Appendix A
SCIENTIFIC NOTATION

Before you become familiar with various units and conversion factors, an explanation of scientific notation is in order. This method of expressing numbers is not difficult at all. In fact, it often makes awkward numbers much easier to work with. In scientific notation, a number is expressed as a decimal multiplied by a power of ten.

For example, the number 4,000,000 would be easier to write when written as:

4.0×10^6.

As an example at the other extreme, 0.0000000001 would be expressed as 1×10^{-10}.

The computer cannot write superscripts. If the result of a calculation is expressed in scientific notation, the computer will print 1.23×10^4 as 1.23 E+4. Similarly, 4.56×10^{-5} will be expressed as 4.56 E-5.

To see if you understand, let's write the following in scientific notation:

1) 2,100,000,000 = ___________

2) 0.00012000 =_____________

3) 3,050 =__________________

In this lab, you won't usually need to express numbers in scientific notation. However, sometimes you will be dealing with extremely small numbers and your computer will express these numbers in scientific notation.

Appendix B
UNITS AND CONVERSION FACTORS

Units are very important. For instance, if you said someone's weight was 80, this information would be useless. It is necessary to designate 80 what. One choice would be newtons, another pounds, etc. In any type of measurement you must include units to make the measurement useful. Often, one type of unit is preferred over another due to the magnitudes of the quantities being measured. In this lab you will usually be using metric or international units. However, you will occasionally be asked to convert metric units to British units. Systems of Measurement are discussed in Hewitt, Appendix I. p. 686.

UNITS AND SYMBOLS

METRIC

QUANTITY	UNIT	SYMBOL
length	kilometer	km
	meter	m
	centimeter	cm
	millimeter	mm
mass	kilogram	kg
	gram	g
	milligram	mg
force	Newton	N
volume	liter	l
	milliliter	ml
	cubic meter	m3
time	second	s
temperature	Kelvin	K
	Celsius	°C
energy	joule	J
power	watt	W

BRITISH

QUANTITY	UNIT	SYMBOL
length	mile	mi
	yard	yd
	foot	ft
	inch	in
mass	slug	sl
force	pound	lb
time	second	s
temperature	Fahrenheit	°F

CONVERSION FACTORS

LENGTH

	cm	METER	km	in.	ft	mi
1 centimete	1	1 x 1($^{-2}$	1 x 1^{-5}	0.3937	3.281 x 1^{-2}	6.214 x1^{-6}
1 Meter=	100	1	1 x 1^{-3}	39.37	3.281	6214 x 1^{-4}
1 kilometer	1 x 1(^{5}	1 x 1(^{3}	1	3.937 x 1^{4}	3281	0.6214
1 inch =	2.540	2.54 x 1^{-2}	2.54 x 1^{-5}	1	8.333 x 1^{-2}	1.578 x $^{-5}$
1 foot =	30.48	0.3048	3.048 x $^{-4}$	12	1	1.894 x $^{-4}$
1 mile =	1.61 x 1^{5}	1610	1.61	6.336 x 1^{4}	5280	1

VOLUME

	METER ^{3}	cm ^{3}	liter^{3}	fee ^{3}	in ^{3}
1 CUBIC METER=	1	10	1 x 10	35.31	6.102 x 1
1 cubic centimet	10^{-4}	1	1 x 1($^{-3}$	3.531 x 1^{-5}	6.102 x 1^{-2}
1 liter=	1.0 x 1^{-3}	1 x 1^{3}	1	3.531 x 1^{-2}	61.02
1 cubic foot=	2.832 x $^{-2}$	2.832 x 1^{4}	28.32	1	1728
1 cubic inch=	1.639 x 1^{-5}	16.39	1.639 x $^{-2}$	5.787 x 1^{-4}	1

MASS

	gran	KILOGRAM	slug
1 gram=	1	1 x 1($^{-5}$	6.85 x 1
1 KILOGRAM=	1 x 1(^{3}	1	6.85 x 1^{-2}
1 slug=	1.459 x ^{4}	14.5(	1

FORCE

	dyne	NEWTON	pounc
1 dyne=	1	1 x 1^{-5}	2.248 x $^{-6}$
1 NEWTON=	1 x 1^{5}	1	0.2248
1 pound=	4.448 x ^{5}	4.448	1

Appendix C
GRAPHING DATA

Whenever you collect a set of data, usually in a table of some fashion, it is useful to then create a graph of that data. A graph gives you a visual representation of the data set. It smoothes out irregularities and provides continuity between the data entries. There are a number of different types of graphs that can be used in a given situation, but the most useful for experimentation such as you will be doing is the X-Y graph, (Figure 1).

