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Name : ______________________________

Data Presentation

Objectives:

1. Data Presentation: Capable of reading, understanding, and interpreting data presented in the form of tables and graphs. Ability to construct accurate tables and graphs with raw data.
2. General Rules of Graphing: Produce properly constructed graph
3. Understand the significance between dependent & independent variables
4. Know when it is appropriate to use a line vs. bar graph
5. Extrapolate information from a graph including rate, amplitude, duration, frequency, pattern
6. Construct a "standard curve". Use a standard curve to determine unknown values

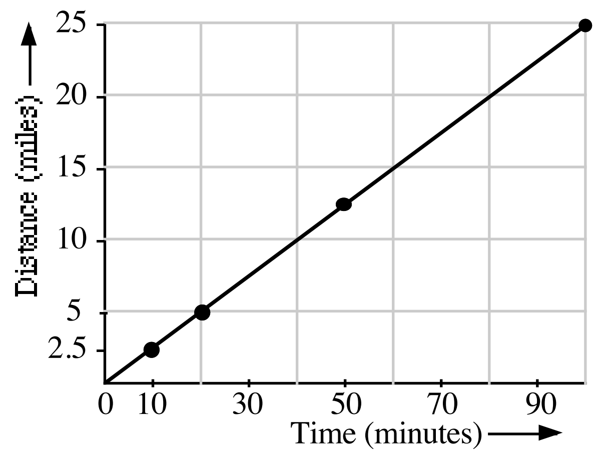
1. Introduction:

In addition to being comfortable with the different measurement systems (particularly the metric system) and simple algebra (i.e. dimensional analysis), it is important that you are thoroughly familiar with data presentations. It is often said "a picture is worth a thousand words". Nowhere is this more true than when it comes to the presentation of research and physiological data. Most physiological processes are represented as an accumulation of many individual data points. To help interpret physiological phenomena, data is organized into tables, charts, and graphs. Tables and charts allow the physiologist to quickly organize and manipulate data, where as graphs allow the physiologist to quickly visualize tends and patterns in the data. To get the most out of your education in physiology it is important that you are able to extract all of the information contained in the tables, charts and graphs that you will be presented. In addition, it is important that you feel comfortable organizing your own data into clear, understandable formats for your own interpretation.

Although it is helpful to use charts and tables to quickly organized data, graphs allow the researcher to *quickly visualize tends and patterns in data*. For example, the table below (table1) shows the distance traveled by a cyclist over a 10 hr period. The graph adjacent shows the same information, but easily demonstrates much more information.

Distance (miles)	Time (mins)
2.5	10.0
5.0	20.0
12.5	50.0
25.0	100.0

Table 1: Distance traveled / mins



Exercise 1.A:

1. What information is more readily available in the graph that is not as available in the table?

A significant part, if not the majority of physiological information, is presented graphically. To get the most out of your training in physiology we will learn more about how to extract information from a graph as well as the tools needed to correctly construct one.

1A. Graphing:

In physiology graphs are typically used to present relationships between related measurable phenomena or *variables*. Usually variables are expressed in a "cause" and "effect" relationship. The variable expressing the *cause* is defined as the **INDEPENDENT VARIABLE** while the variable expressing the *effect* is defined as the **DEPENDANT VARIABLE.** The effect (or dependant variable) is generally the process being studied (measured and evaluated) in an experiment. For example, if you are determining the effect of a high protein diet on muscle mass gain, the gain in muscle mass is the dependent variable (measured and evaluated or "effect") and the quantity of protein in the diet is the independent variable ("cause").

