitude. Lines of **latitude** circle the earth parallel to the equator. The equator is zero degrees latitude and latitude increases degree by degree in each direction north and south of the equator toward the poles. Maximum latitude is 90° at each pole.

Lines of **longitude** circle the earth from pole to pole. The zero line of longitude is the prime meridian, which runs through Greenwich, England (near London). Longitude increases east and west of Greenwich degree by degree around the globe until 180° is reached on the opposite side of the globe.

The latitude and longitude of every topographic map is shown at the corners of the map, with subdivisions shown along the map edges.

Topographic maps usually cover two degrees of area or less. Measurements are in seconds, minutes, and degrees. There are 60 seconds in a minute and 60 minutes in a degree. Written for example as 75° 30’ 25”:seventy-five degrees, thirty minutes, twenty-five seconds”. 

Revised - 8/5/2014  7.2
Figure 7.2 Generalized system of meridians and parallels. The location of point X is longitude 45° West, latitude 45° North.

TOPOGRAPHIC MAPS AND RULES OF CONTOURS

Topography is the general configuration of a land surface, including its relief and the position of its natural and man-made features. (Etymology: Greek *topos* "place", and *graphien* "to write".)

A topographic map shows a surface relief by contours drawn at regular intervals above mean sea level. It is generally on a sufficiently large scale to show in detail selected man-made and natural features including relief and such physical and cultural features as vegetation, roads, and drainage.

Contour lines are imaginary lines, or lines on a map or chart, that connects points of equal value such as elevation of land surface.

The contour interval is the difference in value between two adjacent contours, eg. the vertical distance between the elevations represented by two successive contour lines on a topographic map. It is generally a regular unit chosen according to the amount and abruptness of the change involved and the scale of the map.

Benchmarks are a permanent metal tablet or other mark firmly embedded in a fixed and enduring natural or artificial object, indicating a precisely determined elevation above or below a standard datum (usually sea level), bearing identifying information, and used as a reference in topographic surveys and tidal observations. Abbr. BM

The Rules of Contour Lines:

1. All points on a contour line have the same elevation.

2. The surface immediately on the inside of a normal contour line is always at a higher elevation than the surface immediately on the outside of the line.
3. Contour lines that are close together indicate a **steep slope**, while contour lines that are far apart indicate a **gradual slope**.

4. A contour line crossing a stream bends in the general form of a “V” with the apex of the “V” pointing upstream.

5. Contour lines eventually close, or connect end to end, creating an enclosed area, although this may happen outside the map area.

6. Contour lines **never branch or split.**

7. Contour lines **never intersect or cross.**

8. Hachured contour lines represent hollows or closed depressions.

**There are usually six colors used on topographic maps:**

- **Brown** – relief – hills, valleys, mountains, plains
- **Blue** – water – lakes, ponds, stream, canals, swamps
- **Black** – culture – roads, railroads, buildings, land boundaries
- **Red** – major roads
- **Green** – forests, scrubs, woodlands, vineyards, orchards
- **Purple** – features added from aerial photographs during map revision. (The changes are not field checked).
### Topographic Map Symbols

#### Boundaries
- National
- State or territorial
- County or equivalent
- Civil township or equivalent
- Incorporated-city or equivalent
- Part, reservation, or monument
- Small park

#### Land Survey Systems
- U.S. Public Land Survey System:
  - Township or range line
  - Location doubtful
- Section line
- Location doubtful
- Found section corner; found closing corner
- Witness corner; mader corner

#### Roads and Related Features
- Primary highway
- Secondary highway
- Light duty road
- Unpaved road
- Trail
- Dual highway
- Dual highway with median strip
- Road under construction
- Underpass, overpass
- Bridge
- Drawbridge
- Tunnel

#### Buildings and Related Features
- Dwelling or place of employment: small; large
- School; church
- Barn, warehouse, etc.: small; large
- House; omission list
- Racetrack
- Airport
- Landing strip
- Well other than water; windmill
- Water tank: small; large
- Other tank: small; large
- Covered reservoir
- Gaging station
- Landmark object
- Campground; picnic area
- Cemetery: small; large

#### Railroads and Related Features
- Standard gauge single track: station
- Standard gauge multiple track
- Abandoned
- Under construction
- Narrow gauge single track
- Narrow gauge multiple track
- Railroad in street
- Railjump
- Roundhouse and turntable

#### Transmission Lines and Pipelines
- Power transmission line: pole; tower
- Telephone or telegraph line
- Aboveground oil or gas pipeline
- Underground oil or gas pipeline

#### Contours
- Topographic:
  - Intermediate
  - Index
  - Supplementary
  - Depression
  - Cut, fill
- Bathymetric:
  - Intermediate
  - Index
  - Primary
  - Index Primary
  - Supplementary

#### Mines and Caves
- Quarry or open pit mine
- Gravel, sand, clay, or borrow pit
- Mine tunnels or cave entrance
- Prospect; mine shaft
- Mine dump
- Tailing

#### Surface Features
- Levee
- Sand or mud area, dunes, or shifting sand
- Inorganic surface area
- Gravel beach or glacial moraine
- Tailing pond

#### Vegetation
- Woods
- Scrub
- Orchard
- Vineyard
- Mangrove

#### Coastal Features
- Foreshore flat
- Rock or coral reef
- Rock bars or swash
- Group of rocks bar or swash
- Exposed wreck
- Depth curve; sounding
- Breakwater, pier, jetty, or wharf
- Seawall

