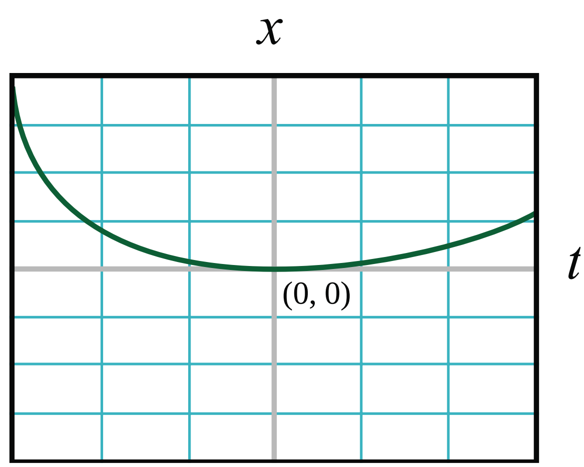
Unit 2 Homework Problems

To get credit for the homework problems, you must include all of the following:

1. All equations must be solved in symbol form before substituting in any numbers.
2. All numbers substituted into the equations must have the correct units and number of significant figures.
3. All final numerical answers must have the correct units and number of significant figures.
4. All problems should include a reference to the Activity Guide activity or activities that are related to the problem, a discussion of ***how*** the activity is related, and a discussion of the ***concepts*** that were learned in the activity.

Homework after session one

2-1) Sketch small graphs relating position to time that depict the following relationships between x and t. Each of your graphs should have an origin at its center like the sample graph shown on the right. In our sample graph, x is not a linear function of t and it is not proportional to t although the graph does pass through the origin. We would characterize the function of x vs. t as a curve passing through the origin that depicts x decreasing with t for $t < 0$ and increasing with t for $t > 0$. In this graph x is always positive.



(a) Sketch a linear graph for which x is always negative and always decreases with t. Can x be proportional to t? Why or why not?

(b) Sketch a graph for which x is always increasing with t and is proportional to t.

(c) Sketch a graph for which x is not a linear function of t but is always increasing with t.

2-2) You are working in your spare time for a consumer organization that is checking on whether or not the local Subway Sandwich shop's foot long submarines are really 1 foot long. You have acquired a centimeter ruler from a reputable manufacturer that is certified to be accurate to three significant figures to do the measurements.

(a) You made the following careful length measurements on five of the submarines sold at the local Subway shop on a particular day (N=5): 29.9 cm, 30.3 cm, 30.1 cm, 29.2 cm, and 29.5 cm. (a) Using the method described in Appendix C on pg. A-19 of the Workshop Physics Activity Guide, find the average and standard deviation of the measurements to four significant figures. Note: It's OK to do this either by hand or using a spreadsheet for this calculation as long as you follow the Appendix C procedures. However, please do not use the Excel spreadsheet functions entitled "AVERAGE (...)" and "STDEV (...)" for this problem.

(b) Is there any evidence of uncertainty in the measurements or are they precise? Explain.

(c) Is there any evidence of systematic error in the lengths of the submarines that are being produced at the Subway Shop? Explain.

(d) Is this systematic error most likely to be caused by inaccurate measurements or actual variations in the length of each submarine. Explain the reason for your answer.

(e) State the best estimate and uncertainty for the length of a typical submarine sandwich based on your sample of five. As discussed in Appendix C, the measure of uncertainty is usually taken as the Standard Deviation of the Mean (SDM).

2-3) Cayla and Talmage calculated the averages and SDMs for several types of measurements. They got into a rote mood and copied all the digits that appeared on their scientific calculator. Please boil these down to the "correct" number of significant figures and state how many significant figures is being reported for each best estimate.

(a) 5.666666667 ± 0.028314389 Volts
(b) –18.25723 ± 2.31684 degrees Celsius
(c) 0.0373749738 ± 0.005174523 meters
(d) 3546.78349 ± 188.549763 seconds (express this answer with and without scientific notation)
(e) Explain why the result of rounding off in part (d) is ambiguous unless scientific notation is used.

Homework after session two

2-4) Suppose Linda and Edward each use a slingshot to shoot 5 pellets at a target. The holes in each of their targets are shown in the figure on the next page.

Assume that the picture of each target shown on the next page is *one tenth of its actual size*. Set up a spreadsheet column to record your measurements of the distance in meters of each of Edward's shots from the center of the bull's-eye. (*Hint*: You'll need to print the next page and use a ruler.) Generate the same type of column to record the distances for Linda's shots. Examine the scale drawings of each target and/or use the data you have taken to answer the following questions. Note: You should hand in a printout of your spreadsheet with your name, section, etc. (all that info we want) and label the sections of your spreadsheet that contain the answers (a), (b), (c) etc. Save space on your printout to include your short essays for parts (a) and (d)

(a) Each student is trying very hard to hit the bull's-eye each time. Discuss in essay form which of the two students has the least *uncertainty* associated with his or her shots and is thus *more precise*. Is one of the students *less accurate* in the sense of having a *systematic error* associated with his or her shots? What factors like eyesight and coordination might cause one to be more precise and another more accurate?

