Controls Lab

Course Description

The format of the course will be one lecture and one lab per week. So we will be doing a lab each week.

All of the labs are individual and you should count on spending a fair amount of time in the lab completing the lab assignments each week. This is true of any laboratory class because sometimes it takes some time to get things working in the lab. But your time will be well spent because you will learn a lot also.

I am looking forward to working with you this term.

Course Website Location: www.me.pdx.edu/~davet/ME_454_Controls_Lab/Index.htm

Lecture Videos: Type the following address in your browser:
https://media.pdx.edu/channel/ME_454_Controls_Lab/89852342

Grading

Your grade will be based on your weekly lab demonstrations, homework assignments, one formal report, and final exam that may have written part and a practical part.

Labs:

1. Introduction to Equipment (power supply, function generator, oscilloscope, Digital Multi-meter) and Introduction to experimental frequency response. Implement a simple RC filter and determine the frequency response. (1 week)
2. Introduction to OP-Amps I - Basic Circuits (1 week)
3. Introduction to OP-Amps II - Control Circuits (1 week)
4. System Identification of a DC motor. Using frequency response methods identify (i.e. determine the transfer function) of a DC motor system. Design a proportional controller and another type of controller (PI, PD, Lead, or Lag) to improve the performance of the motor system. (1 week)
5. Implement a basic closed loop velocity control system with op amps. (2 weeks)
6. Introduction to Digital Control Using LabView - Basic control loop (1 week)
7. Digital Position control using various controllers (lead, lag, PD, state space) (2 weeks)

Final exam: TBD

Equipment:

For some of the smaller items you could coordinate your orders with other students to save on shipping. I would recommend you get the items that I suggest, and don't make substitutions, to make sure you will have everything you need for the labs. If you do make a substitution make sure what you are getting is equivalent. You will need almost everything for the first lab (Monday March 28), except where noted. So get things ordered soon.

1. One Large Breadboard (similar to one of the breadboards below). If you are taking both the labs (ME454 and ME460) you will need two of these. Evan if you are taking just ME 454 some students have found it useful to have two of these breadboards so that you can keep the previous labs hooked up and don't have to disconnect them to do the next lab.
   https://www.sparkfun.com/products/12614

   https://www.amazon.com/Elenco-Breadboard-Total-Contact-Points/dp/B0002H4W0K/ref=sr_1_7?dchild=1&keywords=large+electronic+breadboard&qid=1615836079&sr=8-7

2. Hook up Wire (solid 22 gage wire red, black, green)
   http://www.amazon.com/Electronix-Express--Hook-Wire-Solid/dp/B00B4ZRPEY/ref=sr_1_1?ie=UTF8&qid=1463595171&sr=8-1&keywords=hook+up+wire+solid

3. Resistor kit (There are slightly cheaper kits but for organizing defiantly get one in which the resistors are separately bagged and easy to access. Also if you choose a different kit make sure it has the same resistor values as this kit). This is the one that I normally recommend, but this seems to be currently unavailable.
   http://www.amazon.com/Joe-Knows-Electronics-Value-Resistor/dp/B003UC4FSS/ref=sr_1_8?ie=UTF8&qid=1457040790&sr=8-8&keywords=resistor+kit

   This one is a good alternative.
   https://www.amazon.com/Precision-Electronic-Assortment-1ohm-1Mohm-Geekstory/dp/B079FP5WD9/ref=sr_1_5?keywords=resistor+kit&qid=1583345199&sr=8-5

   20k resistors The kit doesn't have these but they are useful for multiple of 2 gains
   https://www.amazon.com/EDGELEC-Resistor-Tolerance-Resistance-Optional/dp/B07HDGCGB3/ref=sr_1_3?dchild=1&keywords=20k%2Bresistor&qid=1618870136&sr=8-3&th=1