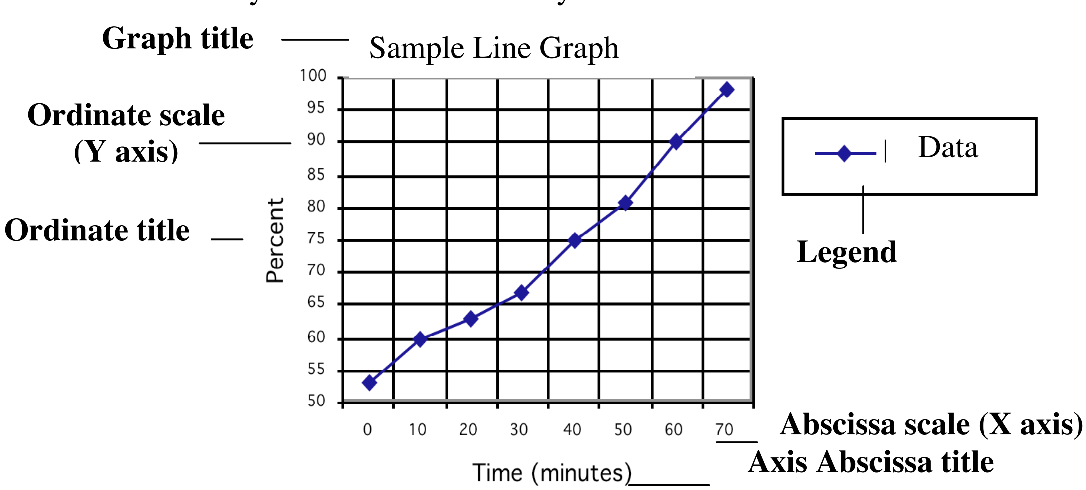
There are typically three different relationships between variables commonly graphed. The first shows how a variable changes with respect to time. These graphs can be deceptively simple, but in fact can reveal a significant amount of information and are the hallmark of physiology. The second shows how one variable changes relative to effects of a second variable. And the third shows how two or more variables (experimental groups) change compared to each other under the same conditions. The third type of graph is characteristic of multi-group experiments where the effect of a variable is revealed by comparing experimental groups and a control group.

1B. General Rules for Graph Construction:

Regardless of the information contained within a graph, every graph has common features and utilizes the same basic rules in its construction. **1.** First, since the purpose of a graph is to reveal something about the data presented it should be both *large enough* and *scaled* so that all the data takes up the majority of the graphing space with little unused space. **2.** Second the graph should always be *clearly labeled with a legend* denoting the information contained within. **3.** Third always graph the dependant variable on the Y-axis axis (ordinate) and the independent variable on the X-axis (abscissa). **4.** Finally, be sure that the axis scales (x-axis & y-axis) is uniform and units are clearly labeled.

Examine the graph on below for all of the following components:

1. Data is scaled and large enough to fill the graphing space
2. The graph is clearly labeled: Title, x-axis title, y-axis title, legend
3. Dependant and independent variable correctly assigned; scales are uniformly spaced
4. Axis uniformly scaled and units clearly labeled



Whatever the situation, the function of a graph is to make data easily visible. Let us use the complicated phenomena of the electrical conduction of the heart as an example. Although most of you will recognize the electrocardiogram (ECG), many of you have probably not thought of it as a graph! Figure 2 graphs the electrical changes in the heart over time. Because when the data as measured affects the electrical signal, time is the "*independent*" variable. On the other hand, the electrical charges produced by the heart depend on the point in time in the heart cycle being measured, thus it is the "*dependent*" variable. Notice all of the same rules apply, no matter how complicated the graph may seem.

The graph is titled indicating what is being presented. Again, by convention the vertical or Y axis is used for the *dependent variable* (electrical activity) and the horizontal or X axis is used for the *independent variable* (time). The axis is clearly labeled identifying the variable and the scale of measurement. The scale on the axis is consistent, uniform, and adjusted to fit the range of data presented. Finally, the graph is both large enough and scaled so that all the data can be shown with little extra space.

