

Tasks & Applying Knowledge of ECE

Work Breakdown Structure

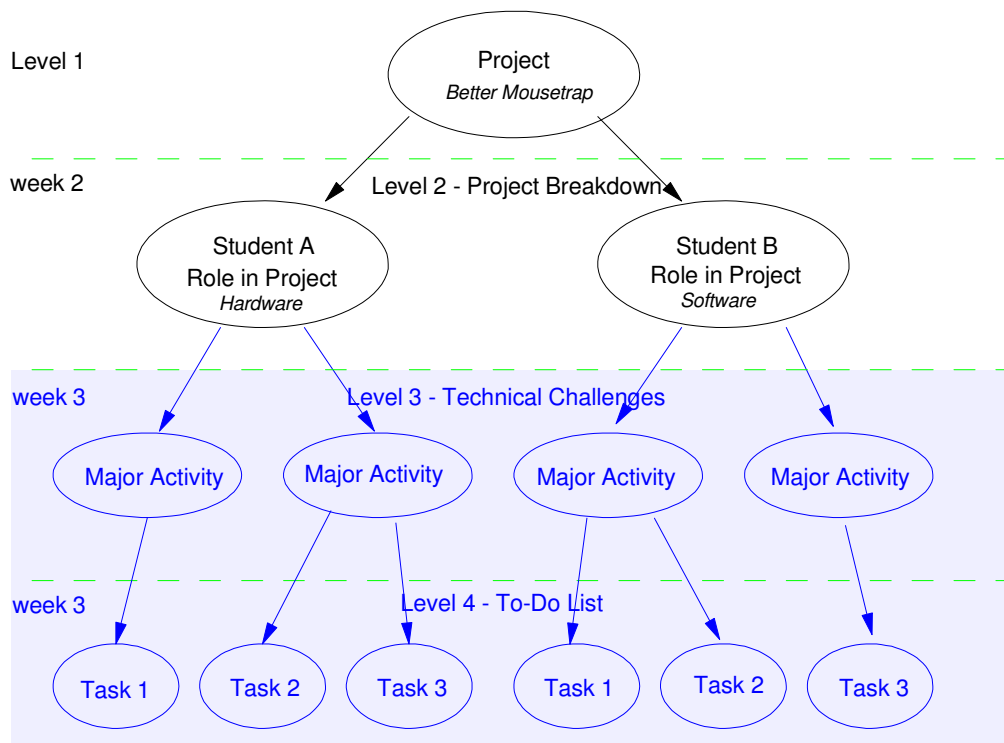
At this point, you should have

- Your Senior Design Project
 - Level 1 of the Work Breakdown Structure
- The role of each student in your project
 - Level 2 of the Work Breakdown Structure

This week, the goal is to fill in the next two levels and define

- The technical challenges you need to solve for your part of the design (level 3),
- What tasks or activities you need to complete in ECE 403 so that these challenges are solved by the time you start ECE 405 (level 4), and
- Specify how you are going to demonstrate knowledge of ECE while doing so.

The last bullet is kind of important. Since students taking ECE Senior Design will be getting a degree in electrical, computer, or software engineering, you *do* need to demonstrate knowledge of ECE in some way. After all, half of your grade in ECE 403 depends upon this.



Level 3: Major Activities (Technical Challenges) (HW3)

Level 3 breaks your project down into a list of major activities, or identifies what the technical challenges need to be solved so that you're ready when ECE 405 starts.

Think about

- What your project is and what your role is for this project, and
- What technical challenges you need to solve in ECE 403 for your project to work.

Add this list to your section of OneNote.

For example, suppose your project is to build a better mouse trap (level 1). Some of the technical challenges could be:

Role = Hardware (Level 2)

- Detecting a mouse is in the trap
- Opening and closing the door

Role = Software (Level 2)

- Communicating with a cell phone to indicating the mouse trap is empty / full
- Communicating with the hardware to open/close the door
- Communicating with the hardware: mouse is present / not present

Level 4: Tasks (To-Do list) (HW3)

(And apply knowledge of ECE)

Once you've identified what technical challenges you need to solve in ECE 403, come up with a list of tasks to complete this semester (i.e. a to-do list). Also indicate how you'll be applying knowledge of ECE in your design.

There are many ways to apply knowledge - as long as you've included four, you're good.

