Name_____________________________________

Lesson 1: Introductory Science Topics:

Period________

First, we will examine what Discovery Lessons will be like by performing a sample experiment.

In this section, we investigate some aspects of image formation in a convex lens. We develop techniques that can be used to determine the location of an image.

1.1 Experiment: Parallax 1

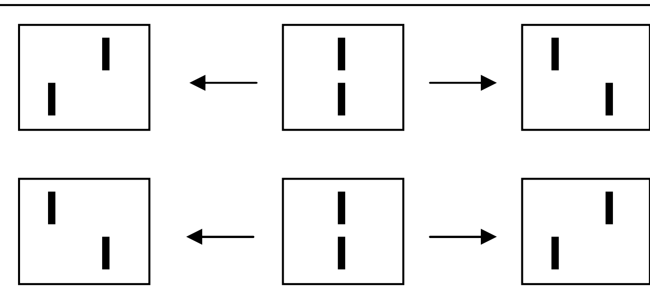
For the first 3 experiments in this lesson, work in groups of 2.

(a) Close one eye and place your open eye at table level. Have your partner place a small piece of paper (1cm by 1cm) onto the table, somewhere within arm's reach.
Hold your finger above the table and then move your finger until you think it is directly above the piece of paper. Move your finger straight down and see if it was actually directly above the paper.
Try this several times without changing your viewpoint, placing the paper in different places each time. Keep your open eye at table level. After several tries, switch with your partner.
Were you and your partner consistently able to locate the piece of paper?

Come up with a way to figure out whether your finger is in front of the paper or behind it when your finger misses the piece of paper. Describe your method:

1.2 Experiment: Parallax 2

(a) Have your partner hold 2 pencils at your eye level, one above the other, about one meter in front of you.
Then have your partner move one pencil about 15cm closer to you.
Close one eye and position your head so that one pencil appears to be directly above the other. Don't let one pencil block the view of the other one. Now move your head from side to side.



It should look like one of these.

How do the pencils move relative to each other and relative to you (in your view)? Describe your observations.

(b) Again, with one eye closed and your head positioned so that the pencils appear one directly above the other,
(1) move your head to the right.
Which pencil appears to be on the right: the one closer to you or the farther one?

(2) move your head to the left.
Which pencil appears to be on the right this time: the one closer to you or the farther one?

Circle the correct italic word: **When I did this, the *TOP / BOTTOM* pencil was closer to me.**

(c) Have your partner move the pencils closer together.
How does this change affect what you observe when you move your head from side to side?

(d) Have your partner place the 2 pencils one above the other.
How does this change affect what you observe when you move your head from side to side?

The apparent change in the relative locations of the 2 pencils you observed when you moved your head from side to side is said to be due to *parallax*.

1.3 Experiment: Parallax 3

(a) Describe how you could use parallax to determine which of two objects is closer to you.

How must the two objects be located relative to one another if you observe no effect of parallax when you move your head from side to side?

(b) Test your method: Repeat either Parallax 1 or Parallax 2 again, but use the method that you just devised to either figure out when your finger is lined up with the paper or when the 2 pencils have been moved directly one over the other.

A lens is an optical device that bends light. Lenses can be divided into two categories according to shape: convex and concave. Convex lenses have at least one surface that curves outward and are thicker in the middle than at the edges.

1.4 Experiment: Image Formation In A Convex Lens

(a) Have your partner hold an object (a coin, a small picture, a bottle cap, etc) a few meters in front of you so it is upright when you are looking at it without the lens. Place the lens directly in front of the object, then move the lens slowly toward your eye. Keep the object fixed in place as you move the lens.
Where, approximately, should you hold the lens so that the object appears to be:
(1) upside down?

(2) right side up?

(3) larger than it is in real life?

(4) smaller than it is in real life?

(5) the same size as it is in real life?

When we look at an object through a lens, we say that we are looking at an *image* of the object. In this experiment, you found that the image can appear to be large or small. It can also appear to be upright or inverted. But *where* do your eyes focus? Where are the images located relative to you and the lens?

(b) Find an arrangement where the object appears larger than it does in real life.
PREDICT: Which is closer to you, the object or the image of the object in this arrangement? [Is the image (the point where your eyes focus to see it) closer to you or farther from you than the actual object is.]