   Additional 10k resistors (Optional) Everyone always uses a lot of these
   https://www.amazon.com/EDGELEC-Resistor-Tolerance-Resistance-Optional/dp/B07HDGX5LM/ref=sr_1_6?dchild=1&keywords=10k+resistors&qid=1616008855&sr=8-6

4. Capacitor kit (There are slightly cheaper kits but for organizing defiantly get one in which the capacitors are separately bagged and easy to access. Also if you choose a different kit make sure it has the same capacitor values as this kit)
   https://www.amazon.com/Joe-Knows-Electronics-Value-Capacitor/dp/B007SVHFXO/ref=sr_1_1?ie=UTF8&qid=1457041045&sr=8-1&keywords=capacitor+kit
   or
   https://www.amazon.com/Capacitor-Assortment-Capacitors-Electronics-Audio-Video/dp/B089W1K4YS/ref=sr_1_3?crid=HVX8W25JCOQU&keywords=capacitor+kit&qid=1647287689&sprefix=capacitor+kit%2Caps%2C125&sr=8-3

5. Additional (higher capacitance) Ceramic (not Electrolytic) Capacitors (Get 10 of the 1uf and 10 of the 10uf). It is not necessary this term to order these additional capacitors this term because the kit above includes these.

   1uf
   https://www.digikey.com/en/products/detail/kemet/C440C105M5U5TA7200/818296?s=N4IgTCBcDaIMIBYEAY4EZkFYCymCqmAKgIIDsYyyIAugL5A
   or
   https://www.amazon.com/mxuteuk-Multilayer-Monolithic-Ceramic-Capacitor/dp/B08BF91KY3/ref=sr_1_5?crid=2AO4NXZAKAOV3&dchild=1&keywords=capacitor+1uf&qid=1615836598&sprefix=capacitor+1uf%2Caps%2C229&sr=8-5

   10uf
   https://www.digikey.com/en/products/detail/tdk-corporation/FG16X7R1E106KRT06/5802770?s=N4IgTCBcDaIGIHECMA2AGgdgEpIKJIAYUBpLAFSJAF0BfIA
   or
   https://www.amazon.com/mxuteuk-Multilayer-Monolithic-Capacitor-10uf-106/dp/B08BFN3Z8V/ref=sr_1_20?dchild=1&keywords=10uf+capacitor&qid=1615836981&sr=8-20

6. Jumper Wire 1 (makes laying out organized breadboard circuits easier)

   https://www.amazon.com/Organizer-Assorted-Preformed-Breadboard-Prototyping/dp/B07YDC9V2C/ref=sr_1_13?dchild=1&keywords=jumper+wire+kit&qid=1615837683&s=hi&sr=1-13

7. Jumper Wire 2 (optional, useful for patching together quick circuits, but messy)

   https://www.amazon.com/Breadboard-Bestlus-Exclusives-Raspberry-Male-Male/dp/B09H2TRZHB/ref=sr_1_12_sspa?crid=VM59W1XRFW3P&keywords=jumper%2Bwire&qid=1647288178&s=hi&sprefix=jumper%2Bwire%2Ctools%2C109&sr=1-12-spons&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUEzOTRRQUZGWjJBQllVJmVuY3J5cHRlZElkPUEwODgzNjUzMTAwVDUyOENLRFM3UyZlbmNyeXB0ZWRBZElkPUEwMzE1MDUwM044SjY1QkYzUEw0SiZ3aWRnZXROYW1lPXNwX210ZiZhY3Rpb249Y2xpY2tSZWRpcmVjdCZkb05vdExvZ0NsaWNrPXRydWU&th=1

8. Wire Stripper:

   https://www.amazon.com/Paladin-Tools-PA1161-Adjustable-Stripper/dp/B07ZHMQV3Y/ref=sr_1_18_sspa?dchild=1&keywords=wire+stripper&qid=1615837897&s=hi&sr=1-18-spons&psc=1&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUEyNFdBQ0Q0OFhXSzNSJmVuY3J5cHRlZElkPUEwMjM4MzE0MzNaRU9ZRjdZSFZTOCZlbmNyeXB0ZWRBZElkPUEwODg3NDQ2MVk3VTZVUE5GSjZJRCZ3aWRnZXROYW1lPXNwX210ZiZhY3Rpb249Y2xpY2tSZWRpcmVjdCZkb05vdExvZ0NsaWNrPXRydWU=