For example, let's go back to the mousetrap. Some tasks along with what ECE knowledge this demonstrates could be:

Challenge: Detecting a mouse is in the trap

- Task: Detect a mouse using an ultrasonic range sensor (software)
 - ECE Knowledge: Timer1 Capture interrupts (ECE 376)
 - Statistics: Student-t test to find the 90% confidence interval (ECE 341)
 - Digital filtering: remove the noise to get a better reading (ECE 343)
- Task: Detect a mouse using a vibration or acoustic sensor (hardware)
 - Instrumentation Amplifier: Amplify sensor to -10..+10V (ECE 311)
 - Analog Filtering: Reduce the noise level (ECE 321)
 - Envelope Detectors: Convert AC to DC, level = amplitude (ECE 321)
- Task: Detect a mouse using motion / shadows (software or hardware)

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- SPI Communications: Read a 16-bit A/D to get better resolution (ECE 376)
 - High-Pass Filters (differentiates): ECE 321 and ECE 311
 - Amplifiers and Mixers (get 0-5V out): ECE 311 and ECE 321

Challenge: Open and Close a Door

- Task: Use a stepper motor to open/close a door
 - Stepper Motor: Drive a stepper motor (ECE 376 - software)
 - H-Bridge: Build an H-bridge to drive the stepper motor (ECE 321 - hardware)
- Task: Use a solenoid to open/close a door
 - BJT Switch (ECE 320)
 - Mosfet Switch (ECE 320)

Challenge: Communicate with a Cell Phone

- Task: Send BlueTooth data with a uP (PIC, Arduino)
 - SCI Communications (ECE 376)
 - LCD Display (watch the SCI data communications - ECE 376)
 - Custom cell phone apps (CSxxxx)
 - Software UART using Timer0 (ECE 376 - if you need a second UART)

Challenge: Coordinate the hardware using software

- Task: Write a C program to read the sensors, drive the actuators, and provide user data on his/her cell phone
 - Top-Down Programming: Writing and testing a C program using top-down techniques (CSxxx)
 - Bottom-Up Programming: Writing and testing a C program using bottom-up techniques (CSxxx)
 - Use of Modules and Subroutines: Writing and testing a C program using CSxxx techniques
 - Use of tables and data bases (CSxxx)

There's almost a limitless number of ways to tackle any given problem. For ECE 403, as long as

- You have a working solution going into ECE 405 for each of your technical challenges, and
- Each student is able to demonstrate his/her ability to apply knowledge of ECE four different ways, you've done enough to earn an A in ECE 403. You can do more, but that is enough to get an A.

Gantt Chart

Gantt Charts help you plan out the semester

- What activities do you need to complete,
- How much time do you allocate for each activity, and
- When these activities are to take place.

Essentially, a Gantt Chart is a tabular form of each person's Work Breakdown Structure. The list of tasks kind of depends upon which project management structure you're using.

Waterfall: If you are going to do your tasks one at a time, your Gantt chart might look something like this:

- Each task corresponds to one of the technical challenges you need to solve in ECE 403, and
- It also specifies which ECE topic you'll demonstrate on that task.

The latter serves as a reminder that when you're doing Task 2, you should include information showing your understanding of and ability to apply your knowledge of filters when designing an acoustic sensor.

Tasks	Week															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Project Selection																
Project Breakdown																
Work Breakdown Schedule																
Acoustic Sensor Task 1: Inst Amp (ECE 321)																
Acoustic Sensor Task 2: Filtering (ECE 311)																
Door Task 3: Stepper Motors (ECE 376)																
Door Task 4: Solenoid (ECE 320)																
Sr Design Expo																

Gantt Chart for a Waterfall-Type Project

Agile: If you are going to start with a rough prototype then keep improving it, your Gantt chart might look like this:

Tasks	Week															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Project Selection	█															
Project Breakdown		█														
Work Breakdown Schedule			█													
1st Prototype Task 1: Detect Mouse, Open Close Door				█	█	█	█									
2nd Prototype Task 2: Improvement								█	█	█	█					
3rd Prototype Task 3: Improvement												█	█	█	█	
Sr Design Expo																█

Gantt Chart for an Agile-Type Project

It's more or less up to you - just specify

- What activities you're planning on doing in ECE 403 (tasks), and
- When you plan on doing these tasks

with the end date being the end of the semester.

OneNote Sections

Documenting this in OneNote is a little tricky since you're trying to do two things at once:

- Document your work on each of your tasks, and
- Demonstrate your ability to apply knowledge of ECE four different ways.