#### Bathymetric Features
- Area exposed at mean low tide; sounding datum
- Channel
- Offshore oil or gas: well; platform
- Sunken rock

#### Rivers, Lakes, and Canals
- Intermittent stream
- Intermittent river
- Disappearing stream
- Perennial stream
- Perennial river
- Small falls; small rapids
- Large falls; large rapids
- Masonry dam
- Dam with lock
- Dam carrying road
- Intermittent lake or pond
- Dry lake
- Narrow wash
- Wide wash
- Canal, flume, or aqueduct with lock
- Elevated aqueduct, flume, or conduit
- Aqueduct tunnel
- Water well; spring or seep

#### Glaciers and Permanent Snowfields
- Contours and limits
- Form lines

#### Submerged Areas and Bogs
- Marsh or swamp
- Submerged marsh or swamp
- Woody marsh or swamp
- Submerged wooded marsh or swamp
- Rice field
- Land subject to inundation
Procedures

Procedure 1 Calculating Scales

Use Figure 7.1 in the introduction, calculate the different scales. You may obtain the fractional scale on the bottom of your map. Put your answers in Table 7.1.

Procedure 2 Information on a Topographic Map

Using the Persimmon Creek, NC topographic map locate the information asked in Table 7.2.

Procedure 3 Determining Relief and Elevation on a Topographic Map

Local relief is the difference between two points. Total relief is the difference between the highest elevation and lowest elevation in a region or on a map.

Gradient is the rate of ascent of an inclined surface of the earth (steepness of a slope). Gradient is calculated as the Rise/Run or the difference between the high and low elevations of a particular area/the measurement straight down the slope (using a bar scale).

Please calculate the requested relief and gradients and enter your results in Table 7.3.

Procedure 4 Drawing Contour Lines

STEP ONE Find the highest elevations on the map and mark them with an X. These will be the tops of hills and the contour lines will circle them.

STEP TWO Draw contour lines. The lakeshore is the first contour line at 0 feet. Use a contour interval of 10 feet to draw the 10 feet, 20 feet, etc. contour lines around the hills. Estimate where the contour lines are between the elevations provided.

Procedure 5 Constructing an Elevation Profile

Using the topographic map in Figure 7.5, construct an elevation profile.

STEP ONE Use a straightedge to project the intersection of each contour line, stream, hilltop that crosses the line AB down onto the correct elevation on the topographic profile. Start with 980 feet and label the graph every 20 by skipping every other line until you reach the top, link in Figure 7.3.

STEP TWO Complete the elevation by connecting all the points of the elevation on the profile, like in Figure 7.3.
Figure 7.3 How to construct a geographic profile from contours.
Data Sheet Laboratory 7

Name: ___________________________  Partner(s): ___________________________

Table 7.1 Procedure 1 Calculating Scales

1. Calculate the verbal scale for each of the fractional map scales.
   a. 1:24,000
      2000 ft/in
      _______ mi/in
      _______ km/cm
   b. 1:62,500
      _______ ft/in
      _______ mi/in
      _______ km/cm

   eg: 1 inch on map = 24,000 inches on ground
       1 inch on map = 24,000 \div 12 = 2,000 feet on ground

2. Write the fractional scale of the Persimmon Creek, NC map___________

3. Measure the verbal scale of feet per inch from #1 against the graphic scale at the
   bottom of the map. Are they the same? ______________

Table 7.2 Procedure 2 Information on a Topographic Map

1. Write the latitude of the map (north end). ____________

2. Write the latitude of the map (south end). ____________

3. What is the distance in degrees, minutes, and seconds from north to south on
   the map? ____________

4. Write the longitude of the map (west side). ____________

5. Write the longitude of the map (east side). ____________

6. What is the distance in degrees, minutes, and seconds from west to east on the
   map? ____________

7. What is the approximate latitude and longitude of Canady Gap? ____________

8. Calculate the real distance from north to south in kilometers. ____________

9. Calculate the real distance from east to west at the south end of the map in kilometers. ____________

10. When was the map published? ____________

11. When was the map photorevised? ____________

12. What is the contour interval? ____________
**Table 7.3 Procedure 3 Determining Relief and Elevation on a Topographic Map**

1. What is the local relief between Ghormley Mountain and Bearpaw Creek?

2. What is the highest elevation on the map? ____________

3. What is the lowest elevation on the map? ____________

4. What is the total relief of the Persimmon Creek, NC map? ____________

5. What is the difference in elevation (in meters) between the high elevation at Damons Mountain and the low elevation at Garland at the highway? ____________

6. What is the distance in kilometers straight down the slope from the highest elevation to the highway? ____________

7. Calculate the average gradient of the slope in a fractional scale of meters of fall per kilometer. (calculate to smallest possible terms) ____________

8. What is the highest benchmark elevation? ____________

9. What is the lowest benchmark elevation? ____________
Figure 7.4 Procedure 4 Drawing Contour Lines.
Figure 7.5 Procedure 5 Creating an Elevation Profile.
LABORATORY 8

MINERALS

Equipment

Hand lens, HCl acid, unglazed porcelain streak plate, glass plate, knife blade, copper penny, magnet, minerals, and mineral identification reference book.

