

## ME 461 Prelab #5

Fall 2016

**Question 1 is due by the beginning of your lab period either 10/6/16 or 10/7/16. The remaining problems are due at the start of lecture on 10/12/2016**

### Suggested Reading:

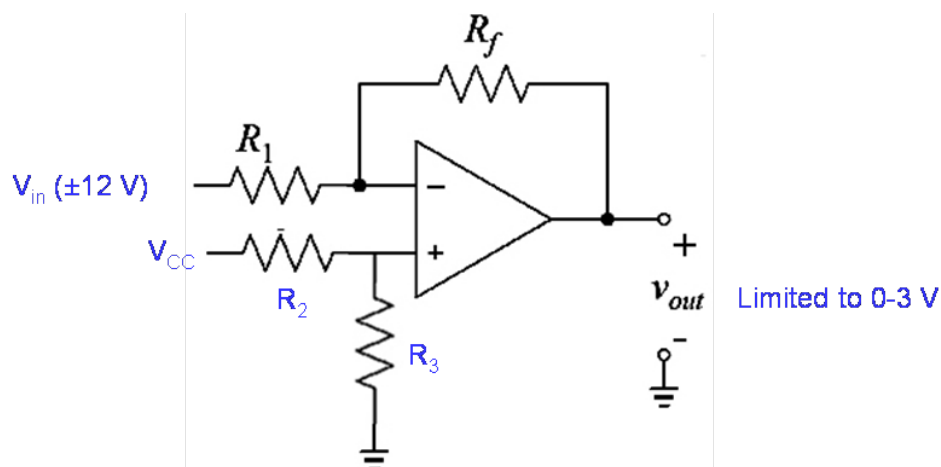
Lecture Notes

[LMD18200 Datasheet](#)

[LM741 Datasheet](#)

[Lab 5 manual](#)

1. With your lab partner, solder your microcontroller board as per the lab write up and the demo board. There is an additional circuit board that you will solder for the Op Amp circuit used for gain and shift. You will notice that the output of the Op Amp is not wired to an ADC input yet. Make sure to leave it that way until lab when you will adjust the gain of offset to the 0 to 3.6V range of the ADC. After you are finished soldering the Op Amp board, make sure to study it and understand that it is wired as per the schematic given in lab exercise 1. There is also a five pin header that you need to wire and solder to get you ready for lab exercises 4-7.
2. In question one above you soldered the Op Amp circuit given here and in the lab. Using the "Golden Rules" of an ideal amplifier to show (derive) that  $V_{out}$  is given by the below equation. If we would like this Op Amp circuit to take as the input an analog voltage in the range of -12 V to 12V and output a gained and shifted analog voltage in the range of 3-0 V, what should be the ratio of  $R_f/R_1$ ?



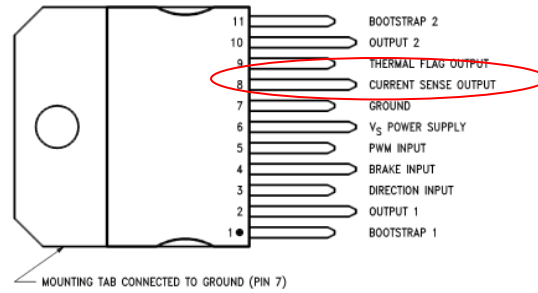
$$V_{out} = -\frac{R_f}{R_1} V_{in} + \left( \frac{R_3}{R_2 + R_3} + \frac{R_3}{R_2 + R_3} \frac{R_f}{R_1} \right) V_{CC}$$

3. Draw a schematic design using a NPN transistor to enable an I/O pin of the MSP430F2272 to turn on and off a 12V relay that has a coil resistance of  $250\Omega$ . The relay's electromagnet is an inductive device so make sure to add a fly back diode. The relay could turn on and off many different large current loads but for this problem have it turning on a motor to spin in one direction. Below is a picture of a relay. Make sure to explain how you chose the transistor's base input resistor in order that the transistor is working as an on/off (or saturation/cutoff) switch.



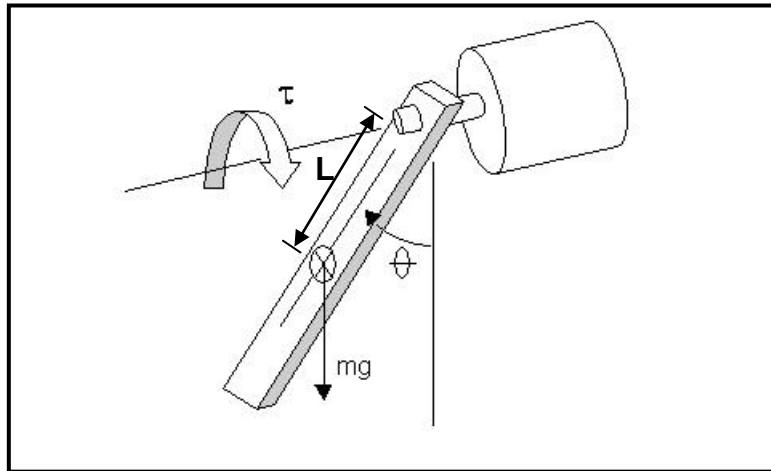
4. Draw the schematic of the standard H-bridge circuit we discussed in lecture. Make sure to include the fly back diodes. Explain which transistors need to be on and which transistors need to be off to make the motor spin in the positive direction. You will need to specify the motor+ and motor- connections of the motor. What needs to happen to reverse the motor's direction? What On-Off configuration of the transistors can be used to help stop the motor from spinning (this is called the brake mode)? It may be helpful to draw three schematics for this problem noting the flow of current in the three cases, but make sure to also explain in words the three cases.

5. Suppose a  $1\text{ k}\Omega$  *Sense* resistor is connected between the LMD18200 current Sense pin and GND.



What is the motor current if the voltage across the *Sense* resistor is  $1.43\text{ V}$ ? (Hint:  $V_{\text{sense}} = i_{\text{sense}}R_{\text{sense}}$  and  $i_{\text{sense}} = K_{\text{sense}}i_{\text{motor}}$ , where  $K_{\text{sense}}$  is a constant.)

6. Draw a free-body diagram for the linkage plus DC motor shown below and determine the equation of static equilibrium for the link plus motor.



Assume that motor torque is related to motor current by  $\tau_{\text{motor}} = K_{\text{motor}}i_{\text{motor}}$ , and that you can determine the motor current as you did in the previous question. Show that the voltage across the *Sense* resistor is directly proportional to the sine of the link angle,  $V_{\text{sense}} = K\sin\theta$ , where the constant  $K$  depends on  $K_{\text{sense}}$ ,  $R_{\text{sense}}$ , mass  $m$ , acceleration due to gravity  $g$ , link effective length  $L$ , and motor constant  $K_{\text{motor}}$ .