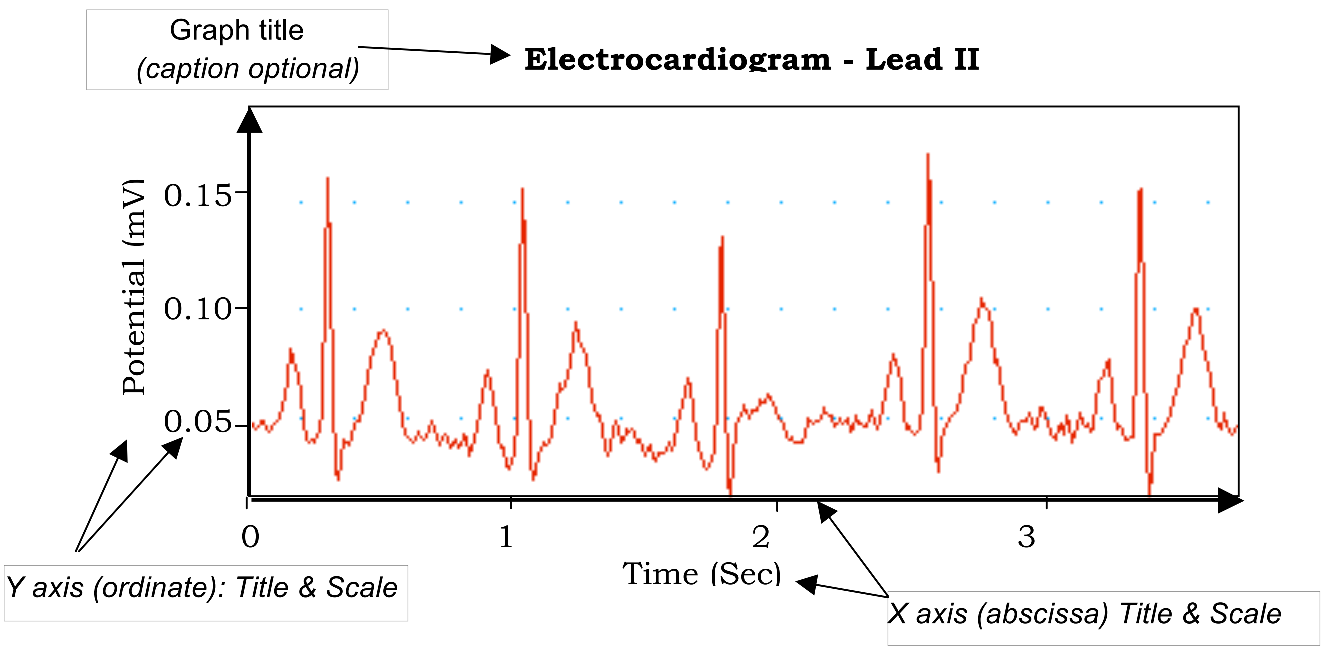


Figure 2 – Characteristics of a typical graph of physiological data

2. Preparation & Use of: Line and Bar Graphs

Line vs. Bar Graphs: Uses when comparing two experimental groups

Graphs can portray in a visual fashion the relationship of *two or more variables*. Line graphs are well suited for observing the changing in a variable over the course of an experiment (typically time is the independent variable). Bar graphs are well suited for comparing two variables against one another, especially when data is limited.

a. Line Graph :

Line graphs are constructed when, as measurements are made, they are plotted and a single line is used to join all data points. As the variable changes, the single line represents the manner in which the variable is changing. When more than one variable is plotted not only is the change in each variable portrayed, so is the difference between the two variables.

b. Bar Graph: Bar graphs are constructed when columns are used to depict the quantity of change for a variable. Bar graphs are usually resorted to when there are *few or insufficient points available* to give a definitive shape to a line graph. Bar graphs are cruder than line graphs, but still give an overview of a situation.

Consider the following example where the average weight changes in two groups of rats, one on a *complete diet* (control), and one on a *sodium "free"* (experimental) diet are recorded. The average weight of each diet group represents a variable. The relationship between weight and time, and the difference between the two diet groups is not easily seen in the table of data. In a graph, however, they are easily distinguished (Table 1).

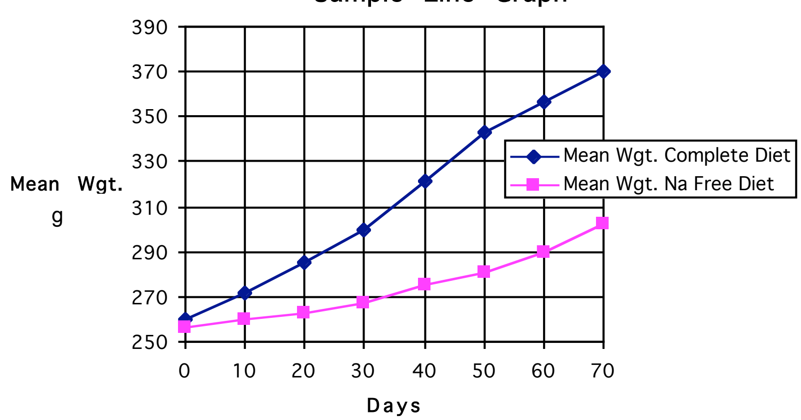
Day	Mean Wt. Na+ Free Diet (g)	Mean Wt. Complete Diet (g)
0	256	260
10	260	272
20	263	285
30	267	300
40	275	321
50	281	343
60	290	357
70	302	370