Pre-lab Exercises

1) Are the following minerals? (Answer Yes or No)
   a) oil
   b) synthetic diamonds
   c) amethyst
2) Name two minerals that you can scratch with your fingernail.

Purpose

The purpose of this lab is to learn how to identify minerals.

Introduction

A mineral is a naturally occurring, inorganic solid with an orderly arrangement of atoms (called crystalline structure) and a definite chemical composition. Minerals are identified by a variety of properties, some of which are listed below.

- **Magnetism** is the presence of the magnetic field. Certain minerals are ferromagnetic meaning they have permanent magnets.
- **Effervescence** is the “fizz” that occurs when certain minerals (called carbonates) react with hydrochloric (HCl) acid due to the release of carbon dioxide. Place one drop of HCl acid on a mineral and note if it effervesces. Rinse the mineral immediately with water.
- **Hardness** is the ability of a mineral to resist scratching. Harder minerals scratch softer ones. The Moh’s Scale of Hardness lists some index minerals and common objects on a scale from 1 to 10, with higher numbers corresponding to harder minerals. For example, a glass plate (hardness=5.5) will scratch fluorite (hardness=4), but will not scratch quartz (hardness=7).
- **Luster** refers to the way a mineral reflects light. Examples of luster include metallic, glassy, pearly or dull.
- **Color** is not a reliable way of identifying a mineral because colors may vary, depending on the presence of trace elements. For example, quartz can be clear (ordinary quartz), pink (rose quartz), purple (amethyst) or smoky (smoky quartz).
- **Streak** (the color of a mineral in powdered form) is generally more reliable. To find the streak, rub the mineral across an unglazed porcelain tile.
- **Cleavage** refers to the property of breaking nicely along smooth planes (e.g., flake into sheets or break into cubes). Minerals that do not have cleavage are said to fracture. Without breaking a mineral, it is not always obvious to determine if a mineral has cleavage or fracture.
Testing for Luster, Color, and Streak

Luster refers to the way a mineral reflects light. Examples of luster include metallic, glassy, pearly or dull.

**Metallic minerals are usually**
- a. gold, silver or black
- b. shiny, polished
- c. opaque
- d. always have a streak

**Nonmetallic minerals are usually**
- a. not gold or silver
- b. shiny to dull
- c. transparent, translucent, or opaque
- d. rarely have a streak

Cleavage Patterns

Cleavage refers to the property of breaking nicely along smooth planes (e.g., flake into sheets or break into cubes). Minerals that do not have cleavage are said to fracture. Without breaking a mineral, it is not always obvious to determine if a mineral has cleavage or fracture.

<table>
<thead>
<tr>
<th>Number of cleavage directions</th>
<th>Shape</th>
<th>Number of flat surfaces</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Flat sheets</td>
<td>2</td>
</tr>
<tr>
<td>2 at 90°</td>
<td>Rectangular cross section</td>
<td>4</td>
</tr>
<tr>
<td>2 not at 90°</td>
<td>Parallelogram cross section</td>
<td>4</td>
</tr>
<tr>
<td>3 at 90°</td>
<td>Cube</td>
<td>6</td>
</tr>
<tr>
<td>3 not at 90°</td>
<td>Rhombohedra</td>
<td>6</td>
</tr>
<tr>
<td>Fracture</td>
<td>Irregular shape</td>
<td>0</td>
</tr>
</tbody>
</table>
Procedure 1 Identifying Minerals

1. There are 13 containers of minerals (nine have numbers and four have letters). Each container has the same mineral even though they may look quite different. Be careful to keep track of the minerals so that you can return them to the correct container when the lab is finished. The nine numbered minerals are those on the Moh’s scale of hardness (i.e., all except diamond). Please put them on Table 8.2, the Mineral Organization chart, and put the sample number of the mineral below.

2. Now test each one for magnetism by touching the magnet to each and observe if the magnet sticks. Put the results in Table 8.4, the Mineral Properties chart. Then put a drop of HCl solution on each sample observing whether the sample reacts with the sample, or fizzes. Put your results in Table 8.4.

3. Now take each sample and try to scratch the mineral samples the different objects (fingernail, copper penny, and knife), or in the case of the glass, observe whether or not the mineral scratches the glass. Arrange the samples in Table 8.3 according to what it scratches or is scratched. Then record the hardness in Table 8.4.

4. Finally scratch each mineral on the white plate to see if there is a streak for each mineral and record the mineral streak, color, luster, and from Figure 1 in the introduction.

5. Now type http://geo.browardcentralsscience.org/minid.html into your computer’s web browser (or use the mineral book provided) and follow the instructor’s instructions on identifying your sample from Table 8.4. Once identified, please record your sample’s identities in Table 8.5.

Procedure 2 Investigating the Hardness Scales

1. Now graph the data in Table 8.1 with the Moh’s Scale (x-axis) versus Knoop’s Scale (y-axis) on a piece of graph paper.