9. Small 3 mm flat Screwdriver: Available at any Hardware store or in a set at Harbor Freight

   http://www.harborfreight.com/6-piece-precision-screwdriver-set-47823.html

10. OP Amps (get 10-20) Number depends on how many you plan to burn up. (I will provide the Op Amps this term)

    https://www.digikey.com/product-detail/en/texas-instruments/LM348N/296-12849-5-ND/476163

11. Banana Plugs – Optional but useful

    https://www.amazon.com/WWZMDiB-Speaker-Banana-Plugs-Open-Connectors/dp/B0BTYKFGLN/ref=sr_1_7_sspa?dib=eyJ2IjoiMSJ9.JVDlKreo9rg5TCCCPJVvaI6iLHxz0seqBqWGkq0x9eLy4bznPJxvgY8VFbnYgDkiY1KLh0lVJ_a9qCwBX6ERUC2ujRYRp1vFeLLKjKFi3UhCHPUHIg2YZHKi3wKP9qPg-gqbum-nv2C6tGzalr1JhlmshcKADpMAmMGuGmtQShw3X8_PDGm6o00UzuGAMF7Ik4CK4VbeWyDYx69LEYVzbvz2hfnOVmpG-oINTHSSwuA.--MpsrKx_tleQV6XBcBY_yq4klp-eyaQxwgrjPzoHt0&dib_tag=se&keywords=banana%2Bplugs&qid=1710261284&sr=8-7-spons&sp_csd=d2lkZ2V0TmFtZT1zcF9tdGY&th=1

12. Inductor Coil 100 mH (approximately $5.00) (Not needed until week 5)

https://www.digikey.com/en/products/detail/bourns-inc/70F101AF-RC/774933?s=N4IgTCBcDaIOwAYBiBGBKCCSC0AlAwiALoC%2BQA

13. One Potentiometer (5k) (Not needed until week 2)

https://www.digikey.com/en/products/detail/bourns-inc/PV37W502C01B00/666610?s=N4IgTCBcDaIAoDUDMB2A6gVgAxgMJYEYAhLLEAXQF8g

or from Amazon

https://www.amazon.com/Kalevel-Resistor-Potentiometer-Assorted-Precision/dp/B015RK632Q/ref=sr_1_20?dchild=1&keywords=5k+potentiometer&qid=1615838739&sr=8-20
or
https://www.amazon.com/Hilitchi-120-Pcs-Multiturn-Potentiometer-Assortment/dp/B07146ZJJ3/ref=psdc_306810011_t1_B015RK632Q

14. Teensy 4.1 Development Board (TEENSY41_PINS with Pins Soldered) (Not needed until week 5)

https://www.pjrc.com/store/teensy41_pins.html

without pins: (get this one if the one with pins is not available, will need to solder the pins on)

https://www.amazon.com/PJRC-Cortex-M7-Processor-iMXRT1062-Without/dp/B088JY7P2H/ref=sr_1_1?crid=BC8T20W4S2AN&dib=eyJ2IjoiMSJ9.-RBOr7VJyn_8qDhLapoMmfX6PLCKFXpQObFA-oVMQhQvNUpIlmc9jVZVJZM8Md6PzSUdFhhXJA4x8uMlFEHy4vNcuLzpX__d4uSFlcNFFrI3gDA3Y1nysGsgRT83qpPfKidQRjKoqTxglbNQsN4u4zgObuajamDxfCtmfP3RUri7DmoVkCFxH8U8oHLqFXYUfRseD9e8mEq-4C8f279Sdz8FtuINpdycdnA4TeHanGY.7AhKcm1vdMYN7HxwM4ZCNm2F0dkTSjsx3BaL1jtb7Mg&dib_tag=se&keywords=teensy+4.1+with+pins&qid=1710262050&sprefix=Teensy+4.1%2Caps%2C138&sr=8-1