Control Group

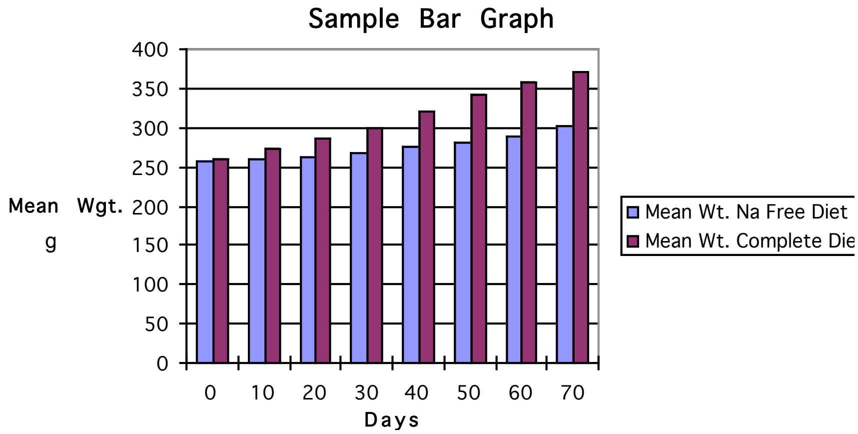
Table 1

Line Graph: To plot a line graph, set up weight (the dependent variable) along the vertical (Y) axis and time along the horizontal (X) axis. Your axis should be just large enough to cover all of the recorded values and be scaled to clearly reveal variations in the data. Always title your graphs and label your axis, giving units (i.e. time in days). If more than one dependent variable is plotted on the graph include a legend to the plotted lines.

Sample Line Graph



Bar Graph: The same data can be plotted as a bar graph. In this case the line graph is the better format for this data, however, if you only wanted to compare the data for the two groups at 0, 40 & 70 days the bar graph would be a better choice. Line graphs are good for illustrating change over time while bar graphs are good for comparing data at two or more static time points (when few data points are available).



3. Line graphs used as Standard / Calibration Curves:

All too often a physiological event of interest is not easily measured directly. In these cases it is important to find a related and easily measurable variable. If we can determine the relationship between the measurable variable and the variable that we are interested in at several points we can infer the relationship at other points graphically. Such a graph is called a "*standard*" or "*calibration*" curve (graph) and is a very useful tool.

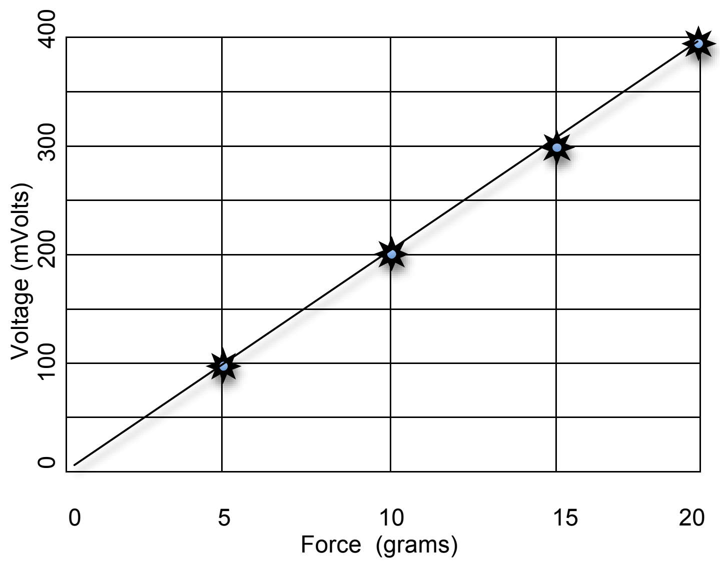
In the physiology lab this type of graphing becomes important when using a recording device to measure a desired physiological property, but the recording device cannot record that property directly. For example, we will be using force transducers to measure the strength of cardiac contractions. The transducer can only measure the extent to which it is bent by force, but not the force directly. It must therefore be calibrated. A known set of weights can be used to calibrate the transducer and a calibration curve can be constructed to determine contraction strengths. In this situation we must prepare a "calibration" or "standard" curve (graph) that represents the relationship between what we are interested and what the recording equipment can measure.

Force transducers measure the displacement of a "blade" in milli-volts. The greater the blade is displaced (bent) the greater the milli-volt measurement. In order to calibrate the force transducer we would expose the transducer to a series of known weights and record the millivolt displacement recording. Below is a table with this information.

Known weight (g)	Displacement (mV)
5g	100 mV
10g	200 mV
15g	300 mV
20g	400 mV
Unknown Force___	225 mV

With this information a calibration curve (graph) can be constructed in order to determine the amount of force in grams exerted on the transducer. Once calibrated the transducer can measure many different sources of force. For example, if the force transducer is connected to a beating heart we could determine the differential strength of atrial and ventricular contractions.

Using the following calibration curve for our force transducer, determine the approximate force produced when the mvolt displacement is 225mV.