Table 8.1 Knoop versus Moh’s

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Knoop (MPA)</th>
<th>Moh’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gypsum</td>
<td>42.01279</td>
<td>2</td>
</tr>
<tr>
<td>Calcite</td>
<td>97.11153</td>
<td>3</td>
</tr>
<tr>
<td>Fluorite</td>
<td>124.6609</td>
<td>4</td>
</tr>
<tr>
<td>Apatite</td>
<td>332.6587</td>
<td>5</td>
</tr>
<tr>
<td>Quartz</td>
<td>542.7226</td>
<td>7</td>
</tr>
<tr>
<td>Topaz</td>
<td>819.5938</td>
<td>8</td>
</tr>
<tr>
<td>Corundum</td>
<td>1515.215</td>
<td>9</td>
</tr>
<tr>
<td>Diamond</td>
<td>5509.874</td>
<td>10</td>
</tr>
</tbody>
</table>
Table 8.2 Procedure 1.1 Mineral Organization Chart

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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</tbody>
</table>

Revised - 8/5/2014
Table 8.3 Procedure 1.3 Determining Mineral Hardness

<table>
<thead>
<tr>
<th></th>
<th>Fingernail (Hardness = 2.5)</th>
<th>Copper Penny (Hardness = 3.5)</th>
<th>Knife Blade (Hardness = 5.1)</th>
<th>Glass Plate (Hardness = 5.5)</th>
</tr>
</thead>
<tbody>
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</tr>
<tr>
<td></td>
<td>Magnetism</td>
<td>Yes/No</td>
<td>Luster</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Effervescence</td>
<td>Yes/No</td>
<td>Streak</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hardness</td>
<td>Color</td>
<td>Cleavage</td>
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<td>Yes/No</td>
<td>Streak</td>
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<td>Hardness</td>
<td>Color</td>
<td>Cleavage</td>
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<td>23</td>
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<td>Luster</td>
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<td>Effervescence</td>
<td>Yes/No</td>
<td>Streak</td>
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<td>Hardness</td>
<td>Color</td>
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<td>24</td>
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<td>Yes/No</td>
<td>Streak</td>
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<td>32</td>
<td>Magnetism</td>
<td>Yes/No</td>
<td>Luster</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Effervescence</td>
<td>Yes/No</td>
<td>Streak</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hardness</td>
<td>Color</td>
<td>Cleavage</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>Magnetism</td>
<td>Yes/No</td>
<td>Luster</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Effervescence</td>
<td>Yes/No</td>
<td>Streak</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hardness</td>
<td>Color</td>
<td>Cleavage</td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>Magnetism</td>
<td>Yes/No</td>
<td>Luster</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Effervescence</td>
<td>Yes/No</td>
<td>Streak</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hardness</td>
<td>Color</td>
<td>Cleavage</td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>Magnetism</td>
<td>Yes/No</td>
<td>Luster</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Effervescence</td>
<td>Yes/No</td>
<td>Streak</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hardness</td>
<td>Color</td>
<td>Cleavage</td>
<td></td>
</tr>
</tbody>
</table>
Table 8.5 Mineral Identification Chart

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Mineral</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td></td>
</tr>
<tr>
<td>37</td>
<td></td>
</tr>
<tr>
<td>43</td>
<td></td>
</tr>
</tbody>
</table>

**Question**

1. Which property did you find most useful in identifying calcite? Why?

2. If diamond is the hardest mineral, how can jewelers cut diamonds?

3. What is the relationship between pressure (Knoop) and the Moh’s scale (linear, other)? Why do you think that this occurs?

4. Looking back at your Topography Lab, where are the softest minerals most likely to occur? Where are the hardest minerals most likely to occur? Defend your answer in terms of pressure.
LABORATORY 9

ROCKS

Equipment

Igneous Rocks (labeled I1 - I6), sedimentary rocks (labeled S1 - S5), metamorphic rocks (labeled M1 - M5), rulers, hand lens, HCl acid.

Pre-lab Exercise

Go to http://geo.browardcentralscience.org/rocktypes.html and answer these questions:

1. Write a brief definition of each of the three major rock types.
2. Which rock type is most likely to contain fossils?
3. Which rock type is produced by extreme temperatures and pressures?

Purpose

The purpose of this lab is to learn to identify the three major rock types (igneous, sedimentary and metamorphic), as well as to gain an understanding of how these rock types form.

Introduction

Identifying Igneous Rocks

Igneous rocks are cooled from lava and are subdivided into two groups: plutonic and volcanic, as shown in Table 9.1. Plutonic rocks cool slowly beneath the Earth's surface, allowing coarse-grained crystals to form. Finer-grained volcanic rocks (e.g., lava flows) cool rapidly at the Earth's surface.

Table 9.1 Igneous Rock Identification

<table>
<thead>
<tr>
<th>Dominant Minerals</th>
<th>Light Color</th>
<th>Medium Color</th>
<th>Dark Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plutonic (Coarse-grained)</td>
<td>GRANITE</td>
<td>DIORITE</td>
<td>GABBRO</td>
</tr>
<tr>
<td>Volcanic (Fine-grained)</td>
<td>RHYOLITE</td>
<td>ANDESITE</td>
<td>BASALT</td>
</tr>
</tbody>
</table>

Identifying Sedimentary Rocks

Sedimentary rocks are subdivided into two groups: detrital and chemical. Detrital sedimentary rocks form from mechanical weathering. For example, granite can be weathered to produce sand, and then the sand gets compacted to a detrital sedimentary rock called sandstone. Detrital rocks are categorized according to their grain size, as shown in Table 9.2.
**Table 9.2 Detrital Sedimentary Rock Chart**

