Today is the last day of class ☺. We will

- Do some review example problems to help you prepare for the final exam

Comments:

- Today, I will cover as many review example problems as time permits, but I will not get to cover them all.
- However, I will write out the solutions to *all* of the example problems before posting this lecture. These examples will be useful in studying for the final exam.
- Tables and equations sheets will *not* be provided for the final exam. You are responsible to bring printouts of all the tables and equations that you may need for the open-book portion of the final exam.
- Between now and the final exam, I may update the equation sheet, so check the date stamp to make sure you have printed the latest version.
- Please remember to fill out the on-line SRTE evaluation form for this course (and all of your courses).

Example: Review for Final Exam

Given: A type K thermocouple is used to measure the temperature in a heated chamber. The reference junction is connected properly to an ice bath, and the voltage output from the thermocouple circuit is 2.436 mV. However, the ice has melted, and the ice bath temperature is actually $10^{o}C$ during the time of measurement, unbeknownst to the experimenters.

To do: Calculate the temperature in the chamber *in units of ^{o}C to three significant digits*. *Note*: Use the "brief" thermocouple tables for consistency.

Solution:

Example: Review for Final Exam

Given: Ben uses a thermopile to measure water that is boiling at $100^{o}C$ in a standard atmosphere (this is the true value). From hundreds of readings, Ben calculates the mean temperature as $100.31^{o}C$ and the standard deviation as $0.859^{o}C$.

To do: Estimate the probability that a random temperature reading is greater than $102^{o}C$.

Solution:

Example: Review for Final Exam

Given: Ten video projector bulbs are tested to failure. The sample mean time to failure is 1380 hours. The sample standard deviation of the ten data points is 118 hours.

(***a***) **To do**: Estimate the population mean time to failure and its confidence interval to standard 95% confidence level.

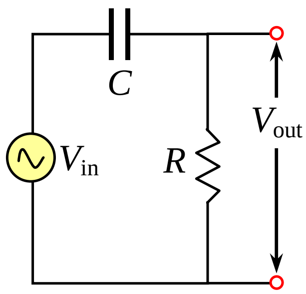
Solution:

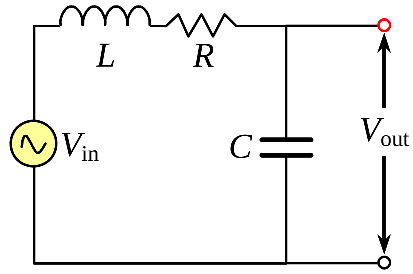
(***b***) **To do**: The bulb manufacturer claims that the bulbs last at least 1300 hours. To what confidence level should we accept the manufacturer's claim?

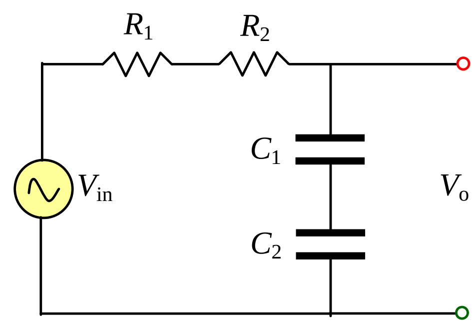
Solution:

Example: Multiple Choice Review Questions for Final Exam (circle the correct one)

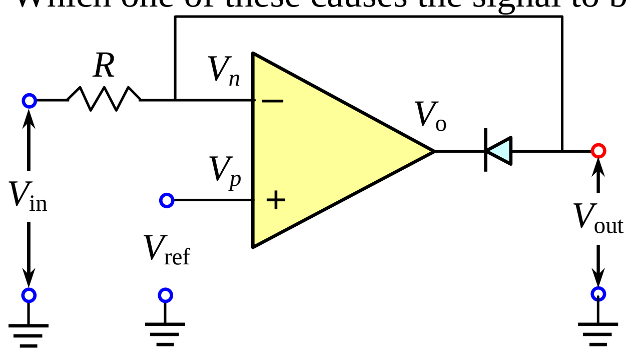
- Which one of these is *not* a low-pass filter?