Answer:
____________________(approximate gram force)

For the above data, ALL of the data points fell neatly along a linear axis, but this is almost always NOT the case. Data will more than likely have some error in the recordings, and therefore many not create an absolutely straight line when the data points are connected. In such cases we must average the error of all the data points and instead of "connecting the dots," a BET FIT line must be constructed which averages the variation in the data. By doing this we can establish the linear relationship between the two variables of interest.

To demonstrate how to construct and use a calibration curve when error exists in the data we will use the following example. Spectrophotometers are recording devices capable of measuring the amount of light that passes through a solution and therefore the amount of light absorbed by the solution. The amount of light absorbed by a solution is directly related to the concentration of light absorbing molecules.

PROBLEM: How can we determine the concentration of iron (a light absorbing molecule) in a sample of human blood?

Solution: By using as spectrophotometer, we can create solutions with known quantities of iron and measure the absorbance by each solution. After creating a standard curve we can then establish the relationship between iron concentration and absorbance. Finally we will be able to sample a patient's blood, measure the absorbance and use the standard curve to determine the concentration of iron.

1. Prepare a set of known concentration solutions (*iron in plasma*). (see standards chosen in Table 3 below: 25 μg/dl, 50 μg/dl, 100μg/dl, 200μg/dl).
2. Determine the amount of absorption by each solution using a spectrophotometer (%Absorption) of these known solutions in the laboratory. (see data listed in Table 3 below)
3. Prepare a "standard curve" with *concentration on the X-axis* and *% Absorption on the Y-axis*.
   a. Plot ALL four data points accurately
   b. Construct a *straight line* which ***best fits*** the data plotted (ie: do not connect the dots – draw a straight line which averages the placement of the data)
   c. The "*best fit*" line represents the slope of the data. The slope is the rate of change between the independent and dependant variable = *speed*
4. Measure the % Absorption of the patient's plasma sample and determine its yet unknown concentration using your "standard" curve.

Table 3

	Concentration	% Absorbance (%A)
Standards	25 µg/dl	70.0
	50 µg/dl	73.35
	100 µg/dl	80.0
	200 µg/dl	93.0
Unknown:	___?___	90.0

Normal Plasma Iron: 50-150 µg/dl

Exercise 3 : Standard Curve : Plot the standard curve below. Use the standard curve to determine the “Unknown” patient sample iron concentration

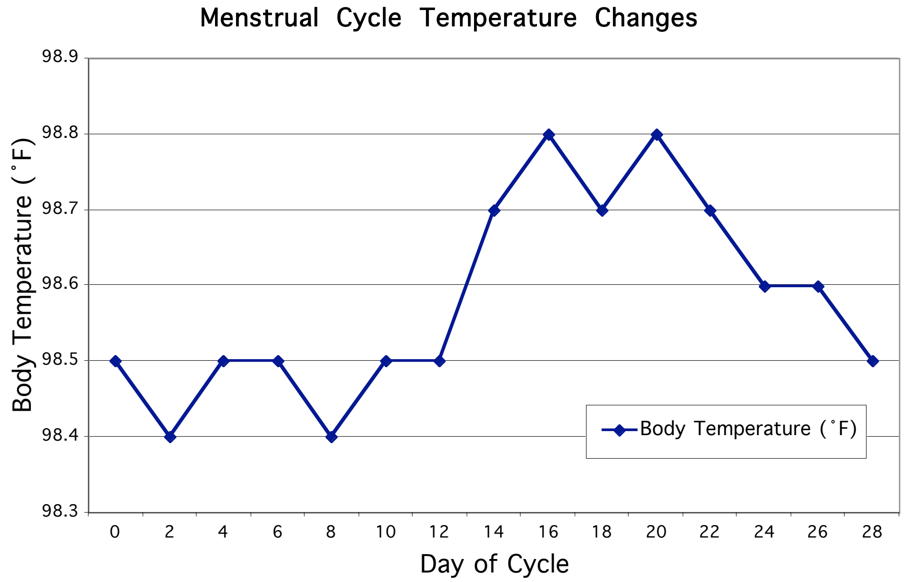
Patient’s Sample =_________ µg/dl

4. Using Line Graphs to Observe Changes Over Time (Time Dependant)

Often the changes occurring relative to time for a physiological phenomenon is of interest. In these instances a graph can be used to illustrate the time related changes that occur. A simple example of this is a graph of depicting the temperature changes occurring in a female over a reproductive month. Such a graph can show the dramatic changes in temperature and relate them to a physiological event. When dramatic changes are noted they can lead to important connections. In this case the dramatic increase in temperature is related to the time of ovulation.

