

Due by 5:00 PM Friday, February 5
NO LATE PAPERS ACCEPTED!

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

Instructions

- This is **NOT** an open-book, open-note take exam. You MAY NOT consult any human or nonhuman resource besides Dr. Lamp as you complete the exam. This exam **MUST** be completed **INDIVIDUALLY** and in your own words. Group work or plagiarism will result in a zero for the exam.
- You will be allowed to ask Dr. Lamp a maximum of two (2) questions regarding the exam. Additional questions may be asked at a 3-point penalty per question. If you are working on the exam in the evening, you may try to reach Dr. Lamp on his cell phone at 660-341-0067 before 10:00 PM.
- Before opening the exam, prepare for it like you would for a traditional, in-class exam. Review concepts and examples from the text, as well as those discussed in class. This preparation will help to maximize your effort on the exam and allow you to complete it more efficiently.

Time Restriction

You may spend no more than two (2) hours working on this exam. This must be in one continuous block of time. You are on your honor to adhere to this restriction and record the time spent in the chart below.

Date	Time Began	Time Finished	Total Time
Total Time Spent on the Exam			

Pledge

I pledge on my honor that I have completed the exam in accordance with the above instructions and that I have not provided or received unethical assistance. I realize that failure to comply with these instructions will result in a score of zero on the exam.

Signature

Date

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Warm-up (2 points each)

1. The _____ in a power supply converts the incoming AC voltage to an oscillating voltage of either all positive or all negative sign.
2. One can reduce _____ noise by increasing the frequency at which the signal is sampled.
3. _____ of a power supply can cause a decrease in the output voltage of the power supply itself.
4. Digital filtering using _____ can help to remove the contributions of specific frequencies to time-dependent signals.

Answer in a sentence or two, or with a calculation. Complete five of the following. Clearly indicate which problem is not to be graded. (10 points each)

5. You have a box that contains 50 op-amps and five each of the following resistors: 1, 2, 5, 10, 20, 50 k Ω . Design an op-amp circuit to do the following calculation:

$$V_o = 20(5V_1 - V_2) + 2V_3$$

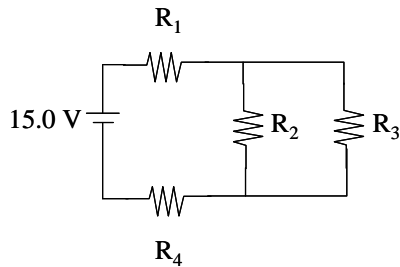
(You may not need all of the components in your box.). Qualitatively describe the function of each op-amp in your circuit.

6. For a spectrophotometric analysis, the following calibration curve was obtained:

$$\text{Signal} = (0.467 \text{ units/ppm}) \times \text{concentration} + 0.024 \text{ units}$$