<table>
<thead>
<tr>
<th>Texture</th>
<th>Grain size</th>
<th>Composition</th>
<th>Rock name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine</td>
<td>&lt; 1/16 mm</td>
<td>Clay</td>
<td>Shale.</td>
</tr>
<tr>
<td>Medium</td>
<td>1/16 - 2mm</td>
<td>Mainly Quartz</td>
<td>Sandstone</td>
</tr>
<tr>
<td>Coarse</td>
<td>&gt;2mm</td>
<td>Mainly Quartz</td>
<td>Conglomerate (rounded grains) Breccia (angular grains)</td>
</tr>
</tbody>
</table>

Chemical sedimentary rocks form from material that precipitates out of water. For example, calcite (CaC03) precipitates out of water to form the chemical sedimentary rock limestone, which is the most common rock in Florida. Chemical rocks are categorized first according to their composition and secondly by texture, as shown in Table 9.3.

**Table 9.3 Chemical Sedimentary Rock Chart**

<table>
<thead>
<tr>
<th>Composition</th>
<th>Texture &amp; grain size</th>
<th>Rock name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcite (CaC03)</td>
<td>Crystals (fine to coarse)</td>
<td>Crystalline limestone</td>
</tr>
<tr>
<td>Calcite (CaC03)</td>
<td>Loosely cemented shells</td>
<td>Coquina limestone</td>
</tr>
<tr>
<td>Calcite (CaC03)</td>
<td>Strongly cemented shells</td>
<td>Fossiliferous limestone</td>
</tr>
<tr>
<td>Halite (NaCl)</td>
<td>Crystals</td>
<td>Rock salt</td>
</tr>
</tbody>
</table>

**Identifying Metamorphic Rocks**

Metamorphic rocks were once igneous or sedimentary rocks, but they have been changed by intense heat and/or pressure. Minerals may become regularly orientated (i.e., foliated) during metamorphism, or they may retain a random orientation (i.e., non-foliated). Metamorphic rocks are categorized first according to foliation and secondly by grain size, as shown in Table 9.4.

**Table 9.4 Metamorphic Rock Chart**

<table>
<thead>
<tr>
<th>Foliated?</th>
<th>Grain Size</th>
<th>Comments</th>
<th>Rock Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>Fine (not visible)</td>
<td>Hard, smooth, finely laminated.</td>
<td>Slate</td>
</tr>
<tr>
<td></td>
<td>Medium (visible)</td>
<td>Various mineralogy (e.g., biotite schist)</td>
<td>Schist</td>
</tr>
<tr>
<td></td>
<td>Coarse</td>
<td>Pronounced color banding</td>
<td>Gneiss</td>
</tr>
<tr>
<td>No</td>
<td>Variable</td>
<td>Interlocking calcite grains</td>
<td>Marble</td>
</tr>
<tr>
<td></td>
<td>Variable</td>
<td>Interlocking quartz grains</td>
<td>Quartzite</td>
</tr>
</tbody>
</table>

**Procedure**

Identify each type of rock using the tables above. Look at each rock with the magnifying glass to look at each rock to look at the crystals. For the sedimentary rocks, also apply HCl to determine if the rock is chemical (fizzes) or detrital (does not fizz). Also apply the hardness and streak test to determine mineral composition.
Data Sheet Laboratory 9

Name: ____________________________ Partner(s): ____________________________

Table 9.5 Identifying Igneous Rocks (I1 – I6)

- Three of the igneous rocks are plutonic; the other three are volcanic.
  - Write the numbers of the rocks that appear to be plutonic: __________
  - Write the numbers of the rocks that appear to be volcanic: __________

- Of the three plutonic rocks listed above, write the number of the rock that is the:
  - Darkest in color: _________
  - Lightest in color: _________

- Of the three volcanic rocks, write the number of the rock that is the:
  - Darkest in color: _________
  - Lightest in color: _________

- Based on your answers to the questions above, identify each igneous rock by choosing the appropriate name from Table 9.1
  - I1: _______________________
  - I2: _______________________
  - I3: _______________________
  - I4: _______________________
  - I5: _______________________
  - I6: _______________________

Table 9.6 Identifying Sedimentary Rocks (S1 – S5)

<table>
<thead>
<tr>
<th>Composition (CaCO3, SiO2, NaCl)</th>
<th>Detrital or Chemical?</th>
<th>Other information (texture, grain size, etc.)</th>
<th>Rock name</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 9.7 Identifying Metamorphic Rocks (M1 – M5)

<table>
<thead>
<tr>
<th>Mineral Composition</th>
<th>Foliated?</th>
<th>Other information (texture, grain size, etc.)</th>
<th>Rock name</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Questions

Revised - 8/5/2014
1. Looking the properties of each rock, where is each likely to occur? Defend your answer in terms of these properties

<table>
<thead>
<tr>
<th>Rock</th>
<th>Locale of Formation</th>
<th>Why?</th>
</tr>
</thead>
<tbody>
<tr>
<td>I1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
LABORATORY 10

A VISIT TO THE PLANETARIUM

Equipment

Ruler, Flashlight (with Red Filter), calculator, star chart

Pre-Lab Exercise

1) Clip a horoscope column from a local computer and bring it to class.
2) According to the dates given in the column, what horoscope sign would you be if you were born today.

Purpose

The purpose of the lab is to understand the motion of the stars, Sun, and planets using the planetarium.