How you organize your OneNote section is up to you. As long as you meet both objectives and the grader can find this information, any organization works.

Some suggestions based upon how your project is organized follows:

WaterFall: With a waterfall-type of project, you work on the tasks one at a time. This works well in OneNote: each page can contain:

- A different task, and while working on that task,
- Demonstration of your ability to apply knowledge of ECE

Note: You only need to demonstrate your ability to apply knowledge of ECE four different ways. If you have more than four tasks, it's perfectly OK to complete the latter tasks without dwelling on how you're applying knowledge of ECE in these latter sections.

If you're using a WaterFall approach for your project, your OneNote document might look something like this:

OneNote Section	Pages Within Section	Content
Student A	HW3: Work Breakdown	Role in Project Major Activities (technical challenges) Tasks to complete in ECE 403 Gantt Chart for ECE 403
	HW4: Task #1 (ECE Topic #1)	Task and/or Technical Challenge you're solving. Include: <ul style="list-style-type: none"> - Task Description - Advanced ECE Topic this demonstrates - Analysis & schematics - Simulation results (analysis is good) - Breadboard results (analysis is good) - Photos and videos
	HW5: Task #2 (ECE Topic #2)	ditto but for <ul style="list-style-type: none"> - A different task / challenge, and - A different area of knowledge of ECE
	HW6: Task #3 (ECE Topic #3)	ditto
	HW7: Task #4 (ECE Topic #4)	ditto
	HW8: ECE Tools	Note which two ECE tools you used to validate your design was working

Possible OneNote organization for a waterfall-type of project

Agile: With an Agile-type of project, you focus on getting a prototype out quickly. Then, with feedback on that prototype, you improve your design several times.

Documenting your work with this format as well as how you've applied knowledge of ECE is a little tricky. One way to do that is to have

- Separate pages for each iteration. This is where most of your documentation and results would go. Then have
- Additional sections where you point out how you applied knowledge of ECE in your design.

The additional sections are important since this amounts to half of your grade in ECE 403. For these sections, you don't need to copy or duplicate information in previous sections - just refer to it. The grader will be able to see your previous pages in OneNote.

OneNote Section	Pages Within Section	Content
Student A	HW3: Work Breakdown	Role in Project Major Activities (technical challenges) Tasks to complete in ECE 403 Gantt Chart for ECE 403
	1st Prototype most of the content is here	Description open/close mousetrap door prototype #1 Analysis & Schematics Simulation Results Breadboard Results Photos of breadboard, oscscope, etc Links to videos showing it worked (YouTube?)
	2nd Prototype	ditto
	HW4: ECE Concept 1	Short discussion on 1st ECE concept you demonstrated in previous pages
	HW5: ECE Concept 2	2nd ECE concept
	HW6: ECE Concept 3	3rd
	HW7: ECE Concept 4	4th
	HW8: ECE Tools	Note which two ECE tools you used to validate your design was working - you don't need to duplicate content - just refer to where you demonstrated use of two different tools

Possible OneNote organization for an agile-type of project

Examples of OneNote Pages:

Assume you're using a waterfall-type of project organization with

- N tasks specified for ECE 403, and
- Each task highlights your ability to apply a different set of knowledge of ECE.

Task 1: Trap Empty / Full Indicator

Description: Turn on an LED when the mousetrap is full, off when empty.

ECE Knowledge: Using a BJT transistor as a switch (ECE 320)

Requirement:

- Input:
 - 12V power supply, capable of 1A
 - A: TTL input: 0V/5V capable of 10mA
- Output: 5W white LED. $V_f = 5V @ 1A$
- Relationship:
 - When A is 0V, the LED is off
 - When A is 5V the LED is on, drawing 500mA, +/- 10mA

Analysis:

Pick a 6144 NPN transistor

- Capable of 3A continuous, 10A peak
- $200 < \text{gain} < 500$
- $V_{be} = 0.7V$
- $V_{ce(sat)} = 0.36V$