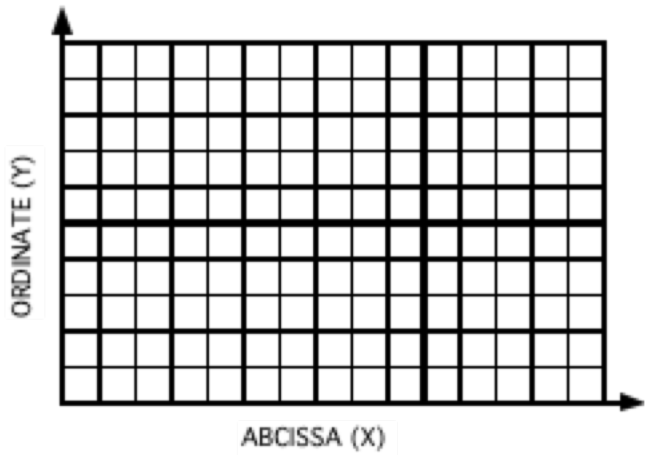


Figure 1

This graph gets its name from the X and Y coordinate axes upon which it is based. Here vertical lines represent the Y-axis and horizontal lines represent the X-axis.
Another name for these axes is ORDINATE (Y) and ABSCISSA (X).
When you do an experiment in lab you are usually trying to determine the relationship between several factors affecting the system under test. In other words, what happens when part of the system is changed. You use instruments to collect the data, but you need graphs to interpret it. Take, for instance, a system undergoing acceleration. You already know, or will soon find out, that the acceleration of an object is equal to the force applied to the object divided by the mass of the object. In formula form this looks like: $a = F/m$. Now suppose you want to test the validity of this formula and to also determine the relationship between acceleration and force. You do this by setting up an experiment where you can change the force applied to the mass, and then measure the acceleration of the mass. You collect the results in a data table such as Table 1.

TABLE 1

Mass 2 kilograms

Trial #	Force applied	acceleration
1	10 Newtons	5 meters/sec.2
2	20N	10 m/s2
3	30N	15 m/s2
4	40N	20 m/s2
5	50N	25 m/s2

The values in the column labeled “Force Applied” represent the different forces used in the experiment. The column labeled “acceleration” shows the result of applying the respective force to the 2-kg mass.
Now, suppose you are interested in what happens at some value of force between those selected for the experiment. A graph can give that information. Here’s how.
First you take a piece of graph paper (you will be provided with graph paper) and label the axes, (go ahead and do this as you read about it.) We’ll label the Y-axis (vertical) the acceleration axis, and the X-axis (horizontal) the force axis. Look at Figure 2 for a comparison. Note that the labels also include the units associated with acceleration and force.

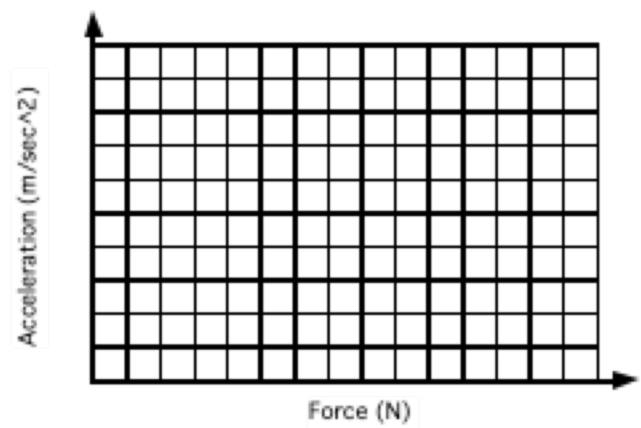


Figure 2

Next you will scale the Y-axis to cover the range of acceleration values from the data chart, and then do the same for the X-axis. Since the acceleration values on the data table range from 5 m/s^2 to 25 m/s^2 it will be convenient to mark our axis from 0 to 50 in increments of 5. The values of force range from 10 N to 50 N so you can mark the axis from 0 to 100 in increments of 10. Check figure 3 to see how this is done.