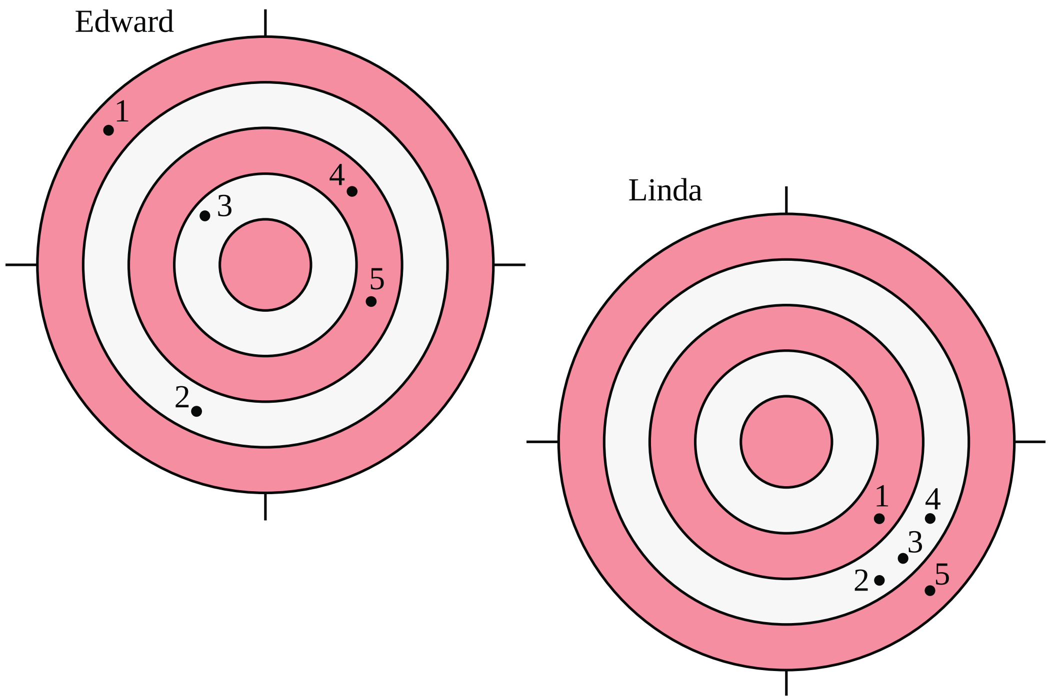
(b) Use the spreadsheet average function to calculate Edward's average distance from the center of the bull's eye. Also calculate Linda's average distance.

(c) Use your spreadsheet STDEV function to calculate the standard deviation of both Edward's set of shots and Linda's set of shots.

(d) Which standard deviation is larger? Is that what you expected? Explain.

(e) Calculate the standard deviation from the mean (or SDM) for Edward and for Linda. Explain the difference between the standard deviation and the standard deviation from the mean (SDM). Hint: See the Workshop Physics Activity Guide Section 2-11 or Appendix C, p. A-21.

(f) In view of the values of the SDM, express Edward's average and Linda's average *to the correct number of significant figures.*



2-5) On January 28th 1986 the space shuttle Challenger exploded shortly after it was launched, killing all seven astronauts who were on board, including Dr. Ronald E. McNair, whom our McNair Scholars Program is named after. Within days after the tragedy, Richard Feynman, a well-known Nobel Laureate in Physics, was asked by the head of the National Aeronautics and Space Agency, NASA, to serve on a panel to investigate the circumstances of the accident. In a fascinating autobiographical work entitled *What Do You Care What Other People Think?* (Bantam Books, 1989, pp. 164-166), Dr. Feynman describes his investigative work for NASA. It appeared at the time that the explosion was caused by the failure of a rubber O-ring to expand rapidly enough to prevent hot gases from leaking out of one of the booster rockets needed to lift the shuttle into its flight path. If the temperature was too low prior to the launch, then it would be possible to conclude that the O-ring could have failed. One of the crucial issues was to make sense of the temperatures in the vicinity of the shuttle during the morning of the launch. Please read Richard Feynman's account of his attempt to reconstruct as accurately as possible what the temperature readings were before the launch and answer the following questions:

(a) Even before Dr. Feynman started his investigation, the original temperature readings were considered to be too low to be accurate. Why?

(b) Was the inaccuracy of the readings due primarily to systematic error, or was it due primarily to statistical uncertainty? Explain your answer.

Homework after session three

2-6) Refer to the blindfolded person's walk activities you completed in Activity 2.9.2. Set up a spreadsheet simulation that allows a blindfolded person to take a hypothetical 18-second walk (instead of the hypothetical 20-second walks they took when you completed Activity 2.9.2). There are tips at the end of Section 2.9.2 on constructing this type of spreadsheet simulation. Run your simulation and record where the blindfolded person is relative to the bar after a 18-second walk. (That is, after one "run" of the simulation how many "steps" is the blindfolded person to the right (+) or the left (-) of his or her starting point?) . Submit a printout of your spreadsheet with your name, exercise number, and the date submitted on it.

2-7) Referring to the spreadsheet simulation you designed in the previous problem, take 25 blindfolded people on 18-second walks, instead of just one person. Also use the spreadsheet to record each blindfolded person's location after his or her simulated walk. In answering the following questions there is no need to print out or submit an additional spreadsheet.

(a) List the locations of the 25 blindfolded people in "steps" right (+) or left (-) from the bar.

(b) If the size of each step is about 0.8 meter, what is the Standard Deviation in meters for the simulated walks taken by the 25 blindfolded people?

(c) What is the standard deviation of the mean (SDM) for the simulated walks taken by the 25 blindfolded people?

(d) The average location of your 25 blindfolded people should be close to zero. (It may not be exactly zero because you've only tested 25 people instead of an infinite number of them.) Assume that the average distance in steps from the door is actually zero. Within what distance, n, in steps from the door would you expect to have a 68% probability of finding the next person who staggers out of the bar and walks for 18 seconds?

(e) Since you have to divide the standard deviation by the square root of a number greater than one to get the SDM (standard deviation of the mean), the SDM is always smaller than the standard deviation. What does the SDM tell you about the average distance from the bar in meters of your blindfolded people compared to the averages found by your classmates who each took 25 other blindfolded people on 18 sec. walks just outside the bar? What proportion of the average blindfolded person's location reported by your classmates should lie within one SDM of the bar?