Calculations:

$$R_c = \left(\frac{12V - 5V - 0.36V}{500mA} \right) = 13.28\Omega$$

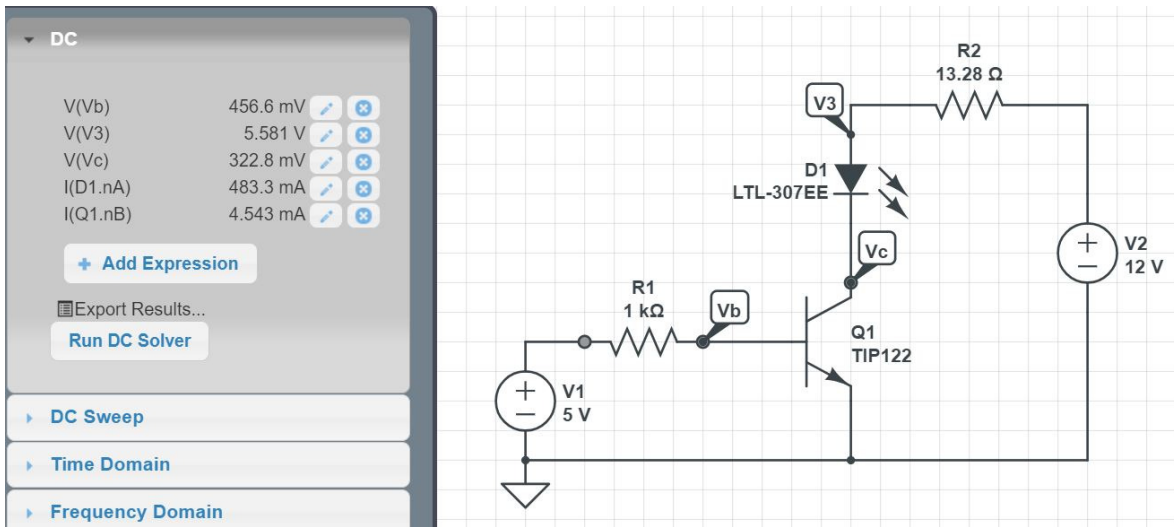
$$\beta I_b > I_c$$

$$I_b > \frac{I_c}{\beta} = \frac{500mA}{200} = 2.5mA$$

Let $I_b = 4.3mA$

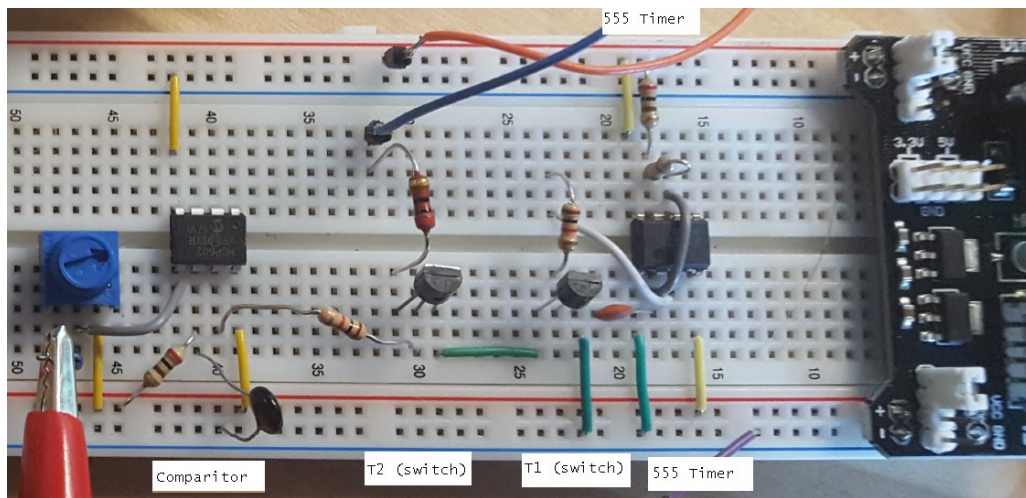
$$R_c = \left(\frac{5V - 0.7V}{4.3mA} \right) = 1k\Omega$$

Simulation:



Breadboard:

(include a photo similar to this - this is actually a different circuit but same idea...)



Summary:

	Calculation	Simulation	Breadboard
12V source	12V	12V	12.13V
5V source	5V	5V	4.89V
Rc	13.28	13.28	12.04
Rb	1k	1k	986
Vb(on)	700mV	456mV	723mV
Vce(on)	360mV	322mV	68mV
Vd	5.0V	5.258V	5.25V
Ib	4.3mA	4.543mA	4.27mA
Ic	500mA	483.3mA	479mA

Comments:

- Task #1 is completed: an LED indicator light can be turned on and off electronically.
- My ability to use a BJT transistor as a switch was demonstrated. The results were similar to what was expected. The slight differences in the voltages and resistances (actual vs. ideal) caused most of the differences.