In this example the primary use of the graph was to *detect a pattern* or trend in the data. In other situations much more information can be extracted from graphically presented data. This is most pronounced with rhythmic phenomena such as a graph of the contraction and relaxation of the heart.

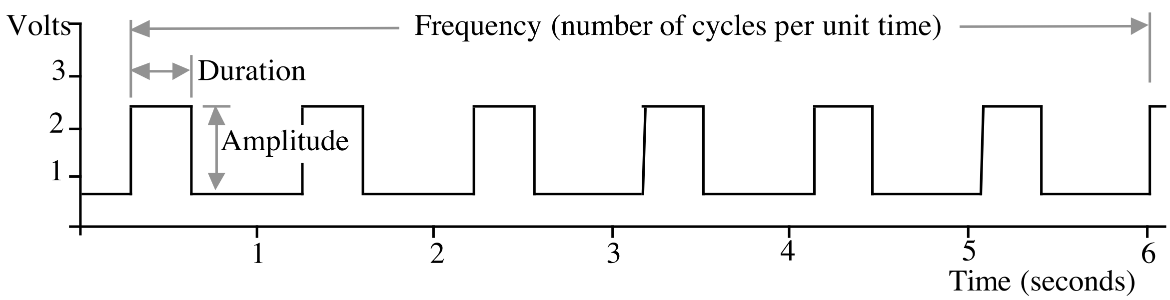
Day of Cycle	Body Temp.
0	98.5
2	98.4
4	98.5
6	98.5
8	98.4
10	98.5
12	98.5
14	98.7
16	98.8
18	98.7
20	98.8
22	98.7
24	98.6
26	98.6
28	98.5



In general graphs representing change over time contain information with *four characteristic measurements* or interpretations:

1. **Pattern** : Any regular repeating structure (pattern) within the record. Patterns will generally correspond to the physiological event of interest. ie: contraction, heart beat,nerve impulse.
2. **Amplitude** : The *height* of a single recorded event (changes in the *y-axis*)
3. **Duration** : The *length* of time a single event is recorded (changes in the *x-axis*)
4. **Frequency** : The *number of times* a recorded event occurs. (events recorded along the *x-axis*)

Below is a graph of electrical pulses applied at regular intervals. This is a very regular pattern characteristic of machines. On it the amplitude, duration, and frequency are indicated.



Exercise 2C: The figures below (fig. a – c) each illustrate differences between a recorded stimulus which is changing either the duration frequency, or amplitude is changing. Determine which is changing in the following figures

Fig. a – Record displays a change in : ________________________

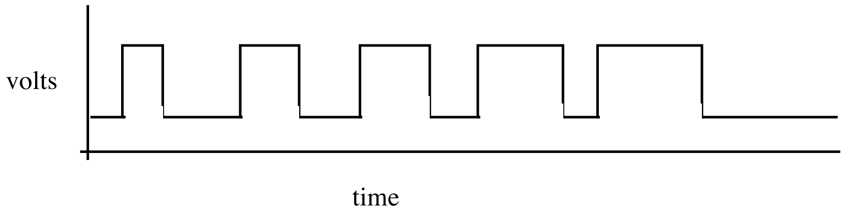


Fig. b – Record displays a change in : ________________________

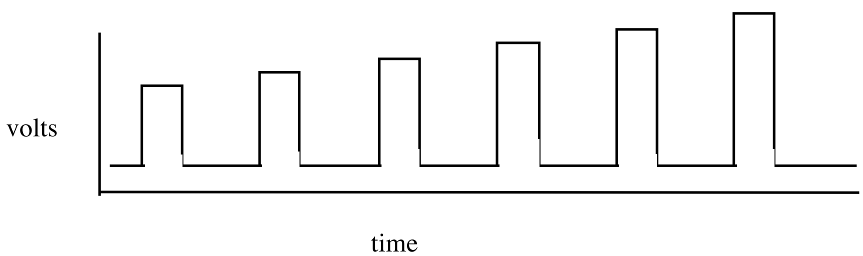
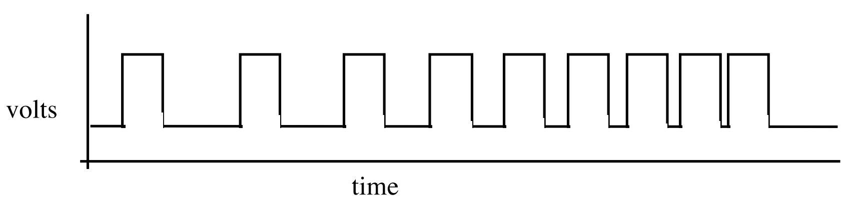