Introduction

From the earliest times, we have studied the stars. In our minds we have created models of how the universe worked. We created patterns out the motion and locations of the stars, Sun, and planets. The apparent patterns we have created in location of the stars are called constellations. Throughout time, we have mapped the constellations in star charts. From these star charts, we can plot the motion of the stars, Sun, and planets. The stars have three motions; diurnal (daily) motion, annual motion, and precession. The daily motion is due the Earth rotating on its axis. The annual motion is due to the Earth orbiting the Sun. And precession is caused by the Earth wobbling on its axis. As the Earth is tilted on its axis, the Sun’s motion in the sky is more complex than stellar motion as it rises and sets in different positions in the sky each day. The most complex motions are the planetary motions as they co-revolve around the Sun along with the Earth.

In this lab, we will use a special tool in astronomy, the planetarium. A planetarium is a projection system that projects the stars, Moon, Sun, and planets on a screen to recreate the sky in both space and time.
Procedure 1 Motion of the Stars

1. The instructor will now advance the planetarium sky to a time several hours later. Observe the path of the sky as they appear to move across the sky. Answer the questions in Table 10.1.

2. Now the instructor will set the planetarium sky to various dates. For each date, not the constellation in which the Sun is located. Then, check your horoscope chart to note the dates for the particular constellation. Record this information in Table 10.2.

Procedure 2 Motion of the Sun

1. Looking on the star chart provided, locate the curvy line on the chart. This is the path of the Sun in the sky, the ecliptic. Looking at the dates that are on the line, locate and circle June 21 and December 21 on the line. Each tick mark on the line is one day. Answer the questions in Table 10.3.

2. Now the instructor will move configure the Sun for each of these dates. Please note the length of the day and where the sun rose/set on each day in Table 10.3.

Procedure 3 Motion of the Planets and Retrograde Motion

1. The instructor will configure the planets for their positions tonight. Please draw the position of each planet onto your star chart. After you draw each planet’s position, the instructor will advance the planetarium sky to a time several hours later. Observe the path of the planets as they appear to move across the sky. Answer the questions in Table 10.4.

2. After answering the questions, the instructor will “fast forward” the planets over a period of time. Observe the retrograde motion of the planets. Now complete the retrograde motion of Mars in Table 10.4 by connecting the lines from 1 to 1, 2 to 2, etc.
Data Sheet Laboratory 10

Name: ____________________  Partner(s): ____________________

Table 10.1 Procedure 1 Motion of the Stars

1) Describe the path of the stars as they move across the sky.

2) Does Polaris move throughout the night? Is Polaris the brightest star in the night sky?

Table 10.2 Procedure 1 Motion of the Stars

<table>
<thead>
<tr>
<th>Date (Month, Year)</th>
<th>Constellation where the Sun is located</th>
<th>Constellation according to the Horoscope column</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 10.1 Procedure 2 Motion of the Sun

1. June 21 is the peak/valley (circle one) of the ecliptic. December 21 is the peak/valley (circle one) of the ecliptic. Make a prediction of which one is the longest day. _______________________________________

2. The straight, horizontal line through the center of the chart is the equator. Which date is
   a. North of the equator? ________
   b. South of the equator? ________
   c. Make a prediction where the Sun will rise/set on each day. _______________________________________

3. What was the length of day for June 21? _____________________

4. What was the length of day for December 21? _________________

5. Were your predictions correct for the lengths, and the position of the Sun on each day? Why or why not?
Table 10.4 Procedure 3 The Motion of the Planets

1) Describe the path of the planets as they move across the sky during the night.

2) Compare this path to sun’s path across the sky during the day.
Questions

1. Describe the Sun’s general motion in the sky throughout the year.

2. Of the various dates considered in Procedure 3, what percentage has horoscope signs that correctly match the constellations that the Sun is located? Show your work. Explain why this percentage occurs.

3. What are your conclusions on the orbit of Mars? How do they reflect reality?

4. Write an explanation on why Polaris does not seem to move in the night sky?
LABORATORY 11
PARALLAX METHOD FOR MEASURING DISTANCE

Equipment

Graph paper, protractor, ruler, pushpins, meter stick, 50 foot tape measure, 0°-90° left and right baseline cards (plates I & II), cardboard or poster board materials.

Pre-Lab Exercise

1) How many degrees are in 1/3 of a circle?
2) Review measuring angles from the first laboratory and tell how many degrees are in a triangle.
3) What is the relationship between distance \( d \) and parallax \( p \) in Equation 11.1?

Purpose: To measure distances using the line of sight angle, or parallax.

Introduction

To measure the distance to objects that cannot be reached with a tape measure, one can use the parallax method. This method was used by Egyptians to survey land across the Nile and by astronomers to measure the distance to the moon, planets, and stars. To understand how this method works, it is necessary to first discuss two geometrical figures, the circle and triangle. Using a compass, a circle can easily be drawn on a piece of paper. The distance from the center of the circle to a point on the circle is called the radius \( R \). The diameter \( D \) is the distance between two opposite points on the circle that pass through the center. The distance around the circle is called the circumference \( C \) and is related to the radius by the equation \( C = 2\pi R \) and to the diameter by \( C = \pi D \) where \( \pi \) is 3.14.