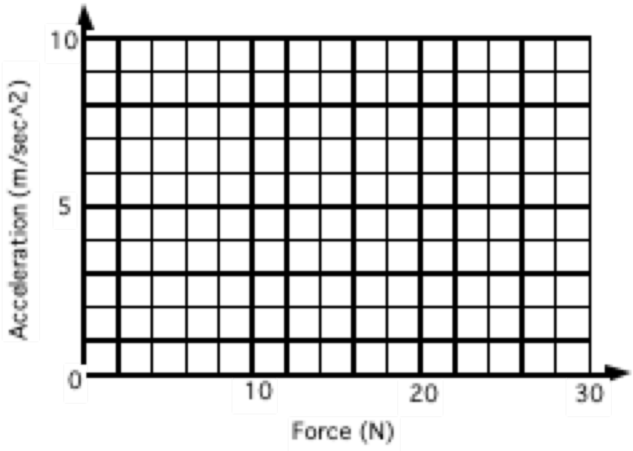


Figure 3

Note that the numbers are assigned to major divisions on the graph paper. Regardless of the actual values of our data you will always try to divide the graph into easily divisible increments (1,2,5,10 etc.) and then plot your actual values on the appropriate division, major or minor. Now it is time to actually plot your data. Look at trial #1 on the data table. The force value is 10N and the acceleration value is 5m/s2. Find the major division on the abscissa that you marked 10.

Move vertically along this line until you are at the horizontal line marked 5. Now, place a small dot at the intersection of these lines and draw a circle around it. The circle is called a point protector and will help you to find your points after you have drawn a curve through them. Repeat this procedure with each of the other datum sets. You should have dots at the intersection of 20 Newtons and 10 m/s2, and so forth. Figure 4 is an example.

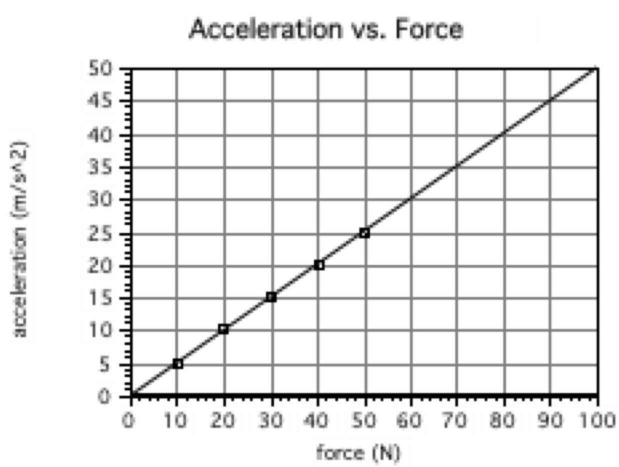


Figure 4

Now you can draw a curve to fit the dots. In this case the curve will be a single straight line, as it will be for most of the graphs that you will make in this lab. It is important to note that it is not necessary for all of the dots to fall exactly on the curve. It is only necessary that you see that the relationship between the variables in our formula is most probably linear. That is, that it looks like a straight-line curve will fit the graph. There are other types of relationships between variables, but these are non-linear(logarithmic, inverse powers, square, etc.), and will generally not be discussed in this lab.

After you have completed your practice graph show it to your lab assistant and discuss any difficulties at that time. If you need additional graphing paper ask for it. Now that your graph is complete, let's take a look at how it can be further utilized to assist in understanding the system under test. Suppose you want to know the acceleration of the system if the force applied is not an even increment of 10N. The curve that you drew on the graph is made up of an infinite number of points; any one of which has corresponding X and Y values. For instance, find the point on the curve that corresponds to a force value of 23N. Yes, that's right, you may have to guess a little bit. That's called interpolation. Now, what value of acceleration corresponds to 23N? Do you come up with a value of 11.5 m/s2? You should be fairly close. Try doing this (interpolation) with some other values. By the way it works the other way, too. If you know the acceleration of the system you can determine the force. This is the beauty of the graph. For practice plot the data set given in Table II on the same graph and axes as before.