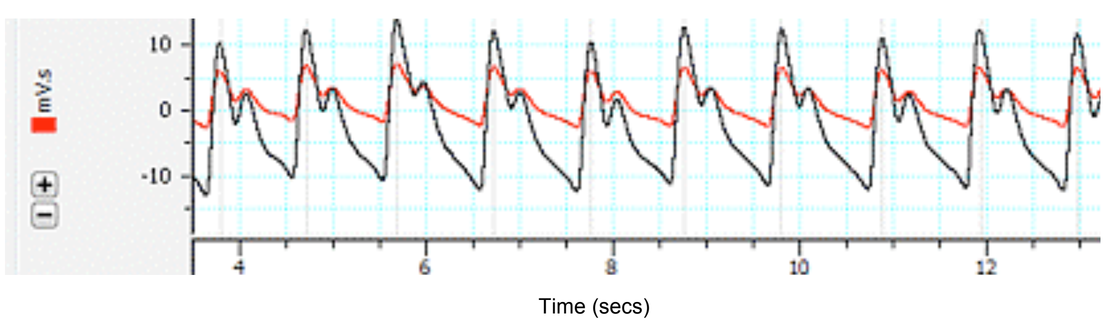
Fig. c – Record displays a change in : ________________________



2D: Determining Frequency of events from data recordings.

Determining amplitude and duration is pretty straight forward, but frequency may need some further explanation. When calculating the frequency of an event, it is best to include several events into the calculation so that you can get an average frequency.

For example, if you where calculating beats per minute, you would count 3-4 beats and determine the amount of time it took for all 3 or 4 beats to occur.



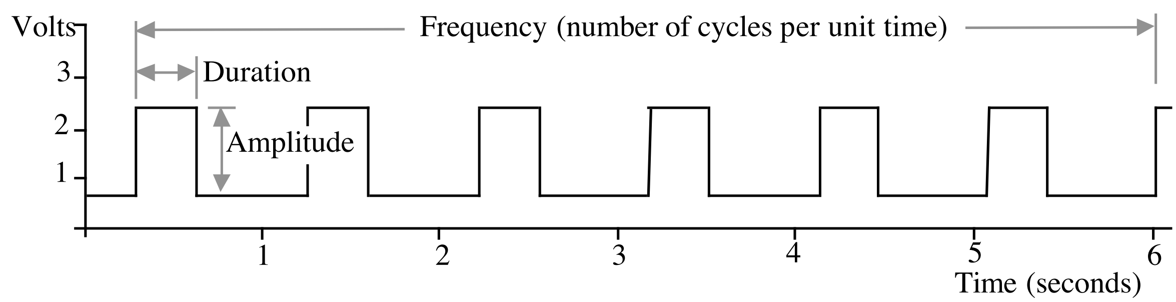
In the preceding data recording, find the beginning of the pulse recording occurring at ~5.5 secs. Count three complete pulses, ending on ~8.5 secs. Frequency is the number of events occurring in a determined amount of time. In this case there were three pulses occurring in 3 secs, or one pulse every sec. To determine this simply divide the number of events by time.

Calculation: 3 pulses / 3 secs = 1 pulse / 1 sec

The next step would be to convert the data units from secs to mins. Since you know that there are 60 secs in one minute, you can easily convert to find that the pulse rate is 60 pulses per minute.

Calculation: 1 pulse / 1 sec x 60 secs / min = 60 pulses / min

Exercise 2D: Using the recording below, determine the following.



a. Amplitude (Volts) :

b. Duration (sec) :

c. Frequency : events / sec AND events / min

2

Name : ________________________________

Data Presentation

Instructions: Complete the following activities. You can use the graph paper provided in lab or use some from home.

Exercise 1: Practice constructing line and bar graphs:

Using the glucose tolerance data provided below, draw both a line and a bar graph (use half the paper for each). For the line graph, plot *all* the data provided. For the bar graph, use the data at *0, 30, 60, 90, and 120* minutes. Use a ruler and be sure to label all graph elements. *(note: your axis for blood sugar should not begin at zero because this would create a lot of unused graphing space between zero and your lowest point of 81.)*

Time (min)	Subject One Blood Sugar (mg/dl)	Subject Two Blood Sugar (mg/dl)
0	100	85
15	135	93
30	162	106
45	178	115
60	201	123
75	185	118
90	166	109
105	151	97
120	130	81

Exercise 2 : Determining correct Axis Labeling: Student study time vs. grades earned

If the grades earned in physiology were plotted against the number of hours each student spent studying, what would each of the variables be considered? Which axis would be correct to use for each?