An angle is the separation between two lines meeting at a point called the vertex point. The lines are called the sides of the angle. The separation of the lines is measured in degrees of arc, minutes and seconds and written as 15° 30’ 15” to distinguish angular measurement from temperature and time measurement.

For measuring angles a circle is divided into 360 equal parts called degrees of arc. Just as a ruler measures the length of a line, a protractor measures the size of an angle. A protractor is usually semicircular in shape. In this exercise measurement to the nearest degree will be sufficient. There is 60’ (arc minutes) in one degree and 60” (arc seconds). We can measure this distance with a protractor.
Examine the diagram below. You should be able to see two triangles. This type of relationship is referred to as similar triangles. By now you know enough about angles, triangles and similar triangles to measure the distance to some object without ever going to the object, such as the distance from the bottom to the top of a tree or the distance across a river or lake. The easiest way to do this is via a graphical method using graph paper. This method is similar to adding vectors only it is simpler.

Now for large distances we will be able to relate the angle to the distance. We define these distances in parsecs. And the equation for this is:

\[
\text{distance} = \frac{1}{\text{parallax}} \quad \text{Equation 11.1}
\]
**Procedure 1**

1. Assemble your measuring apparatus as shown below. First, place a large piece of cardboard or poster board material on a lab table. Then measure a baseline of at least two feet on the board. The larger the baseline the more accurate will be your measurements. Next using pushpins place the left and right 0-90° protractors (plates I & II) on the baseline as shown so the distance between the protractor vertices is the baseline length. Note that the bottoms of the plates are on the baseline.

![Diagram](image1)

2. Place a pushpin at vertex of each of the protractors as shown. Next place a second pushpin at 90° for the right protractor (plate I). These two pins on the right side will define one of the lines of sight.

3. Now pick out some object in the lab for which you will determine the distance. Rotate your poster board such that when you sight using one eye from pin 1 it lines up with pin 2 on the plate I and with the distant object. You will probably have to put your eye close to the poster board to see the alignment. Without moving the board measure the distance from the plate I vertex to the object using a tape measure or meter stick. Record this distance as the Actual Distance on data sheet.

![Diagram](image2)

4. **Each student must do this part.** Using plate II, **position your eye** to line up the pin at the **vertex** with the **object**. Without moving your eye, reach over the vertex pin and place a 2nd pushpin on the plate such the **two pins and the object form a straight line up**. Read and record the angle to the object as measured by plate II. This angle will be used to determine the **observed distance** using a graph.

![Diagram](image3)
4. Make a scale drawing like the one shown at the right. Draw the baseline to scale using convenient units such as 6 or 12 squares equals a foot. (The scale is up to you.) Then, draw a line from vertex of plate I such that it is $90^\circ$ to the baseline and in the direction of the object. Now from the end of the baseline on the graph draw the other angle that you measured to the object using plate II. Point where this line intersects the perpendicular line from plate I will give you the observed distance in terms of the scale that used for the graph. Record this distance in the table and determine you experimental error.

7. Repeat the procedure for another object in the room that is at a different distance.

**Procedure 2**

1. Now look at the parallax angles for two different stars that are listed in the Table below. Using Equation 11.1, please find the distance in parsecs for each. Enter the table below.
Data Sheet Laboratory 11

Name: ___________________________  Partner(s): ______________________

Procedure 1 - Short Distance for 1st object ______________________________

<table>
<thead>
<tr>
<th>Student Name</th>
<th>Length of Baseline</th>
<th>Observed Angle</th>
<th>Observed Distance</th>
<th>Actual Distance</th>
<th>Experimental Error</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Procedure 1 - Short Distance for 2nd object ______________________________

<table>
<thead>
<tr>
<th>Student Name</th>
<th>Length of Baseline</th>
<th>Observed Angle</th>
<th>Observed Distance</th>
<th>Actual Distance</th>
<th>Experimental Error</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Procedure 2 Distances for Stellar Parallax

<table>
<thead>
<tr>
<th>Star Name</th>
<th>Parallax (p)</th>
<th>Distance (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>61 Cygni</td>
<td>0.3”</td>
<td></td>
</tr>
<tr>
<td>J0030+0451</td>
<td>0.003”</td>
<td></td>
</tr>
</tbody>
</table>

Questions

1. What is the relationship between the distance and parallax angle? Does your data support this?

2. How would you improve your measuring apparatus?

3. Discuss possible sources of error with this experiment.
LABORATORY 12
THE LENS EQUATION

Equipment
Optical Bench, Three Bench Sliders, Object Plate, Lenses (100 mm, 150 mm, 200 mm), Screen, Screen Holder, Lens Holder, Light Source

Pre-Lab Exercise

1. Put an object in a glass of water. How does the object appear when it is inside the water?
2. Put an object in the bottom of a soda can (not bottle) filled with water. How much water does it take to see the object indirectly, not looking into the can?
3. What is the focal length of a lens which’s object distance is 210 mm and image distance 386 mm?

Purpose
To study the central idea of the science of optics, the lens equation.