Task #2: Noise Reduction

Description: Reduce the noise level on a temperature reading. This reduces the size of the 90% confidence interval for the actual temperature.

ECE Knowledge: Active Low-Pass Filters (ECE 321)

Requirements:

- Input: +/- 5V analog signal, capable of 10mA, 20-20kHz
- Output: +/- 5V analog signal, capable of 10mA, 20-20kHz
- Relationship:
 - $0.9 < \text{gain} < 1.1$ $0-100\text{Hz}$
 - $\text{gain} < 0.2$ $f > 200\text{Hz}$

Analysis:

Number of poles needed in the filter

$$\left(\frac{250\text{Hz}}{500\text{Hz}}\right)^n < 0.2$$

$$n > 2.32$$

Let $n = 3$.

Pick a 3rd-order Chebychev filter with a corner at 238Hz

With a corner at 1 rad/sec

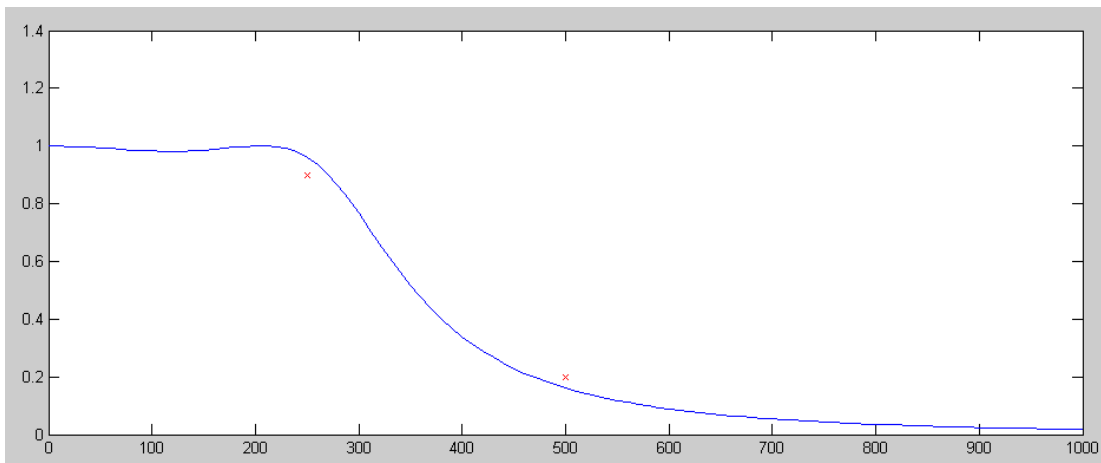
$$G(s) = \left(\frac{1}{(s+0.85)(s+1.21\angle\pm 69.5^\circ)} \right)$$

With a corner at 238Hz:

$$G(s) = \left(\frac{k}{(s+1275)(s+1815\angle\pm 69.5^\circ)} \right)$$

Checking in Matlab if this meets the requirements

```
>> f = [0:10:1000]';
>> w = 2*pi*f;
>> s = j*w;
>> p1 = 1500 * 0.85;
>> p2 = 1500 * 1.21 * exp(j*69.5*pi/180);
>> p3 = conj(p2);
>> G = p1*p2*p3 ./ ( (s+p1).*(s+p2).*(s+p3) );
>> plot(f,abs(G), [250,500], [0.9,0.2], 'rx');
```