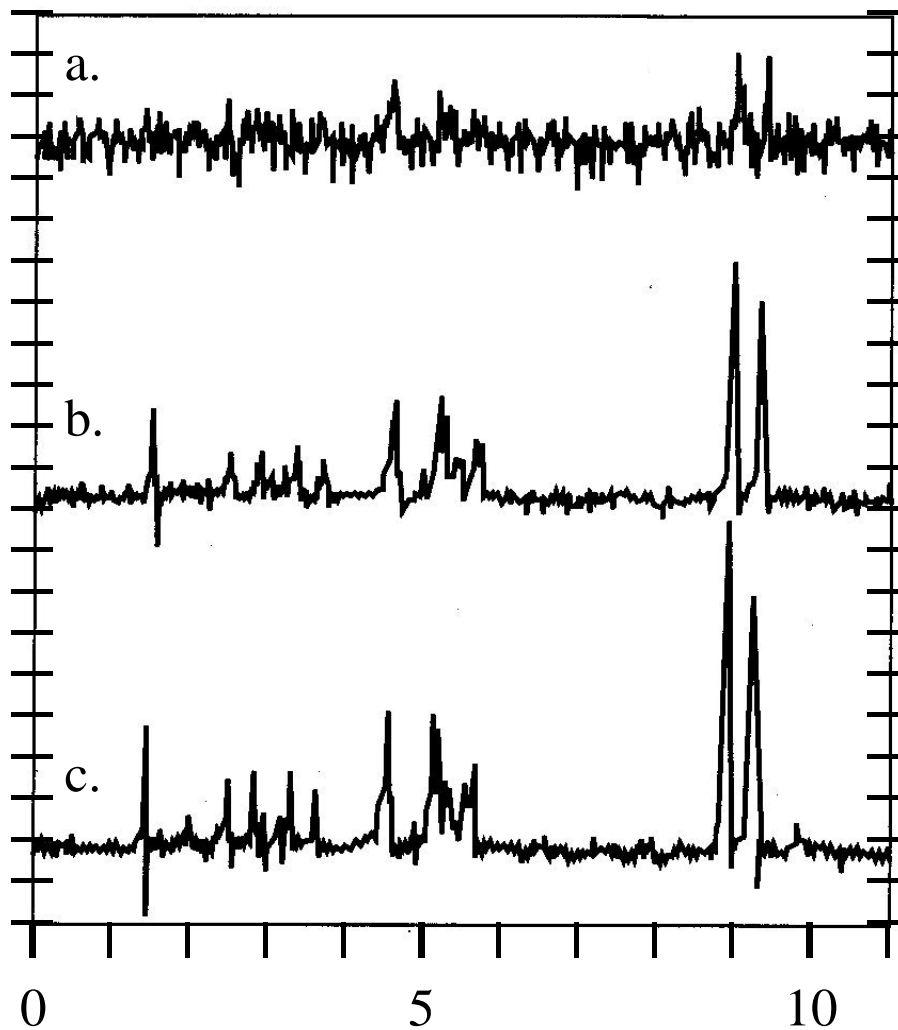
- a. If five blank readings gave 0.022, 0.027, 0.021, 0.025, 0.022 units, what is the detection limit for this measurement?
 - b. Does working near the detection limit have a greater influence on the accuracy or the precision of a measurement? Briefly explain.
7. White noise corresponds to extraneous signals whose intensity does not depend on frequency. Two of the types of noise we've discussed can be classified as white noise. Name and briefly describe the physical phenomena that give rise to these two types of noise. How do we minimize their contribution to a measured signal?
 8. In electronics lab 2 (the op amp lab), we used reverse-biased diode to produce a small current. Describe the properties of the diode that lend itself to this application. What considerations must be made to ensure that only a very small current is produced?

9. Consider the following circuit. If the current through R_1 is $10.94 \mu\text{A}$ and the current through R_2 is $4.69 \mu\text{A}$, what is the value of R_3 ? What is the power that is dissipated by R_1 ? What is the potential drop across R_4 ?



$$\begin{aligned} R_1 &= 200 \text{ k}\Omega \\ R_2 &= 400 \text{ k}\Omega \\ R_3 &= ? \\ R_4 &= 1 \text{ M}\Omega \end{aligned}$$

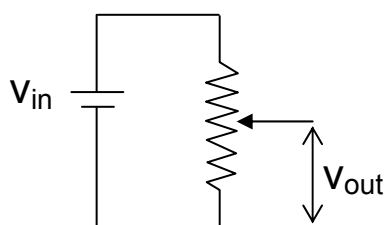
10. Estimate the S/N ratio in data sets a and c below. Be sure to briefly describe the procedure you used to estimate the S/N. If data set a is the result of four scans, how many scans must have been averaged to produce set c?



