CHEM 322 **Name**_____
Exam 1 **Fall 2012**

Complete these problems on separate paper and staple it to this sheet when you are finished. Please initial each sheet as well. Clearly mark your answers. YOU MUST SHOW YOUR WORK TO RECEIVE CREDIT.

Homework Problem (10 pts): The signal processing homework problem will be graded out of 10 points and added to the total for these problems.

Warm-up (2 pts each)

1. The range of frequencies that a measurement is sensitive to is called the frequency _____.

2. Application of large reverse-bias potentials to diodes can lead to _____, resulting in a large current at essentially constant potential.

3. The _____ is the span of concentrations over which instrument response is directly proportional to concentration.

4. The _____ of a measurement can be described using the slope of the calibration curve for the measurement.

Answer in a few sentences, or with a calculation. Complete *FOUR* of the following. Clearly indicate which problem is not to be graded. Show all work for calculations. (10 pts each)

5. You have a box that contains 50 op-amps and ten each of the following resistors: 1, 2, 5, 10, 20, 50 kΩ. Design a circuit to do the following calculation: $v_{out} = 30(v_1 + 2v_2) - 10v_3$ (You may not need all of the components in your box.). *You do not need to do calculations to prove your result;* it just needs to be correct.

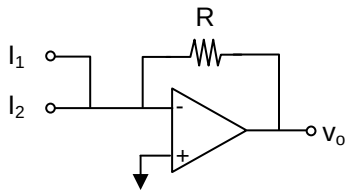
6. Considering the four types of noise we discussed, what characteristics should a measurement have to minimize the contribution of all four noise sources?

7. Clearly outline the steps you would take to determine the detection limit for an absorbance measurement based around Beer's Law (A = abc). Identify the data that you would need to collect and how you would use the data to calculate a LOD.

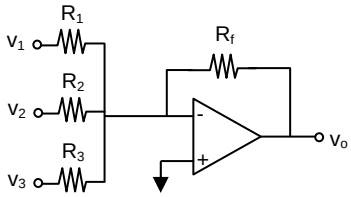
8. There are the two primary properties of an A/D or D/A converter that limit its ability to accurately convert between analog and digital values. Identify each of these parameters and describe how they limit the accuracy of a conversion.

9. *Derive* the relationship between the input and output signals for ***two*** of the following circuits. Show all work.

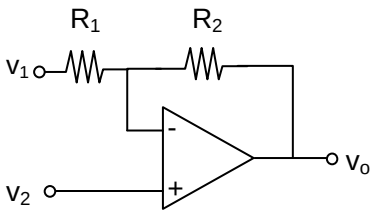
a.



b.

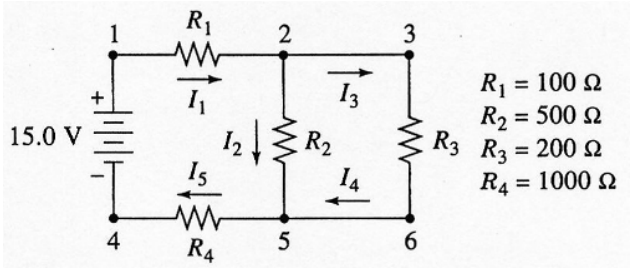


c.

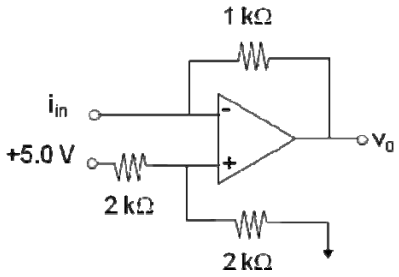


A little more involved. Complete three of the following. Be clear and concise. Clearly indicate which problem is not to be graded. (14 pts each)

10. For the following circuit, the current, I_4 is 8.65 mA. Calculate:
    (a) the potential difference across resistor R_2.
    (b) the current through resistor R_4.
    (c) the power dissipated by resistor R_1.
    (d) the potential difference between points 3 and 4.



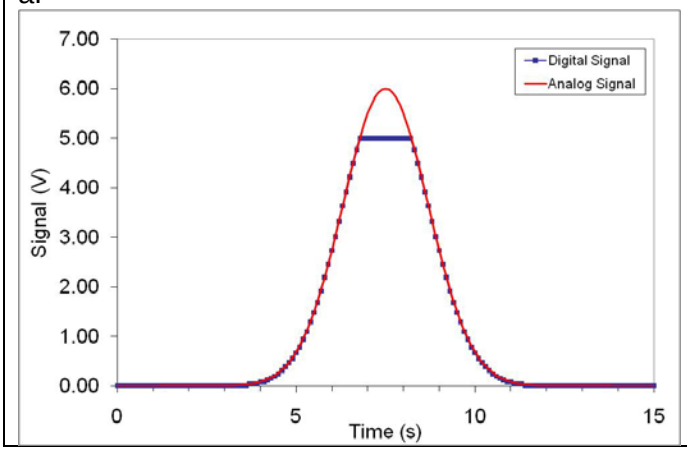
11. Given the circuit below, what output would you expect for a 1.25 mA input current? Derive the relationship between v_o and i_{in}. How would you redesign this circuit to make it suitable for measurement of low current signals (micro- to nano-amp signals)?



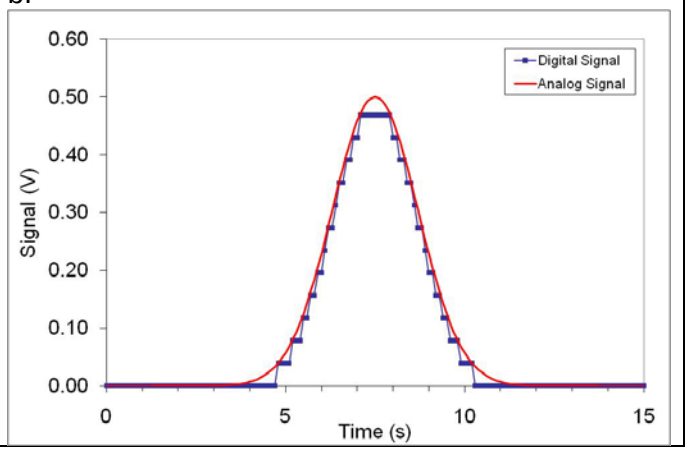
12. Ensemble averaging (also known as *coadding*) and boxcar averaging are two common software-based approaches to improving signal to noise ratios (S/N). Concisely describe each approach and a scenario where boxcar averaging would be preferred over ensemble averaging for S/N improvement. What pitfalls does one need to be concerned with for each method?

13. The plots below show the digital representation of two Gaussian analog signals, as acquired by an eight bit analog to digital converter (ADC) with an input range of ±5.0 V. In neither case is the conversion ideal. For each case, explain what has lead to the non-ideal conversion and suggest a solution to each problem that does not involve buying a new ADC.

a.



b.



Possibly Useful Information

$\frac{dQ}{dt} = I = C\frac{dV}{dt}$	$P = IV = I^2R$
$V = IR$	$v_o = A(v_+ - v_-)$
$v_{rms} = \sqrt{4kTR\Delta f}$	001 + 001 = 010
$\Delta f = \frac{1}{3t_r}$	$i_{rms} = \sqrt{2ie\Delta f}$
$S_m = \overline{S}_{bl} + ks_{bl}$	$c_m = \frac{S_m - \overline{S}_{bl}}{m}$