Introduction
In astronomy, we observe objects with light since the distances are so large. With the light we must combine the other senses of taste, touch, smell, hearing, and seeing. In order to do this, we must manipulate the light. We do this by allowing the light to enter a more dense (i.e. a liquid or solid) object or being bounced off the same object. The two process are called refraction and reflection, respectively. We use lenses made of glass to refract light and mirrors to reflect light. They both focus light onto one point and obey a single equation called the lens equation. In this lab, we will focus on the convex lens, the optical system that most telescopes use this type of lens or its complimentary system the concave mirror system. The convex lens works like this:

where the object is focus into an image on the other side of the lens. The formula to determine the focal length of the lens is:

\[
\frac{1}{\text{Focal Length}} = \frac{1}{\text{Object Distance}} + \frac{1}{\text{Image Distance}}
\]

Equation 12.1
Procedure

1. Obtain the optical equipment; the three sliders, the two holders (lens and image screen holders), the three lenses, the object plate, and the image screen from the instructors desk. Put the three sliders on the optical bench. Then lock down one of the sliders at 0 mm and put the object plate in the slider about an inch up from the slider. Plug in the lamp and make sure the light from the lamp goes through the arrows on the plate. The size of the arrows is 22 mm in length. PLEASE DO NOT TOUCH THE LAMP DIRECTLY AS IT GETS HOT AFTER IT IS PLUGGED IN AND OPERATING. ONLY MOVE THE LAMP USING THE LONG POST AND SCREWS AFTER PLUGGING IN THE LAMP.

2. Once you have inspected the light and see it is entering the arrows, next put the red (100 mm) lens in the lens holder. Only touch the lens from its sides as not put fingerprints on the lens which will add error to your final results. Now put the lens into the next slider and align the lens with the arrows in the object plate. Finally put the image screen into its holder and put the holder into the last slider on the bench.

3. Now move the lens to 150 mm. You will see a blurry image of the arrows formed on the image screen. Move in or out the image screen until you see a clear, sharp image on the screen of the object arrows. There will be a little play, but you will see there is clear image to obtain. Record the image position in Table 12.1. Repeat this procedure with the red lens at 200 mm, 250 mm, 300 mm, and 350 mm.

4. Remove the red lens and put in the blue lens into the lens holder and put the lens at 200 mm and find the focused, sharp image. Record your image positions into Table 12.2 for 200 mm, 250 mm, 300 mm, 350 mm, and 400 mm.

5. Repeat this procedure for the green lens at 250 mm, 300 mm, 350 mm, 400 mm, and 450 mm and record your image positions into Table 12.3.

6. In Table 12.1, Table 12.2, and Table 12.3, calculate the object and image distances. To calculate the object distance subtract the object position from the lens position. To calculate the image distance subtract the lens position from the image position. Do this for all lens tables. Now divide each distance into one to find the inverse (1/object distance and 1/image distance) columns. Finally add 1/object distance to 1/image distance to find 1/focal length using Equation 12.1.

7. In Table 12.4, find the average of 1/focal length of each lens and then divide this number into one to find the experimental value of the focal length.

8. In Table 12.5, compare each experimental focal length to the true focal length for each lens using the error equation in Laboratory 1.
Data Sheet Laboratory 12_____________

Name: __________________________ Partner(s): __________________________

Table 12.1 Procedure 3 Red Lens, True Focal Length = 100 mm

<table>
<thead>
<tr>
<th>Object Position</th>
<th>Lens Position</th>
<th>Image Position</th>
<th>Object Distance</th>
<th>Image Distance</th>
<th>1/Object Distance</th>
<th>1/Image Distance</th>
<th>1/ Focal Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 mm</td>
<td>150 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 mm</td>
<td>200 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 mm</td>
<td>250 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 mm</td>
<td>300 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 mm</td>
<td>350 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 12.2 Procedure 4 Blue Lens, True Focal Length = 150 mm

<table>
<thead>
<tr>
<th>Object Position</th>
<th>Lens Position</th>
<th>Image Position</th>
<th>Object Distance</th>
<th>Image Distance</th>
<th>1/Object Distance</th>
<th>1/Image Distance</th>
<th>1/ Focal Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 mm</td>
<td>200 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 mm</td>
<td>250 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 mm</td>
<td>300 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 mm</td>
<td>350 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 mm</td>
<td>400 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 12.3 Procedure 5 Green Lens, True Focal Length = 200 mm

<table>
<thead>
<tr>
<th>Object Position</th>
<th>Lens Position</th>
<th>Image Position</th>
<th>Object Distance</th>
<th>Image Distance</th>
<th>1/Object Distance</th>
<th>1/Image Distance</th>
<th>1/ Focal Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 mm</td>
<td>250 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 mm</td>
<td>300 mm</td>
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<td></td>
</tr>
<tr>
<td>0 mm</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 mm</td>
<td>400 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 mm</td>
<td>450 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 12.4 Procedure 6 Experimental Focal Lengths

Red Lens:

Blue Lens:

Green Lens:
Table 12.5 Procedure 7 Error Calculations

<table>
<thead>
<tr>
<th>Red Lens:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Blue Lens:</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Green Lens:</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Questions

1. Were your experimental focal lengths close to the true focal lengths? What sources may or may not have caused the discrepancies between the experimental and true focal lengths?

2. Magnification is ratio between the lens focal lengths. Which two lenses would have the greatest magnification? Which would have the least? Can you think of situations which you would need either.

3. Mirrors tend to be lighter than the equivalent lenses. If you were developing a telescope that would need to collect light from a dim source, would you use a lens, multiple lenses, a mirror, or multiple mirrors to build the telescope? Defend your answer.