15. Digital to Analog Converter (DAC) (get at least 2)

https://www.jameco.com/z/MCP4921-E-P-Microchip-Technology-IC-MCP4921E-P-Digital-to-Analog-Converter-12-Bit-DIP-8-pin_2207401.html?CID=GOOG

16. Micro USB cable for the Teensy Board. Like the one below (you only need one cable)

https://www.amazon.com/UGREEN-Braided-Charger-Charging-Controller/dp/B0773N757H/ref=sxin_15_cpf_saw-CPFPecos-dsk-lmlk-asin?crid=3U780TYB8AGAN&cv_ct_cx=micro+usb+cable&keywords=micro+usb+cable&pd_rd_i=B0773N757H&pd_rd_r=0c48e886-9f9b-4acf-bf16-d9014980d00d&pd_rd_w=ylT9u&pd_rd_wg=1Zmym&pf_rd_p=3171e255-0ecb-47e8-9210-cfa1596239ed&pf_rd_r=CPQHC513H679J33KRZA1&qid=1647288805&sprefix=micro+usb+cable%2Caps%2C134&sr=1-3-88bb4e7b-fb79-43dc-9dec-6da196f88672

A lot of the items are available at Digikey so you might want to coordinate ordering those items from Digikey to save on shipping.

Lab Rules

- DO NOT remove any equipment or materials from the lab

- Get to the Lab Lecture on time – Important information concerning your safety, the safety of the equipment and information about the current lab will be discussed. DO NOT attempt to do the lab if you miss the lab lecture.

- Respect the Equipment. Many devices are destroyed if you apply to large a voltage or the incorrect polarity. Before you make any connections to a device make sure all of the power is off and double check your connections before you turn the power on. All of the pertinent information about how equipment should be used is discussed in the lab lecture.

- You will have keycard access to the lab afterhours. Under no circumstances should you ever let anyone into the lab that does not have card key access. Also never prop the door open.

- Work individually. You certainly may discuss the lab with the other people in the class but be certain that you complete each lab individually and completely understand what you did and the reasons for doing it for each lab. Note below that there is a final exam at the end of the term on the lab material. Any work that is presented in your weekly lab review or handed must be your individual work.

- When finished working.
    - Turn off all equipment
    - Completely unhook your breadboard from all equipment and move it out of the way
    - Clean up your area: Remove all loose parts and neatly stow the wires and cables

- When finished using shared equipment or tools return the equipment or tools to the common area.

Lab Tips

- Use red wire for positive voltage (i.e. +15v), use black wire for the ground and use green wire for negative voltage (i.e. -15v)

- Keep the wiring as neat as possible. Run the traces horizontally and vertically whenever possible. A neat wiring job will make it much easier to troubleshoot when things don't work properly. One minute spent laying out the circuit neatly will save 30 minutes troubleshooting. Many students have tested this theory but none have proved it wrong.

Lecture/Lab Format

Monday will normally be a lecture covering background material for the course and lab with time remaining to get started on the lab. On Wednesday there may be a short lecture discussing the lab and the remaining class time can be used to get started on the lab when I am easily available to help.

Lab Presentations

The lab presentations each week should be treated as a regular formal presentation not an informal presentation. In other words, have all of your information organized (in one file) and ready to present in an efficient manner. Your presentation should include background information about what you did and why you did and any conclusions or discrepancies you found. It should include all the required plots and comparisons that you were asked to find. If there is a section of the lab that does not require a plot or something to show in the end show screen shots of what you did and summarize the information in a table if applicable.

Lab Presentation Late Policy: 5% deduction per day late (in increments of 5%)