Guidelines:

1. Work in your assigned teams to complete tasks 1 through 3 in lab today
2. Complete tasks 4-7 on your own (with appropriate help from your teammates)
3. Each student will turn in their own work
4. The objective is to use an experimental Bode magnitude plot to confirm the parameter values we have previously measured

Project Description:

At your station you will see an unloaded DC motor driven by a function generator. Motor speed will be measured by a microprocessor and plotted in Matlab.

Tasks:

1. Determine the range of frequencies you will need to create a Bode plot
   a. We now have estimates for all six parameters of the DC motor transfer function: $\frac{\Omega(s)}{E_{in}(s)} = \frac{K}{(Js+b)(L_a s+R_a)+KK_b}$
   b. The measured and calculated parameters should have been close to the following (but use your own numbers):

$R_a = 9.2\Omega$	$L_a = 0.21\ mH$	$K_b = 0.014\ \frac{V\ s}{rad}$	$K = 0.014\frac{N\ m}{A}$
$b = 3.0 \times 10^{-7}\frac{N\ m}{rad/s}$		$J = 2.8 \times 10^{-7}\ kg\ m^2$	

   c. For motors with small friction, the transfer function can be simplified to the following:

$$\frac{\Omega(s)}{E_{in}(s)} = \frac{\frac{K}{JL_a}}{(s+\sigma_m)(s+\sigma_e)}$$

   Where:

$$\sigma_m = \frac{KK_b}{JR_a} \text{ is the slower mechanical pole}$$

$$\sigma_e = \frac{R_a}{L_a} \text{ is the faster electrical pole}$$

   d. Using your parameter values, calculate the two pole values with this simplified model

   e. List your two poles from Project 2, Task 4b. How close are these values to what you just calculated?

   f. Because the function generator does not have a rad/s setting, find the breakpoint frequencies of your two poles from Task 1d in Hertz (Note: $\omega_{brk} = \sigma_*$ and $\omega = 2\pi f$)

g. Describe a strategy to pick 10 to 20 input frequencies to capture data to make a Bode plot showing the slower breakpoint frequency (you should focus on the range from a decade below your lowest breakpoint frequency to a decade above your breakpoint frequency)

h. Note that this strategy is just a starting point. In reality your lowest frequency will need to be low enough so that you can get at least three measurements before the magnitude drops off significantly. Your highest frequency will be at the point you start to notice that the DC motor can no longer move because the input is too fast to overcome the friction and inertia. This high frequency will likely be well before you get to your faster breakpoint frequency.

2. Install and setup the Matlab script for this project
   a. Download the *Project 3 Matlab Files* zipped folder from D2L, and unzip it to your desktop
   b. Set the correct com port in the *serial_start* file
      i. Start the Device Manager
      ii. Expand out the Ports tab
      iii. Look for which com port the USB Serial Device is on (you can unplug and plug it in if you are not sure which is correct)
      iv. Open the *serial_start.m* file and make sure the correct com port is used in the serial command on line 11
   c. Open the *Project3_BodeData* file

3. Create a Bode plot from measured data
   a. Verify that your function generator is set to create a sin wave with a ground to peak amplitude of 5 V, which is the input of the transfer function.
   b. Set your lowest frequency (in Hz) on the function generator and press the output button to turn it on.
   c. Run the Matlab script *Project3_BodeData.m* which will collect and analyze 5 seconds worth of data (you can change that number if you want)

d. Visually estimate the amplitude of the motor speed plot (in rad/s), which is the output of the transfer function
e. Record data for each of your desired frequency values
    i. In the Mag (Out/In) column, divide the visually estimated Motor speed amplitude by your input voltage of 5 (don't worry about units)

Input Voltage Amplitude (V)		5.00		
Freq. (Hz)	Freq. (rad/s)	Motor (rad/s)	Mag (Out/In)	Mag (dB)

f. Before you leave, carefully read Task 1h and use this information to make sure you have enough data

<u>Individual Portion</u>

4. Make a more accurate estimate of the mass moment of inertia
    a. Graph your Bode plot magnitude data from Task 3e on a semilog plot (you can use the command *semilogx* in matlab)
    b. Estimate the slower breakpoint frequency of your DC motor based on the magnitude plot
    c. Use the equations from Task 1b to calculate your moment of inertia, J

5. Create a theoretical Bode plot of the more accurate DC motor transfer function based on your DC Motor Values
    a. Use your J value from Task 4c, and all other values from previous projects.

6. Reflect on your Bode plot by answering the following questions
    a. Does your Bode plot from Task 4a look like what you would expect from a transfer function with one first order pole (or rather two, but truncated before we see the effect of the second)?

    b. How close is the slower breakpoint frequency from Task 5 to the experimental result from Task 4b?

    c. How closely do the low frequency magnitudes of Task 4 and Task 5 match?

7. Submit the following in class on the due date
    a. This filled in worksheet
    b. The published version of the Matlab plots from Tasks 4 and 5