Student Study time: ________________________ Axis used : ______________

Grades Earned: ___________________________ Axis used : ______________

Exercise 3 : Using a Line Graph as a Standard / Calibration Curve:

	Concentration Hb (g/dl)	Absorption
Standards	0 g/dl	0.0
	4 g/dl	0.025
	6 g/dl	0.0375
	8 g/dl	0.05
	12 g/dl	0.075
Unknown		0.0625

1. Given the above data prepare a standard curve on the graph paper using the absorption values (concentration vs. Absorption), and determine the concentration of hemoglobin (Hb) in the plasma sample. Is it within the normal value range for the average adult (reference your textbook?

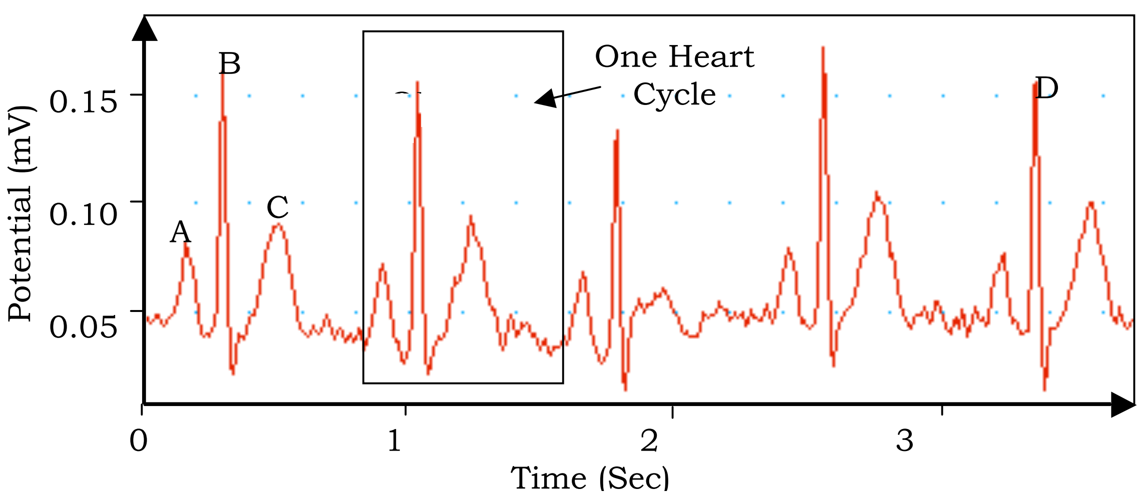
Exercise 4: Using Line Graphs to Observe Changes Over Time (Time Dependant)

Given the scale on the graph it is possible to determine the quantitative values for Amplitude (in volts), Duration (in seconds), and Frequency (in pulses per second, or hertz (Hz)).

Another example of a time related event is the rhythmic activity of the heart. Below is an illustration that is probably familiar, it is an electrocardiogram or ECG (commonly called and EKG, an acronym derived from the German spelling). The ECG represents the electrical activity of the heart and is presented in a graphical format by the instrumentation used to measure it. Therefore an electrocardiogram is a graph. The same four characteristic measurements can be made from this graph. This also is a regular pattern but it is not as perfectly uniform as that above, this is characteristic of physiological phenomenon.

You will learn more about the electrocardiogram during future labs but for now recognize that there are three peaks (called the P, QRS and T waves) that repeat at regular intervals. These peaks collectively make up one heart cycle (representative of a single beat). Measurements are referenced to the indicated baseline.

Lead II Electrocardiogram



Exercise 5 – Procedure

Evaluate the previous graph (Lead II Electrocardiogram) and answer the following questions.

1. *What is the approximate amplitude of peak at "A" measured in millivolts?*
2. *Which peak has the greatest duration? The least duration?*
3. *Approximately how much time separates the beginning of peak "A" from the beginning of peak "B" (known as the P-R interval) measured in seconds?*
4. *How many repetitions of peak "B" are there between point "B" and "D"? (note: do not count the starting point, i.e. peak "B" is counted as zero. Why?).*
5. *How much time separates point "B" and "D"?*
6. *What is the frequency of the peaks between "B" and "D"? (recall: frequency equals repetitions per time, i.e. beats per minute).*

   First calculate cycles (beats) per sec and then convert into cycles (beats) per minute

   (these are the standard units for reporting heart rate).