That works. To build this filter, do it in three stages

$$\left(\frac{1}{RC}\right) = 1275$$

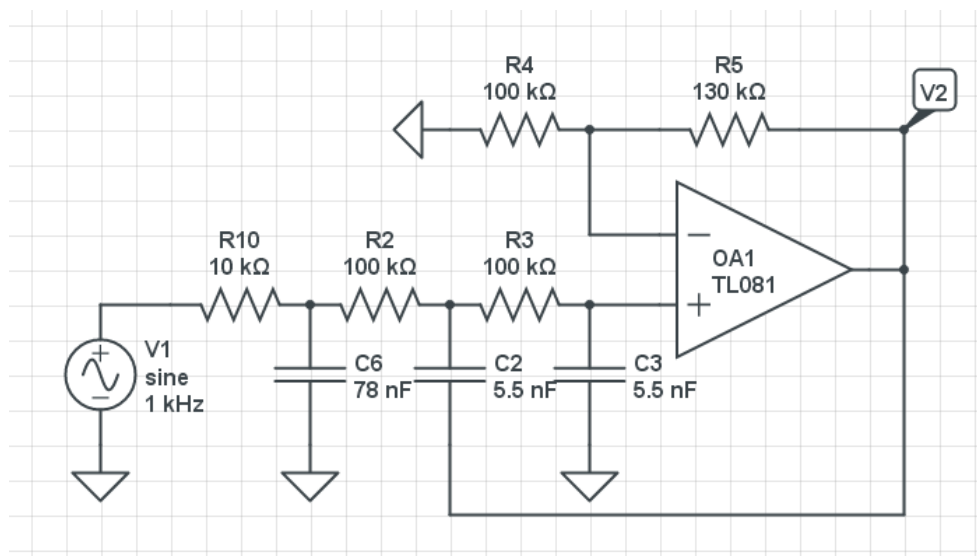
R = 10k, C = 78nF

$$\left(\frac{1}{RC}\right) = 1815$$

R = 100k, C = 5.5nF

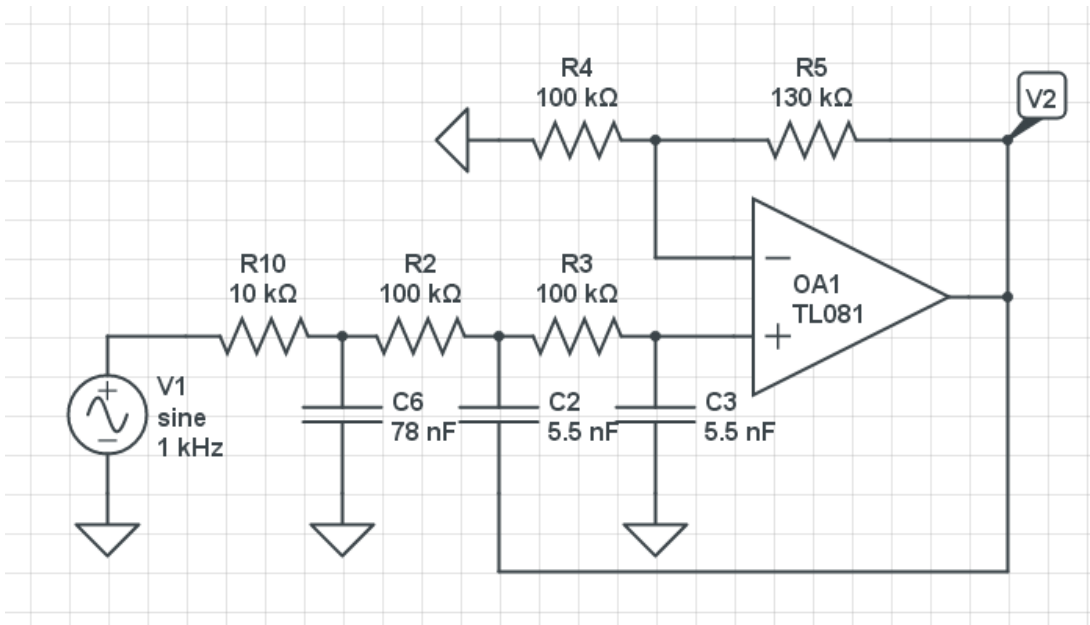
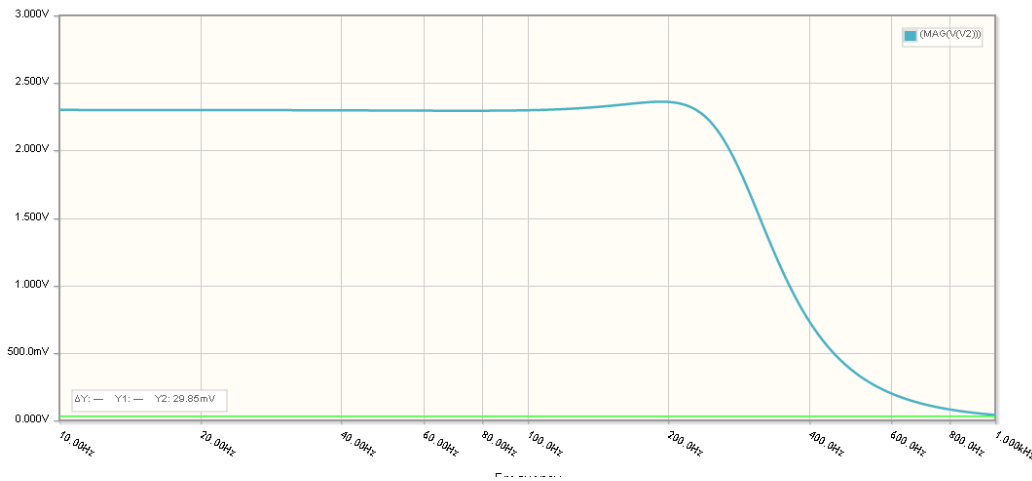
$$3 - k = 2 \cos(69.5^\circ)$$