TABLE 2

Mass 2 kilograms

Trial # Force applied acceleration

1	20 Newtons	5 meters/sec.2
2	40N	10 m/s2
3	60N	17 m/s2
4	75N	20 m/s2
5	90N	25 m/s2

Complete the graph by drawing a straight line which best fits the data. What differences did you observe from the first graph? What might be the cause of the data not fitting a straight line exactly?

In summary, then, let's recall that a graph of our test data provides us with two major aids. First, it helps us to determine the relationship between the variables of a system under test, and second, it enables us to examine this relationship at points other than those that we specifically test.

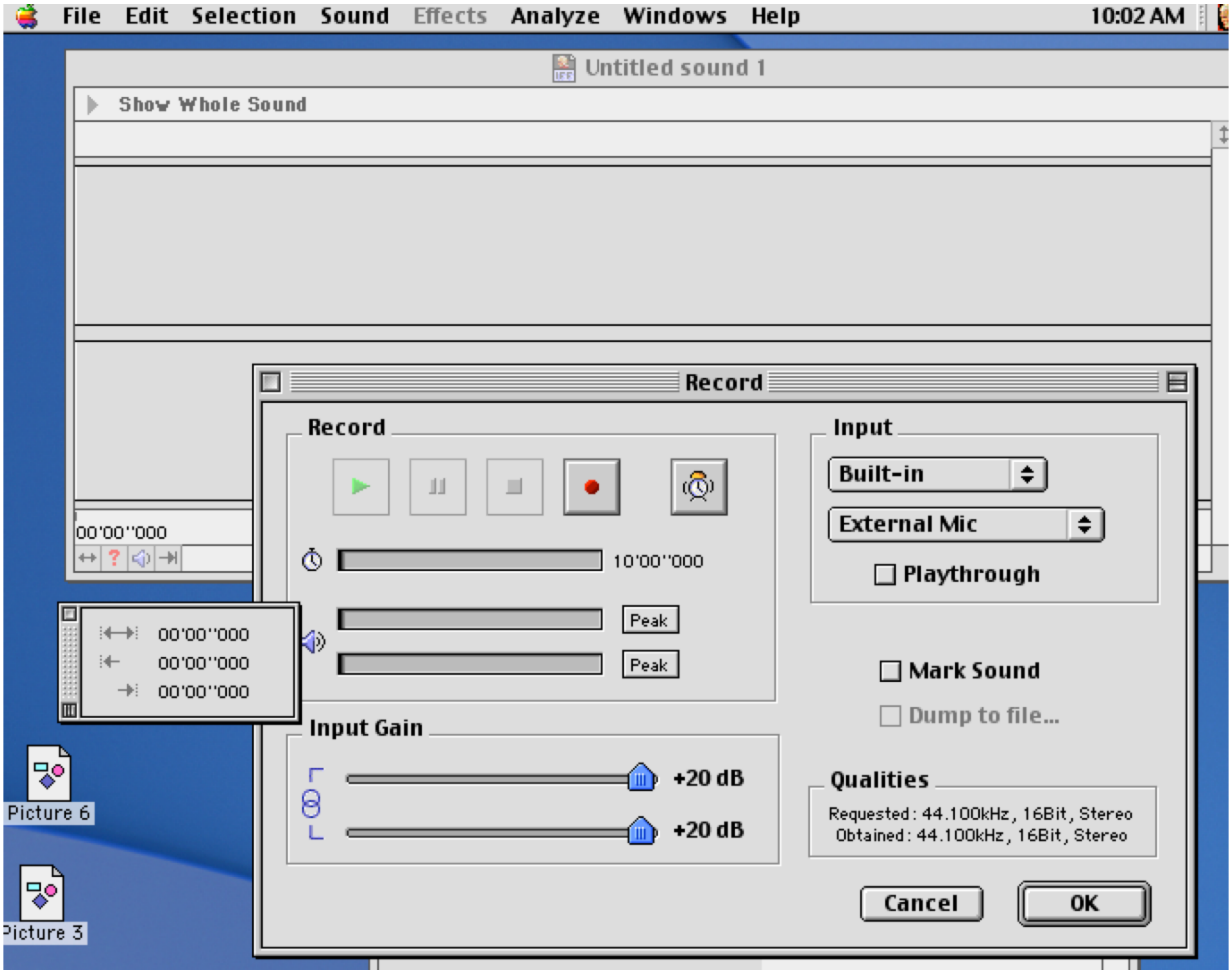
Appendix D
Using the IMac and Amadeus software