Explain your reasoning:

(c) How could you use the method of parallax to find out if you were right?
Design a procedure that you can use to test your hypothesis and write it below:

How will you measure the distance to the actual object?

How will you measure the distance to the image of the object you see in the lens?

(d) Perform your experiment and record your measurements here:

We found the distance to the object to be _________________________

We found the distance to the image to be__________________________

(e) When you see the larger image, is it closer or farther than the actual object?

(f) Why do you think the results came out the way they did? Suggest possible reasons for your results and write them here: (Explain it so that the results make sense, in other words)

(g) The equation that relates object and image locations for the lens is called The Thin Lens Equation:

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

where f = focal length of the lens (each lens has its own), d_o = distance from object to lens, and d_i = distance from image to lens.

Use this equation to calculate the theoretical image location from the lens. Use the focal length of the lens given in class (most are 18cm):

f = ____________________cm; d_o = ___________________cm; d_i = ?

(h) How close was your measurement of the image to the *lens*?

(Depending on your method, you may have to subtract the total distance between you and the image from the distance from you to the lens to find out)

(i) How close did your measured value come to your calculated theoretical value? Compare with words and by subtracting your two values.

measured value – theoretical value = ________________________________

(j) Find the percent difference by calculating this:

$$\frac{|\textit{measured} - \textit{theoretical}|}{\textit{theoretical}} \times 100\% = \text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_}$$

Now we proceed with science introductory topics in an unusually lecture-notes style.

Units, Scientific Notation, Orders of Magnitude, Accuracy & Precision, Conversions, Dimensional Analysis

1.5 Units

Customer: "How much does this cost?"
Cashier: "5. It costs 5."

Measurements don't make sense without ____________________.

English Units versus Metric Units:
___________ units are easier to deal with mathematically because they are divided into tenths.

Standard Units:

a. The standard unit of ____________________ is the kilogram (kg)

   1kilogram (kg) weighs about ______________ pounds (lb)

b. The standard unit of ____________________ is the meter (m).

   1meter (m) is about ______________________ feet (ft)

c. The standard unit of ____________________ is the second (s).

   1 second (s) is about the amount of time to take _______________ steps while jogging.

d. The standard unit of force is___________________________________

   The standard unit of energy is__________________________________

1.6 Conversions and Prefixes (Scientific Notation) – pg. 6 in textbook

10	atto-		10	deka-	
10	femto-		10	kilo-	
10	pico-		10	mega-	
10	nano-		10	giga-	
10	micro-		10	tera-	
10	milli-		10	peta	
10	centi-		10	exa	
10	deci-				

1.7 Order of Magnitude (Powers of Ten)

For very large or very small values, it helps to know how what power of ten would be multiplied in scientific notation. You can make some pretty close estimates this way. This kind of guess is called an "order of magnitude" guess. Try guessing these to the nearest power of ten:

a. There are ___________ seconds in a year.

b. There are ______________ meters in a football field.

c. A housefly is about ______________ meters from front to back.

d. The Earth is about _______________ seconds old.

e. There are about ___________________ meters from the surface of the Earth to its center (the mean radius of the planet).

f. A hydrogen atom is about _____________ meters across (the atom's diameter).

1.8 <u>Conversion Factors (bottom of pg. 911 in textbook)</u>

Multiply by a "fancy" factor of 1

a. 1/1 = x/x =

42/42 = ☺/☺ =

b. 3 ft/3 ft = 3ft/1yd=

1 ft/12 in = 60 min/1 hr =

c. 42*1 = 42*(x/x) =

42*(3ft/3ft) = 42*(60min/1hr) =

d. 3ft*(1) = 3ft*(1ft/12in) =

3ft*(12in/1ft) =

There are many ways to write the same thing. Some ways simplify nicely, some don't. To convert units, we want to multiply in that fancy factor of 1 that will cancel the units we don't want anymore, but leave us with new units (preferably simple ones) while not changing the physical value of the measurement.

e. 4 pm = _____________Gm

f. Circle the correct italicized words in the statement below

A Gm is <u>larger/smaller</u> than a pm, so it makes sense that only 4 picometers (pm) is <u>only a fraction of/many times the size of</u> a Gigameter (Gm).

