EE C128 / ME C134 MagLev Lab Tips

General:

- Units are SUPER important! Always try to keep them straight. You can always use the equations to try to derive what units certain constants need to be.

    o Consider: x, y, a, K_i, K_x

    o Don't forget that there is an implied K_a = 1 A/V conversion through the voltage-to-current amplifier

    o Additionally, try to remember the difference between mass and weight.

- Working (not actual) constants for SMALL ball (make sure to use the appropriate signs!):
        $|a|$ = 600 V/m, $|K_x|$ = 29 N/m, $|K_i|$ = 0.04 N/A

- Hardware:

    o You keep (for now): breadboard, ball, 3 dual op-amp packages (AD822), 2 potentiometers

    o Leave in lab: scale, lifts, rulers

    o In lab: cables (in-between stations 204-02 and 204-03), resistors & wires (wall near window and whiteboard)

    o Each team needs to build their own controller circuit. (Label your bread board to prevent mix-ups with others)

- Your sensor is a photoresistor! This means that ambient lighting conditions will affect readings! Try to perform all measurements and experiments in the same conditions (lighting, positioning of maglev system, etc.)

Controller Design:

- For controller design, use MATLAB `sisotool` command to pick locations of your controller pole (b) and zero (a).

- `sisotool` is great for manually changing your controller design and watching the effects on your system. However, it's not possible to automate it from the command line to bring up your designed controller. Instead, you can use the `margin` command, which is the same as `bode`, except that it also displays the GM, PM, and ω_C.

- The reason for the margin requirements is to make the controller more robust to modeling uncertainties and disturbance. For more information on stability margin, please refer to *FPE6e Section 6.4*.

- How do you design your controller? You're given 3 unknowns: R$_1$, R$_2$, and C. Given that you want a certain Phase Margin, you should have your controller pole (b) and zero (a) from

`sisotool`, giving you two equations to work with. You get your third equation by setting the DC Gain to about 1.

Hardware Debugging:

- The connection diagram of the op-amp AD822 is shown below. Although each AD822 has 2 op-amps, you only need to use one op-amp on each AD822 since you are given 3 AD822 packages. The pins you will use would be PIN #1, #2, #3, #4, and #8. Don't forget to provide V_+ = 7V and V_- = -7V to the op-amps.

CONNECTION DIAGRAM
8-Lead Plastic DIP, MSOP, and SOIC

```
OUT1  1            8  V+
-IN1  2            7  OUT2
+IN1  3            6  -IN2
V-    4   AD822    5  +IN2
```
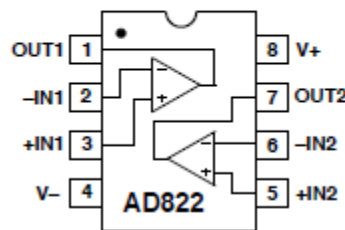
- Do NOT move the wires connecting the voltage-to-current amplifier and its power supply!!! (It's color-coded, so don't mix them up)
- Make sure there is a common ground (circuit, amp, amp power supply, DC power supply, electromagnet, LED, sensor).
- There is no need to measure the current in this lab. (You can measure the voltage input of current amplifier instead of measure its current output)
- If something starts to smell funny or something starts to get hot, TURN OFF THE POWER IMMEDIATELY.
- Common mistakes to check for:
    - Sensor output should be connected to rest of circuit (and sensor needs to be hooked up, too)
    - All outputs from DC power supply need to be on (+7/-7)
    - V_- port of op amps needs to be set to -7 V (why?)
    - I_o (current offset) is a NEGATIVE voltage (why?)
    - Circuit output needs to be connected to amp input
- **Easiest indicator of circuit problems:** cover the sensor entirely with your hand and the output DOESN'T change (bad)

- Best way to debug is methodically. Start at the beginning of your circuit (the sensor), and probe your way forward (voltage offset, then controller, then current offset, then finally output), making sure everything is behaving as it should.

Reading disturbance responses with oscilloscope:

- Inject a reasonable signal (square wave is easiest to see) from the signal generator into the output of your controller.
- Stabilize the ball and adjust the potentiometers if they need to be adjusted.
- Measure your output and disturbance input using two channels of the oscilloscope.
- To read the data from the oscilloscope into the computer:
  - Log into your computer
  - Turn on the oscilloscope
  - There should be a test and measurement device window open
  - Select open with LabVIEW Signal Express
  - Continue through license notification messages
  - Tek TDS1000/2000 should now show up in the left hand menu
  - Uncheck the SignalExpress controls instrument in order to operate the oscilloscope directly
  - You can now save the image or export the data
  - If there are any problems, look at the help file or ask the lab GSI
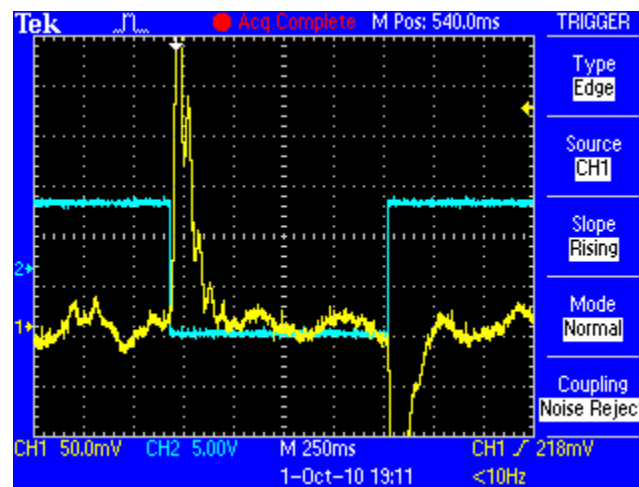
Revision History

Semester and Revision	Author(s)	Comments
Fall 2010 Rev 1.1	Wenjie Chen and Jansen Sheng	Added information about AD822 and reading data from the oscilloscope.
Winter 2008 Rev. 1.0	Justin Hsia	Wrote tips document.