Using the iMac and Amadeus II

Amadeus is a sound recording application for use by an iMac. It was originally intended for sound studios and home hobbyists as a means of acquiring sound information for modification and later play back. If an audio signal is connected into the microphone input on the side of the iMac , this signal is sent to an analog to digital converter. That is, it converts analog audio signals (such as a wave vibrating up and down) into digital data that is understood by a computer (a series of ones and zeros). The computer is able to reconvert the digital data back into analog audio data through its associated software application and it is able to store time data associated with every portion of the input sound signal.

In the physics laboratory we can make good use of the recording and storage features of Amadeus to conduct a number of timing experiments. Since Amadeus cannot distinguish between an audio voltage signal from a microphone and other voltage signals, it records any voltage changes fed into the mike input. Therefore, we can input the voltage signal generated by a phototransistor when it goes from an unblocked or high state to a blocked or low state. The corresponding digital pattern shown by the Amadeus program will include the relative times of the change of states of the phototransistor. By correlating these times with the dimensions of the object passing through the gate, we can derive physical information about the motion of the object as it passed through the photogate.

1. Verify that the photogate is plugged into the photogate power supply and that the power supply is plugged into an electrical outlet. Also make certain that there is a cable from the power supply to the microphone input on the side of the computer.
2. Turn the photogate power supply on and rotate the knob fully clockwise to maximize the photogate signal.
3. Turn the computer on and start the program Amadeus II, which can be found in the Apple menu. If no screen appears select --"*New*" from the File Menu. Go to "*Sound*" on the menu bar and select "*Record*" which will open a record window.
5. Slide the input gain to maximum.
6. Press the record button in the record window (the red square button), move your hand through the photogate to block the light signal, and press stop.



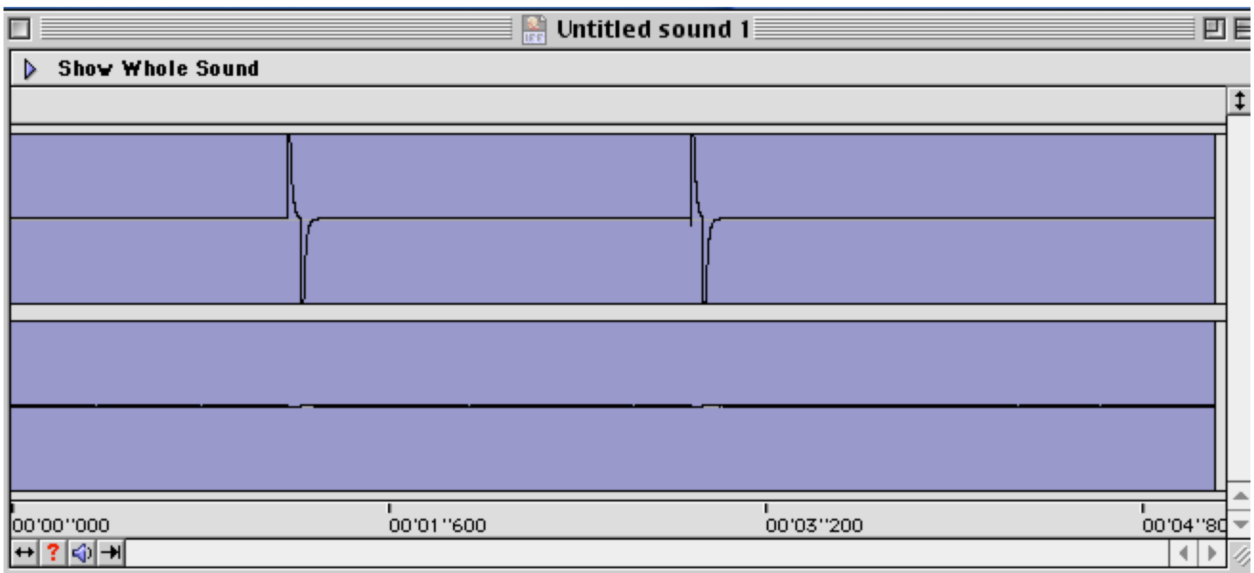
7. Press OK. If everything is connected and working properly, you should see a window with an AC signal of at least two spikes. The positive or upward spike occurs when the light is blocked. The downward spike occurs when the light is unblocked again.
8. Click the cursor on one set of spikes now hit "command g" consecutively until the spikes are spread out so that you can easily distinguish two vertical lines.