g. 25 mi/h = _______________ m/s (Given: 1m = 3.281 ft ; 1 mi = 5280 ft)

h. Circle the correct italicized words in the statement below

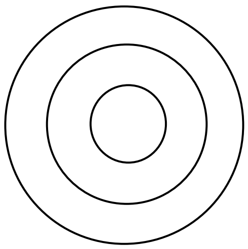
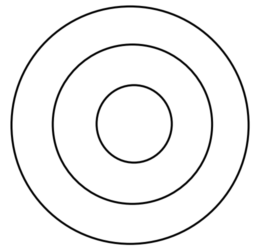
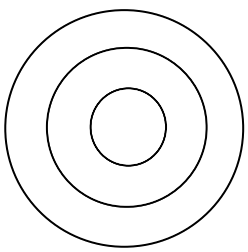
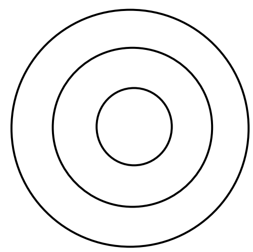
Since there were *<u>more/fewer</u>* m/s than the original 25 mi/h, a single mi/h must be <u>larger/smaller</u> than a single m/s.

Note: 1 mi/h = 0.447 m/s or 1 m/s = 2.237 mi/h

1.9 <u>Accuracy and Precision</u>

Laboratory data can hit or miss the theoretical value expected. Data can also be grouped (always about the same thing) or it can be spread out (values keep coming up different). More closely grouped values are more *precise* values and values that come closer to the experimental value are more *accurate*.

a. Draw in sample "data" as X marks that hit the targets below in a way that is consistent with their description:

<u>Accurate (not Precise)</u> 	**<u>Precise (not Accurate)</u>** 
<u>Precise and Accurate</u> 	**<u>Neither (not Accurate, not Precise)</u>** 

b. If you, as a scientist, have to choose between (A) *precise* data that's not accurate or (B) *accurate* data that's not precise, which would you prefer in a scientific experiment?

Explain your answer.

c. Circle the correct italicized word in the following statement:

Extra significant figures in a measurement mean that the measurement is more *<u>accurate/precise</u>*.

1.10 Dimensional Analysis & Unit Analysis (“Does my answer make sense?”)

There are 5 basic measurements you can make: Length (meters), Mass (kilograms), Time (seconds), Temperature (Kelvins), and Charge (Coulombs). We’re only dealing with Length, Mass, and Time for now. Every other measurement is a combination of these basic measurements. Following the dimensions or the units in your calculations can help you check whether the answer is wrong.

a. Give an example of speed units. (Hint: speed limit signs have an example of this type of units)

b. What are the dimensions of speed?

c. What dimensions do you get when you add lengths to other lengths? (2 inches + 5 inches, for example)
Your answer has units of ______________

d. What dimensions do you get when you add times to other times? (30 minutes + 15 minutes, for example)
Your answer has units of _______________

e. What dimensions do you get when you add lengths to times? (2 inches + 15 minutes, for example)
Your answer has units of _______________

f. What dimensions do you get when you *multiply* units to the same kind of units? (2 meters x 3 meters, for example)
You answer has units of ________________

g. What dimensions do you get when you *divide* units by the same kind of units? (4 kg / 2 kg, for example)
Your answer has units of _________________________

h. Does it make sense to add or subtract different units?

Explain

i. Does it make sense to multiply or divide different units?

Explain

j. Consider the circumference of a circle: C
What dimension does C have?

If C = 2πr, what dimension does 2 have?

What dimension does π have?

What dimension does r have?

k. What do constants and coefficients do to the dimensions in an equation?

l. Check these dimensions algebraically to determine whether it's dimensionally consistent on both sides of the equation (are the types of dimensions the same on both sides, in other words)

$$\mathbf{x = v_o t + \tfrac{1}{2} at^2}$$

x is a Length [L] (brackets show it's a dimension and not a unit)
v_o is a Length per Time [L/T]
a is a Length per Time-squared [L/T^2]
t is a Time [T]

m. Find the units of *v*

$$\mathbf{F_c = mv^2/r}$$

F_c is in (kg*m/s^2)
m is in (kg)
r is in (m)