16-722 Sensing and Sensors **Fall 2020**
Homework Assignment 3 due Wednesday, October 7

Impedance matching and amplification

1. You have a light sensitive resistor whose resistance varies between 20 kΩ in the dark and 10 kΩ in bright room light, and is about 15 kΩ under the ambient lighting in which you want to use it to measure small changes. You decide to monitor it with a very simple circuit: connect it in series with a "load resistor," connect your 5-V power supply across the pair, and monitor the voltage at the junction of the two resistors. What value of load resistor will give maximum sensitivity?
2. Would a Wheatstone bridge provide an improvement to the system in question 1? If so, explain why.
3. You have a flashlight whose bulb has burned out. The battery pack—four cells in series—has an open-circuit voltage that you measure as 6.0 V. You measure the current delivered by the battery as a function of load resistance and find that it extrapolates to a short-circuit current (for load resistance 0 Ω) of 0.5 A. To obtain maximum light output (power), what voltage and wattage rating should you select for the replacement bulb you buy? (If you need help with this problem, look up the *maximum power transfer theorem*.)
4. Question 3 mentions "four cells in series" but doesn't say anything about what size cells—AAA cells, D cells, or some size in between. What is the essential difference between these different sizes? Explain, in terms of size and shape, why it is reasonable that this essential difference has the dependence that it actually does.
5. See the figure on the next page for an off-the-shelf signal amplifier. Under what circumstances would you set the input impedance to 1 MΩ, and under what circumstances would you set it to 50 Ω? Assume that the specified "Input Noise: 9 nV/√Hz" is all Nyquist/Johnson noise. Look up and read about the concept of *equivalent noise resistance*. What is the meaning and significance of this concept? Assuming the instrument is at room temperature, what is the "equivalent noise resistance" of the instrument's input circuitry?

Product Description

PXI Differential Instrumentation Amplifier

DC-100 MHz

Technical Specifications

- Bandwidth: 100 MHz
- Attenuation: 1:1, 10:1, 100:1
- Gain: x1, x10, x100
- Input Voltage: ± 100 V, Differential
- Input Impedance: 1 MΩ, 50 Ω
- Input Noise: 9 nV / √Hz
- Filters: 100 kHz, 1 MHz
- Offset Control