$$k = 2.30$$



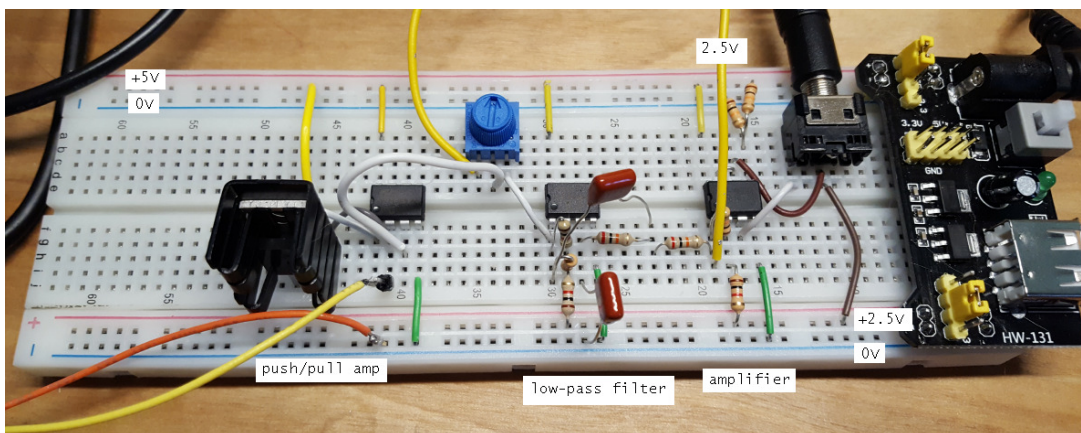
Simulation: Simulate your filter in CircuitLab to verify that it meets your requirements

- $0.9 < \text{gain} < 1.1$ in the pass-band region, and
- $\text{gain} < 0.2$ in the band-reject region



Hardware: Build your filter and verify it meets your requirements.

- $0.9 < \text{gain} < 1.1$ in the pass-band region, and
gain < 0.2 in the band-reject region



Hz	100Hz	250Hz	500Hz	1000Hz
Requirement	$1.1 < \text{gain} < 0.9$	$1.1 < \text{gain} < 0.9$	gain < 0.2	gain < 0.2
Gain (calculated)	0.9825	0.9606	0.1610	0.0177
Gain (CircuitLab)	0.9878	0.8693	0.1533	0.01813
Gain (measured)	xxxx	xxxx	xxxx	xxxx

Homework #3: Work Breakdown Structure

For each student in your group, add pages to your section for HW3 to HW8

Add content to the page for Homework #3 including

- Your role in the project (Level 2 of work breakdown structure)
- Technical challenges you need to solve in ECE 403 (Level 3 of work breakdown structure)
- Tasks you need to complete in ECE 403 (Level 4 of work breakdown structure).
- A Gantt chart for ECE 403
 - The order in which you'll do your tasks
 - When your plan on working on each task

Also list out

- Four advanced ECE concepts you'll apply to your part of the design
- Two ECE tools you'll use
 - Oscilloscope,
 - Multimeter
 - Emulator,
 - etc.

OneNote Section	Pages Within Section	Content
Student A	HW3: Work Breakdown	Role in Project Major Activities (technical challenges) Tasks to complete in ECE 403 Gantt Chart for ECE 403 4x ECE concepts you will use 2x ECE tools you will use
	HW4: Task #1 • ECE Topic #1	<i>fill in later in the semester</i>
	HW5: Task #2 • ECE Topic #2	<i>fill in later in the semester</i>
	HW6: Task #3 • ECE Topic #3	<i>fill in later in the semester</i>
	HW7: Task #4 • ECE Topic #4	<i>fill in later in the semester</i>
	HW8: ECE Tools	<i>fill in later in the semester</i>