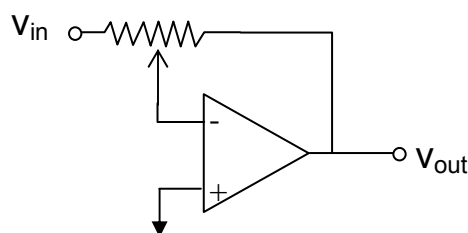
A little more involved. Complete three of the following. Be clear and concise. Clearly indicate which problem is not to be graded. (14 points each)

11. Why is the limit of quantitation larger than the limit of detection for a measurement? When comparing two measurements, is it true that the one with the greatest sensitivity will have the lowest LOD? Explain your reasoning.
12. Consider the two circuits below. Both circuits produce similar output. How is v_{out} related to v_{in} for each circuit? What are the benefits of using circuit B compared to circuit A?

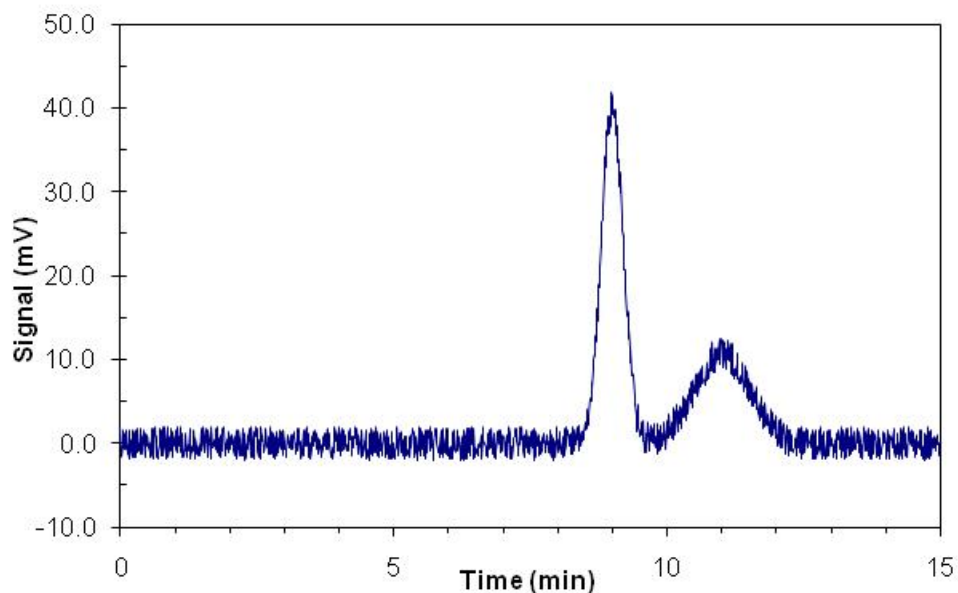
Circuit A



Circuit B



13. You have been assigned the task of interfacing a liquid chromatograph to a computer-based data acquisition system. You have an 8-bit ADC with a ± 10 V range to accomplish this task.
 - a. Because of the design of your LC detector, the maximum output voltage of the detector is 500 mV, with chromatographic peaks typically being a few tens of mV in size. Clearly describe the potential problems using your ADC system to monitor this signal.
 - b. Design an op-amp circuit to help address the primary problems you discussed in part a.
14. Below is an example chromatogram for the system described above. Each run consumes your sample and takes about 15 minutes to complete. The data below is an example of the results of one of your separations. You are unhappy with the signal to noise ratio of your data. Estimate the S/N ratio for the first peak and describe two approaches that are appropriate to this experiment that you might take to improve S/N for **this application**. Note any potential problems with these approaches. You **do not** need to have a solution to problem 13 to complete this problem.



Possibly Useful Information

$\frac{dQ}{dt} = I = C \frac{dV}{dt}$	$P = IV = I^2R$
$V = IR$	$v_o = A(v_+ - v_-)$
$v_{\text{rms}} = \sqrt{4kTR\Delta f}$	$001 + 001 = 010$
$i_{\text{rms}} = \sqrt{2Ie\Delta f}$	<p>Just because you're paranoid doesn't mean people aren't out to get you!</p>
<p>When all else fails, plug in the power cord.</p>	$S_m = \bar{S}_{bl} + ks_{bl}$