9. Click and drag from the first vertical line to the next. You should see a smaller window with three times displayed. The first time is the amount of time your hand took to pass through the photogate beam in milliseconds (1000ths of a second). The second is the time from the collect button section to the time that

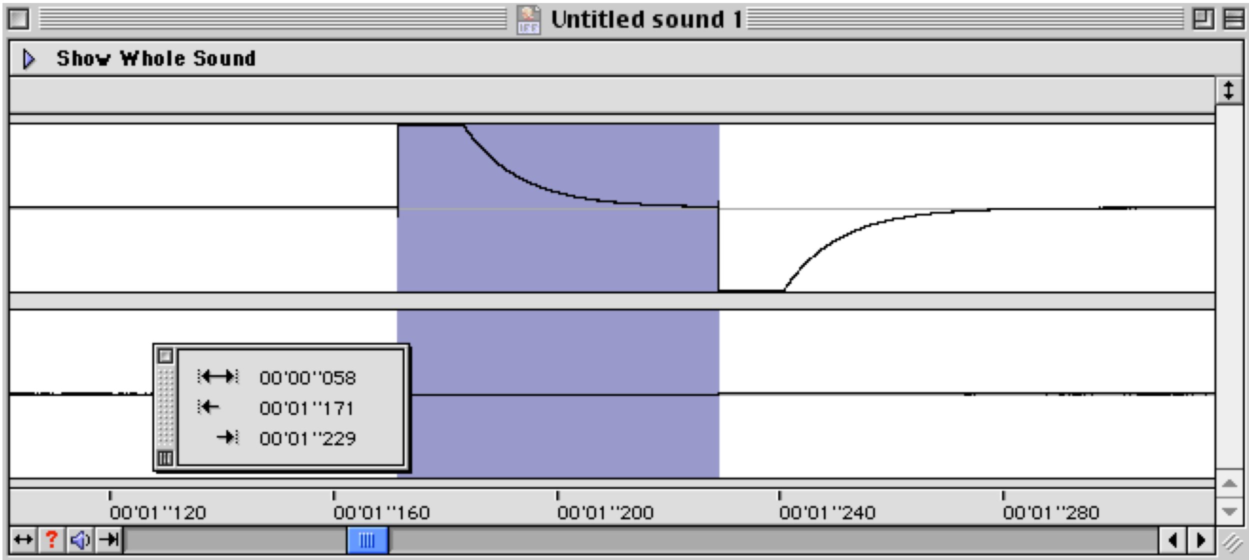
10. the light was blocked. The last time is the time when the light was unblocked. The first time is the time difference between these two time in milliseconds

Determining the Velocity

1. To record a new signal select "NEW" in the file menu.
2. Press record, check that the Input gain is at maximum and press the new record button.
3. Place the car on the track and drive the car around the track passing through the photogate once. Once the car has passed the photogate, click the stop button.
4. Click the ok button and examine your signal.



5. Spread the signal out using the "command g." command.
6. Place a cursor line exactly at the beginning of the leading edge of the first positive peak pulse. This represents the first time that the photogate was blocked during the timed event. Click and drag the cursor from one vertical to the other.
7. Record the time displayed in the cursor time window on a data sheet. It should be much less than one second.



8. Velocity is measured in meters per second, so to calculate the velocity, you must know the exact width of the aluminum bar on the top of the car which blocked the gate when the car passed through the photogate. Use the Vernier caliper to determine the length of the bar. Take note that this width measurement must be converted to meters. The velocity of the car is the measured width of the bar divided by the time determined using the Amadeus program and the computer photogate system. This system of velocity measurement will be used in several laboratory experiments this semester.

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