Homework 2 **ECE 445 Biomedical Instrumentation, Fall 2012**

Due: Monday September 17

Problem 1
Briefly define each of the following in biomedical instrumentation terms. A single phrase should be sufficient, but avoid copying directly from the notes. Some of these may require checking in a medical dictionary.

a. measurand
b. direct operational mode
c. invasive
d. generating mode
e. real-time measurements
f. interfering input
g. correlation coefficient
h. zero drift

Problem 2
List the common categories by which biomedical instruments are *classified*

Problem 3
Below is a list of factors that set design criteria for biomedical instrumentation. Properly identify each as either a medical, signal, environmental, or economic factor.

a. availability
b. size and shape
c. measurement linearity
d. material toxicity
e. stability over temperature
f. input impedance
g. compatibility to commercial standards
h. patient discomfort
i. measurement range

Problem 4
(a) Using mathematics software like Matlab or Excel, determine the following for the data set below using only basic mathematics +, -, ×, √, etc. operations –not library functions. Show enough of your work, code, etc. to show you have followed the rules. Some useful equations provided at the end.

i. mean input
ii. mean output
iii. output standard deviation
iv. output coefficient of variation
v. correlation coefficient

X (input)	0.5	1.5	2.0	5	10.0
Y (output)	0.9	3.05	4.0	9.9	20.5

(b) Which of these statistics would be useful in analyzing the data as an input/output set? Which biostatistics would not be useful and why.

Problem 5

To demonstrate you have the skills to complete this problem, describe in your own words what you did to obtain the results for each step; don't just show a plot/equation/etc.

a) Plot the input/output data from Problem 4 and use a software program (Matlab, Excel) to determine the best linear fit to the data. Show the linear fit equation (slope and intercept)
b) Linear fits are generally found using a "least squared error" technique as described in the Ch. 1 Basics notes. For each input data point, calculate the linear fit value. Then calculate the sum of the squared difference between the data set output and the linear fit. Report this value and show your work (code or clip of Excel file).
c) How well a set of data matches its linear fit is often described by the R^2 value, or R-squared. What is the real/formal name for this statistic (not in notes but easy to google)? How does it relate to other statistics used in problem 4.
d) Try to plot the R^2 value on your plot from part (a). This is pretty easy in Excel and it useful to know how to do. Explain briefly how this is done (click here, there, etc.).

Problem 6

(a) A first-order low-pass instrument has a time constant of 20ms. Find the maximal sinusoidal input frequency that will keep the output error due to frequency response (loss due to high frequency cutoff) less than 5%.
(b) Find the phase angle at this frequency

Equations

Mean (arithmetic)	$\overline{X} = \frac{\sum_i X_i}{N}$
Standard Deviation	$s = \sqrt{\frac{\sum_i \left(X_i - \overline{X}\right)^2}{N-1}}$
Coefficient of Variation	$CV = \left(\frac{s}{\overline{X}}\right)100\%$
Correlation Coefficient	$r = \frac{\sum \left(X_i - \overline{X}\right)\left(Y_i - \overline{Y}\right)}{\sqrt{\sum \left(X_i - \overline{X}\right)^2} \bullet \sqrt{\sum \left(Y_i - \overline{Y}\right)^2}}$