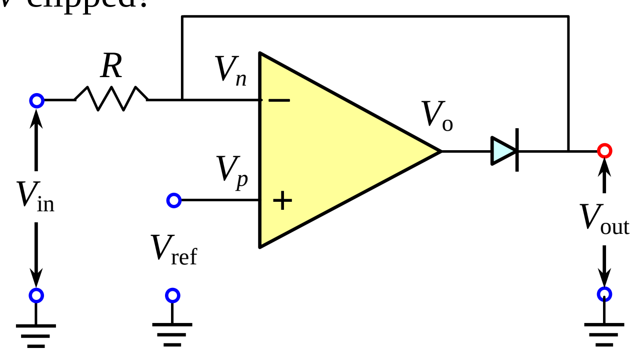




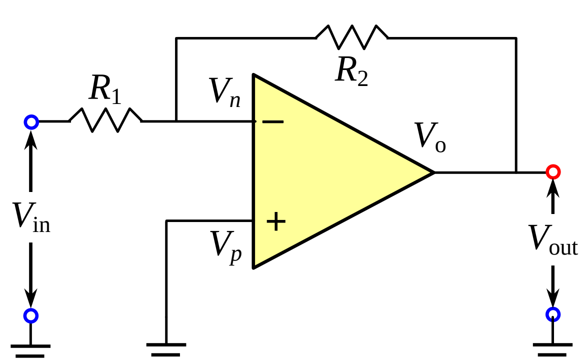


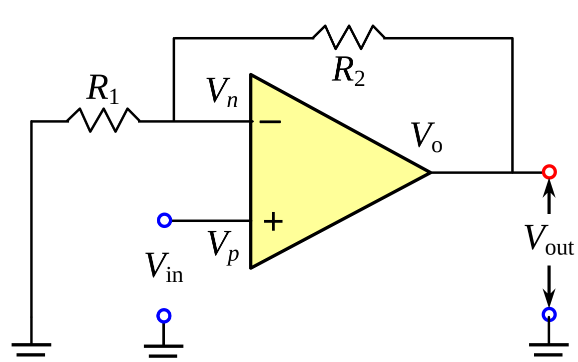
- Which one of these causes the signal to be *low*-clipped?





- Which one of these is an inverting amplifier?





Example: Stroboscopic tachometer

Given: Wayne uses a strobe to measure the rotation rate of a pulley. One dot is painted on the face of the pulley, and the entire pulley is visible.

To do: For each case, how many "frozen" dots does Wayne see? Is he fooled?

(*a*) The pulley is rotating at 2000 rpm, and the strobe is flashing at 500 rpm.

(*b*) The pulley is rotating at 500 rpm, and the strobe is flashing at 2000 rpm.

(*c*) The pulley is rotating at 1500 rpm, and the strobe is flashing at 2000 rpm.

(*d*) The pulley is rotating at 4000 rpm, and the strobe is flashing at 5000 rpm.

Example: Review for Final Exam

Given: An LDV system uses a red helium-neon laser with wavelength λ = 632.8 nm. The angle between the two beams is α = 9.5°. The system is used in a small water tunnel with a speed range of -1 to 3 m/s.

(***a***) **To do**: If no Bragg shifting is used, calculate the expected minimum *and* maximum frequencies (in units of kHz) generated by the LDV output.

Solution:

(***b***) **To do**: Now, Bragg shifting is used so that we can distinguish between positive and negative velocities. Calculate the required frequency shift (absolute value in units of kHz) so that we can measure speeds between -1 and 3 m/s.

Example: Review for Final Exam

Given: Nathan is using a thermocouple in his experiment. Over the range of temperatures expected in the experiment, he performs a linear regression analysis of temperature as a function of voltage. His best-fit equation is T = -0.8563 + 23.782V, where V is the thermocouple voltage in millivolts. Nathan sends the voltage into an A/D converter that is 12-bit with a range of -0.25 to 0.25 V.

To do: Estimate the error in Nathan's temperature calculation due to the quantizing error of the A/D converter.

Solution:

Example: Review for Final Exam

Given: A signal ranges between –0.30 V and 1.20 V. The signal is to be sampled by an A/D converter that has an input range of 0 to 5 V. For maximum resolution, the signal is to be conditioned such that it fits the full input range of the A/D converter. Obviously, a DC offset must be added to the signal, and then the modified signal must be amplified.

(***a***) **To do**: Calculate the required DC offset and amplification (gain).

Solution: We did this part last lecture: $\boxed{\text{Add a DC offset of 0.30 V}}$ so that the *minimum* voltage jumps up from -0.30 to 0.0 V, and the *maximum* voltage jumps from 1.20 to 1.50 V. Then we need to $\boxed{\text{supply a gain of 5.00/1.50 = 3.333…}}$ to get the conditioned signal to range from 0 to 5 V so that it fits nicely into the range of the A/D without clipping and with maximum resolution.

(***b***) **To do**: Suppose the following are available: several 10 kΩ resistors, one 3 kΩ resistor, two type 741 op-amps, a +15 V DC and –15 V DC power supply, and a variable DC voltage supply (range = 0 to 5 V). Design a circuit to provide the necessary DC offset and gain, and draw a schematic diagram. Use inverting op-amp circuits.

Solution:

Example: Review for Final Exam

Given: Mallory has to measure some very high pressures (up to 5 atmospheres gage pressure), and none of the available pressure gages go that high. So, she decides to build a cylindrical strain gage pressure sensor out of a thin-walled cylinder that is available in the lab. She attaches a strain gage on the outside of the cylinder in the circumferential ("hoop") direction, and builds a quarter-bridge Wheatstone bridge circuit on a breadboard. Here are the dimensions and parameters:

- cylinder diameter = D = 2.00 in (0.0508 m)
- cylinder wall thickness = t = 0.085 mm (8.5×10^{-5} m)
- Young's modulus = E = 205 GPa (2.05×10^{11} N/m^2)
- Poisson's ratio = $\nu = 0.318$
- strain gage factor = S = 2.02
- number of active strain gages in bridge = n = 1 (it is a quarter bridge circuit)
- supply voltage to Wheatstone bridge = V_s = 10.0 V

To do: Predict the bridge output voltage V_o for the maximum expected pressure.

Solution: