Tasks & Applying Knowledge of ECE

ECE 403 Senior Design II

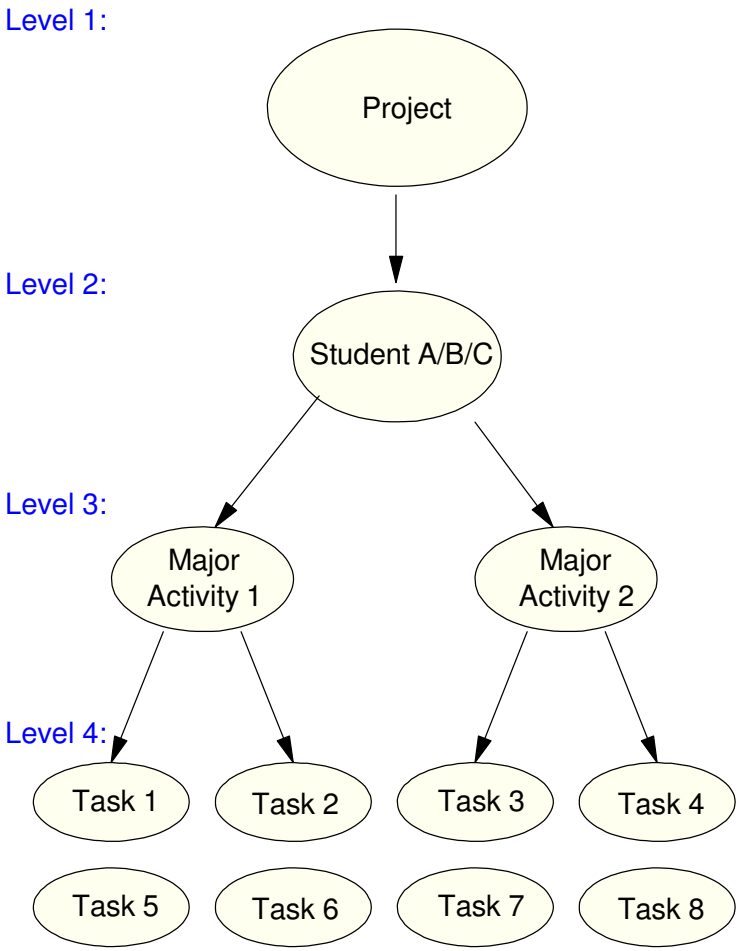
Week #3

Please visit Bison Academy for corresponding lecture notes,
homework sets, and videos
www.BisonAcademy.com

Work Breakdown Structure

At this point, you should have

- Your Senior Design Project
- Who is in your design group
- Major Activities
- List of tasks



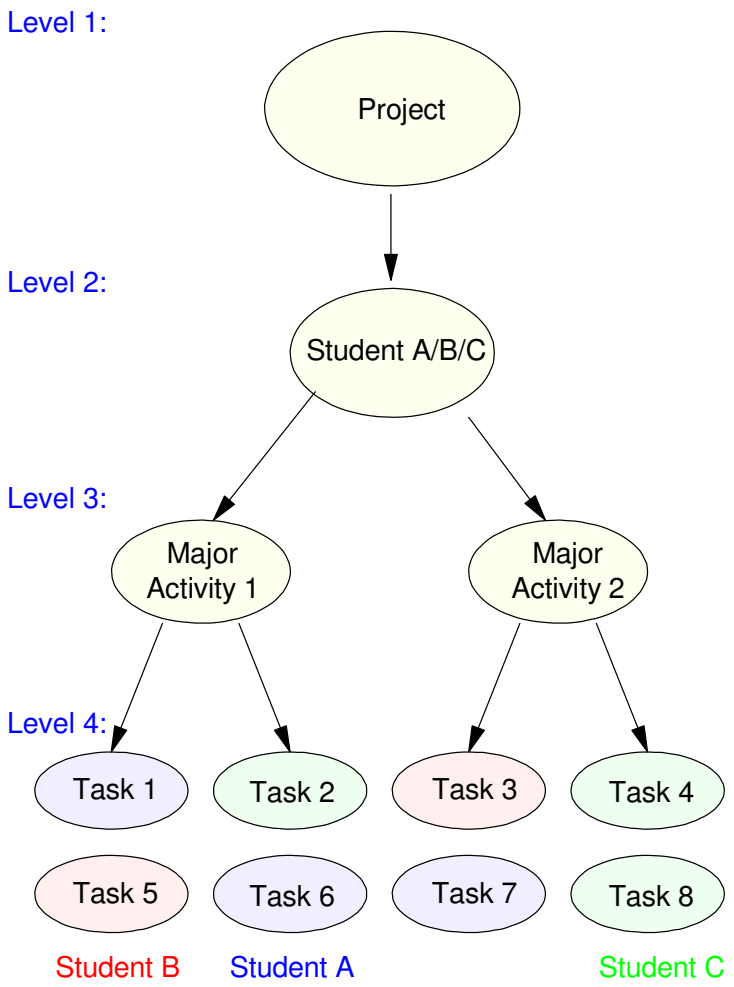
Goal this week...

Define

- What tasks are assigned to each student,
- When these tasks are to be completed, and
- How each student is going to apply knowledge of ECE while completing his/her tasks.

The last bullet is important

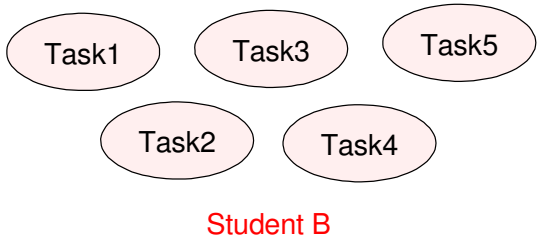
- Relates to your grade in Design II



Apply Knowledge of ECE

How you split the tasks is up to you. But

- Each student should have tasks
- Which allow him/her to apply knowledge of ECE to these tasks:

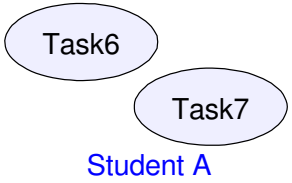


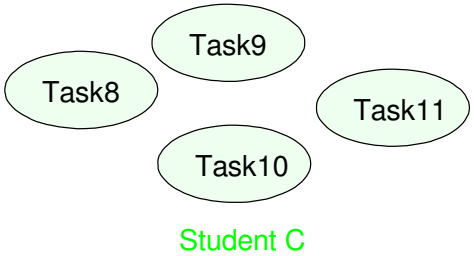
The whole point behind senior design

- Demonstrate that all of our students
- Can apply knowledge of ECE upon graduation.

This is reflected in the course's grading scheme:

- Your grade depends upon your ability to apply advanced knowledge of ECE to your tasks.
- The more knowledge you are able to apply, the higher your grade





How is Design II Graded?

Pretty much determined by your ability to apply knowledge of ECE when completing your tasks

- Assumes you complete the other homework assignments

Grade	# Advanced ECE Topics Applied in Tasks
A	4
B	3
C	2
D	1
F	0

note: This makes Senior Design a last check on the quality of our program: if a student somehow managed to get through all of our courses without learning anything, they won't be able to get through Senior Design.

What if I forget previous courses?

YouTube has a lot of material

Bison Academy also has many courses

- Each course has daily lectures available
- Lectures, recorded lectures
- Homework sets and solutions

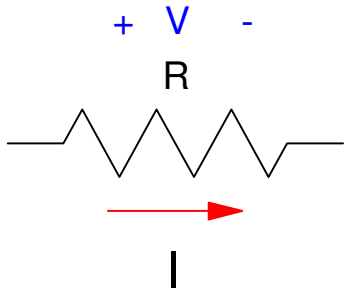
Bison Academy: Lecture Topics				
#	**206 Circuits I**	**311 Circuits II**	**320 Electronics**	**376 Embedded**
2	Kirchoff's Laws	Phasors	Semiconductors	Comp Architecture
3	Series and Parallel	AC Impedance	pn Junction	Assembler
4	V and I Division	Complex Power	Ideal Diodes	Flow Charts
5	V Nodes	3-Phase	LEDs	Counters
6	Super Nodes	Convolution	AC to DC	Timing

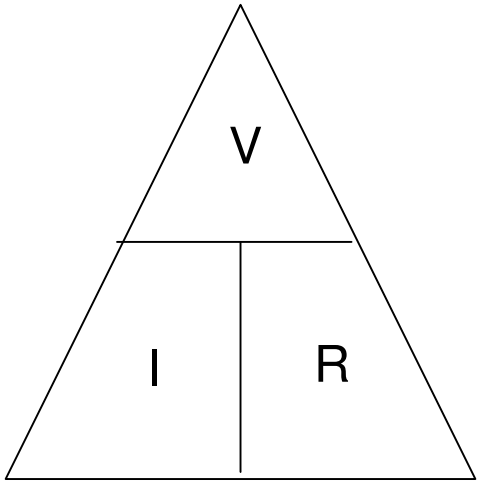
What is advanced knowledge of ECE?

A little vague. If you try to make your four topics

- V = IR
- I = V/R
- R = V/I
- P = VI

you're not going to be happy with your grade.





If I'm being generous, I might give you 2 points out of 10 for being able to apply Ohm's law. It's a pretty basic equation in ECE. The other three are just repeats - no points for demonstrating the same knowledge four times.

Surely, you learned more than that while at NDSU.

Bison Academy

If you forget what topics were covered in courses you took, again, go back to Bison Academy. Each class is divided up in daily lectures, with each lecture usually covering a different topic.

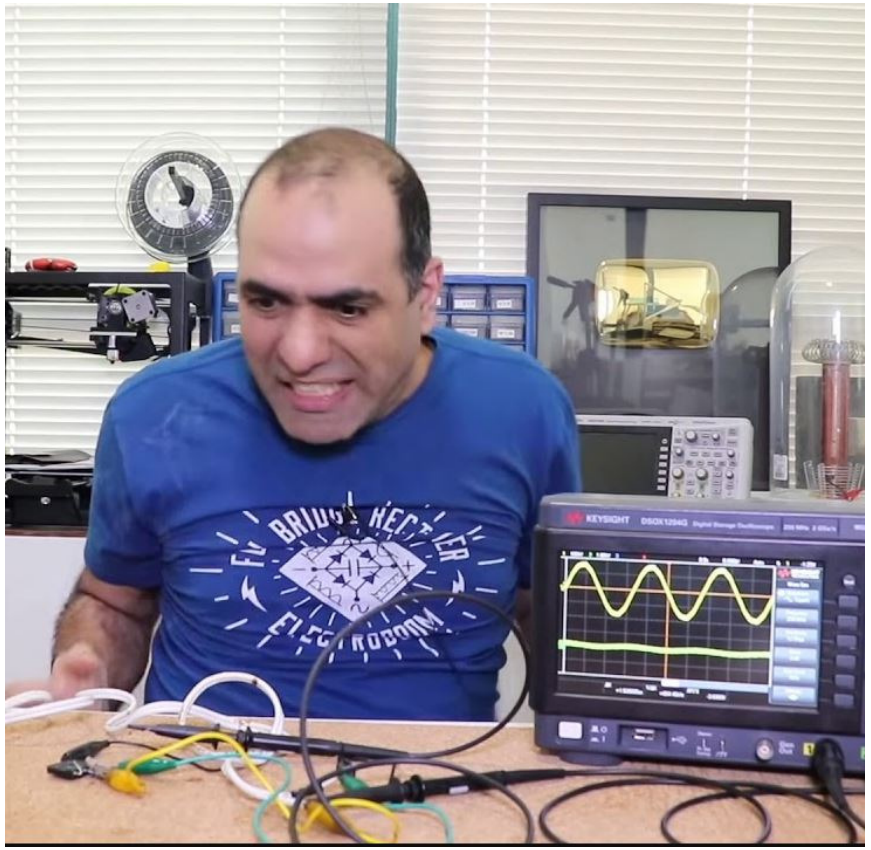
ECE 320: Electronics I

Digital & Analog Electronics

Date	Lecture	Videos YouTube PlayList	Handouts	Homework
Week #2	Semiconductors Slides #4	4 Semiconductors	4 Thermistor	2: Semiconductors Solution #2 (pdf) Solution #2 (YouTube) Quiz #2 Quiz #2 Solution (pdf) Quiz #2 (YouTube)
	The pn Junction Slides #5	5 The pn Junction Diodes (EB)	5 Diode Ckt	
	Quiz			
Week #3	Idea Diodes Slides #6	6 Ideal Diodes	6 Diode Ckt	3: LEDs, AC to DC Solution #3 (pdf) Solution #3 (YouTube) Quiz #3 Quiz #3 Solution (pdf) Quiz #3 (YouTube)
	Light Emitting Diodes (LEDs) Slides #7	7 LEDs Color Wheel 1000W LED	7 LEDs	
	AC to DC Converters Slides #8	8 AC to DC Full Bridge Rectifier (EB)	8 AC to DC	

Advanced Knowledge of ECE (cont'd)

- Electroboom - What is an oscilloscope?
- https://youtu.be/DgYGRtkd9Vs?feature=shared



Knowledge = using math

- You understand the equations that describe what you're doing.
- You're not using a trial-and-error
  - Trial and error doesn't demo knowledge.

Math doesn't always apply

- Software, but
- You can still apply advanced knowledge of ECE with software
- Think about
  - What courses you took,
  - What topics were covered,
  - What you learned from those courses, and
  - How to apply this knowledge when completing your tasks.

Homework #3

Each student is to

- Update his/her section

Include

- A list of tasks he/she is responsible for in Design II
- A comment on how he/she will apply advanced knowledge of ECE while completing these tasks, and
- The tasks to complete (filled in later on during the semester)

One-Note Section	Pages	Content
Student A	List of Tasks	List of tasks you're responsible for How you'll demo knowledge of ECE while doing these tasks
	Task #1	document work on task #1 (completed at a later in semester)
	Task #2	ditto
	Task #3	ditto

Tasks vs. Advanced Knowledge

- Not one-for-one

A given task could have involve no knowledge of ECE.

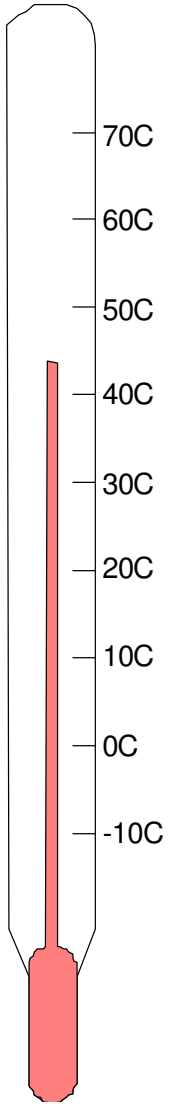
- Example, filling in paperwork
- Necessary but it doesn't show off knowledge of ECE.

A given task could involved many different topics in ECE.

- Example, measure temperature
  - Circuits to convert the temperature to 0-5V analog
  - A Butterworth low-pass filter to remove noise
  - Software to read the analog voltage
  - Calibration and curve fitting to compute the temperature in degrees C
  - Statistics to determine the mean, standard deviation, confidence interval
  - WiFi or Bluetooth so that this temperature is viewable from a cell phone
  - etc.

In Design II, focus on knocking off your tasks.

- Just be sure that you are applying knowledge of ECE along the way.



Can I use an Arduino or Raspberry Pi in my design?

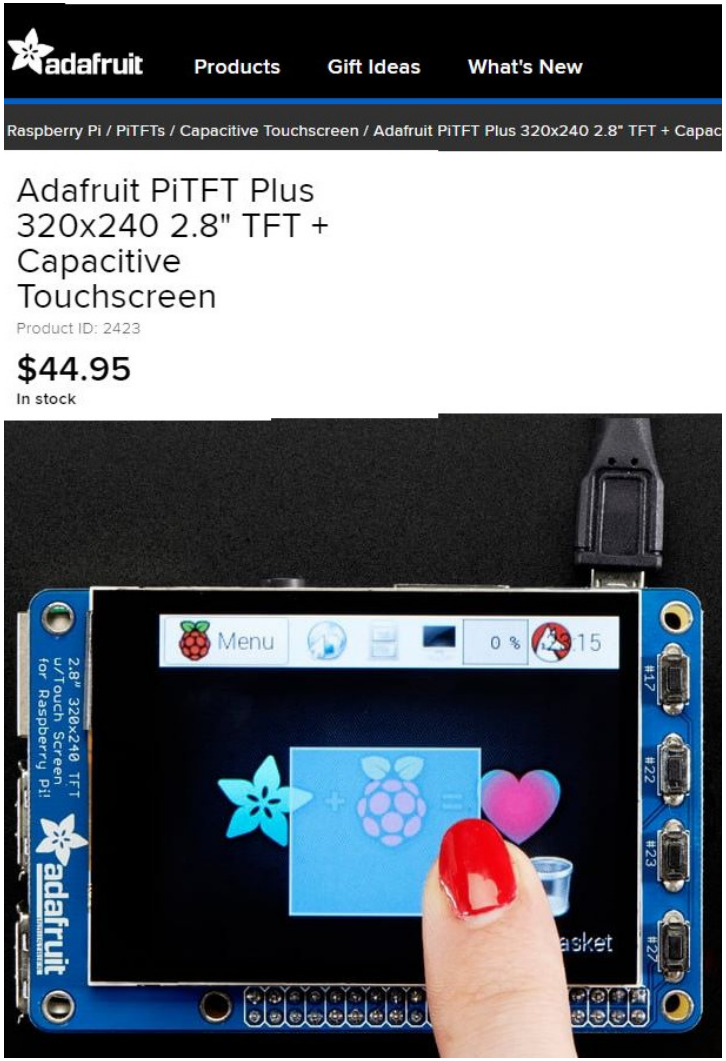
- Design I: No
- Design II & III: Yes

But...

- Make sure you apply knowledge of ECE
- Four different ways

Finding working code online doesn't count

- Writing your own I2C interface counts
- Using top-down programming counts
- You've learned a lot of the past 3 years
- All you need to do is demonstrate that you can apply four of them to your project...



Can I update my OneNote section?

Yes.

- Each student's section of OneNote will be graded every two weeks.
- If you got 2 points out of 10 on one section, keep working on it.
- During the next grading cycle, your revised content will be regarded and the new grade will be updated on blackboard.

Note that the last day to update your OneNote sections is Friday of dead week.

How to I incorporate more ECE topics?

Example

- All tasks completed
- Not much knowledge of ECE shown

This is why homework #3 is important

- Pick tasks that allow you to apply knowledge of ECE

All is not lost... Push your design

- If measuring temperature to 1F
  - Can you measure to 0.1F?
  - Can you measure to 0.01F?
- If you have a program that works,
  - Can you make it more efficient?
  - Can you reduce the execution time?

Can several group members use the same advanced ECE Topics?

- Yes.

Each student's tasks should be different.

- But, there could be overlap in what techniques you used in completing your tasks.

Example:

- Student A uses structured programming with Python
- That doesn't mean no-one else is allowed to use Python or structured programs

The tasks will be different student to student

- The tools used to solve the tasks may overlap

Can several group members work on the same task?

- No.

The point behind Senior Design is that each student is to demonstrate his/her ability to apply advanced knowledge of ECE before graduation.

- Being a part of group where someone demonstrated that ability doesn't count.

That being said, there are many ways to skin a cat.

If a task is to measure temperature, you could...

- Measure temperature using thermistor
- Measure temperature using an RTD
- Measure temperature using a BMP280 sensor
- Measure temperature using a DS17B20 sensor
- Get higher resolution using an external 20-bit A/D
- etc

Each of these is a separate and distinct task.

- You could divide these among different members of your group.

Example (Tasks)

- Project: build a better mousetrap.

Challenge: Detecting a mouse

- Task: Detect using an ultrasonic range sensor
  - ECE Knowledge: Timer1 Capture (ECE 376)
  - Statistics: 90% confidence interval (ECE 341)
  - Digital filtering: Reduce noise (ECE 343)
- Task: Detect using a vibration sensor
  - Instrumentation Amplifier: output -10V..+10V
  - Analog Filtering: Reduce noise (ECE 321)
  - Envelope Detectors: Convert AC to DC (ECE 321)
- Task: Detect using motion sensors
  - SPI Comm: Read a 16-bit A/D (ECE 376)
  - High-Pass Filters (differentiates) (ECE 311)
  - Amplifiers and Mixers (get 0-5V out) (ECE 321)

Adafruit VL53L0X Time of Flight Distance Sensor - ~30 to 1000mm

Product ID: 3317

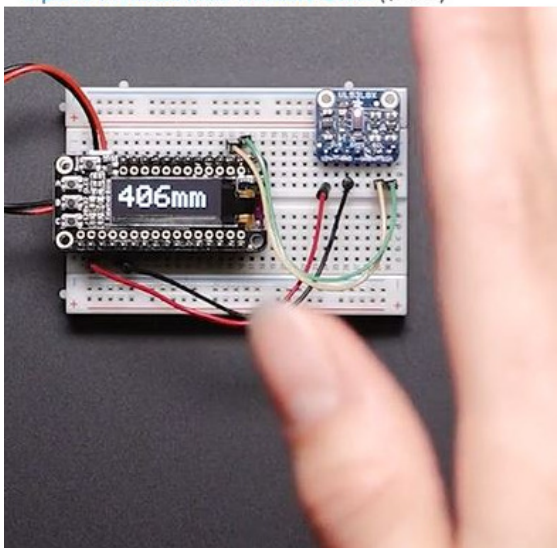
$14.95

In stock

1 Add to Cart

Also include 1 x STEMMA QT / Qwiic JST SH 4-pin Cable - 100mm Long ($0.95)

Also include 1 x STEMMA QT / Qwiic JST SH 4-pin to Premium Male Headers Cable ($0.95)



Example: Better Mousetrap

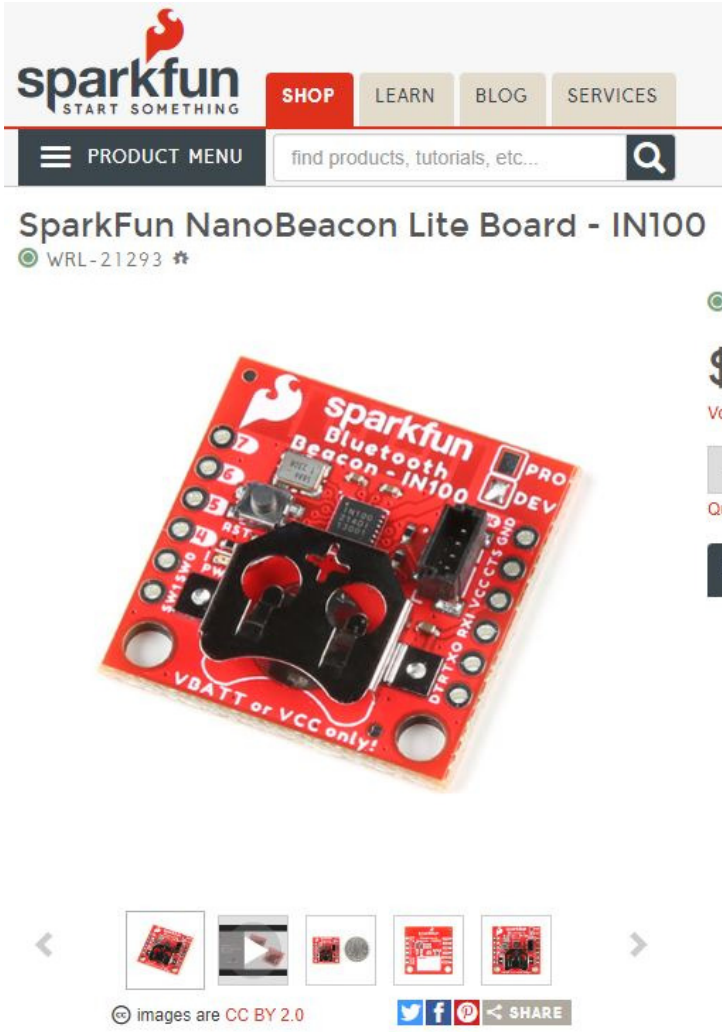
Challenge: Open and Close a Door

- 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)

Example: Better Mousetrap

Challenge: Communicate with a Cell Phone

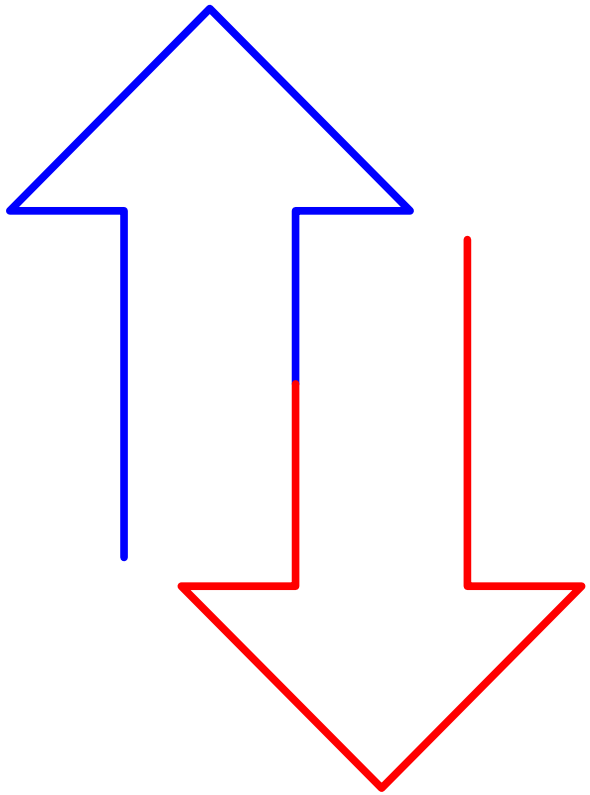
- Task: Send BlueTooth data with a uP (PIC, Arduino)
  - SCI Communications (ECE 376)
  - LCD Display (watch the SCI data communications - ECE 376)
  - Custom cell phone apps (CSxxxx)
  - Software UART using Timer0 (ECE 376 - if you need a second UART)



Example: Better Mousetrap

Challenge: Coordinate the hardware using software

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



Gantt Chart

Gantt Charts help you plan out the semester

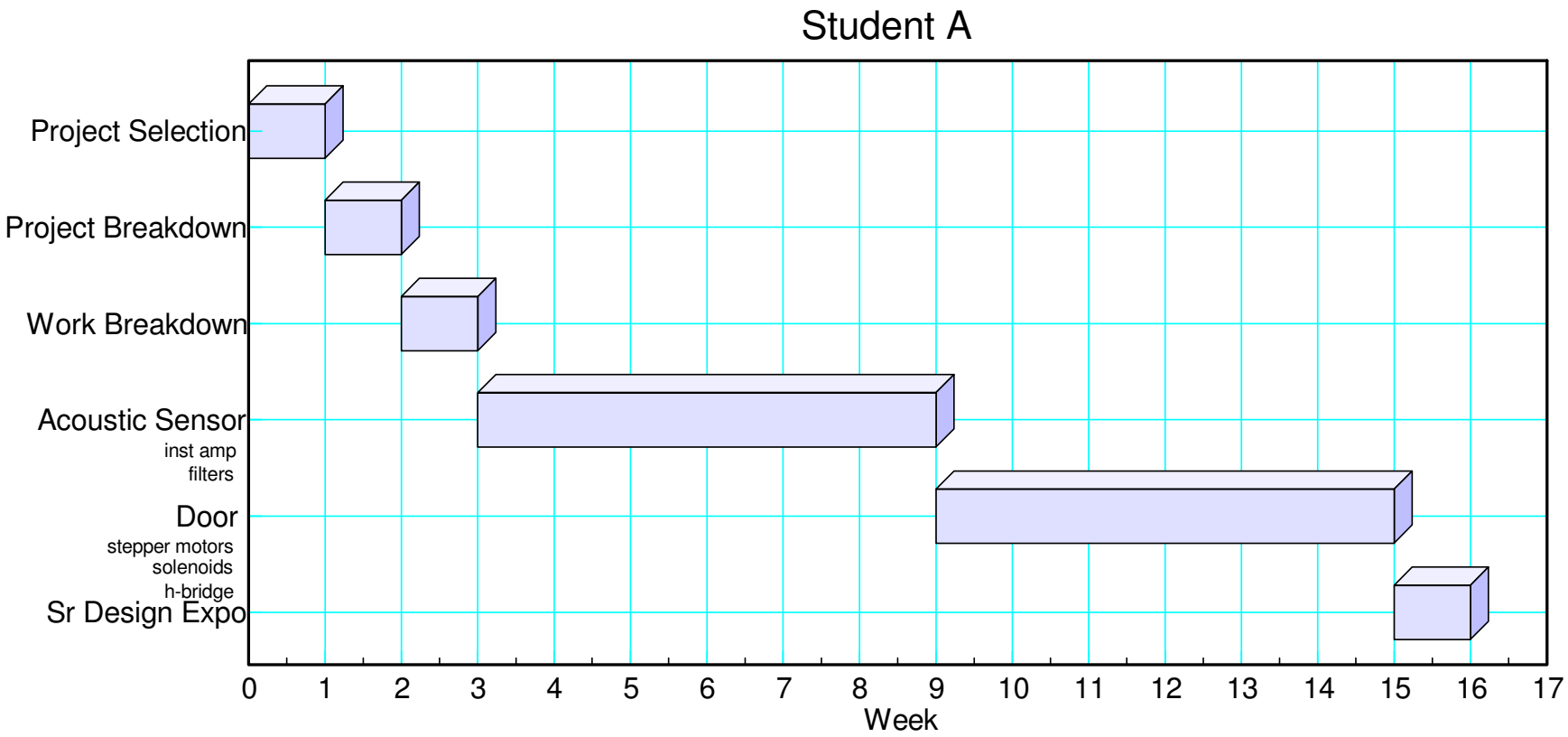
- What activities do you need to complete,
- How much time do you allocate for each activity, and
- When these activities are to take place.

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.

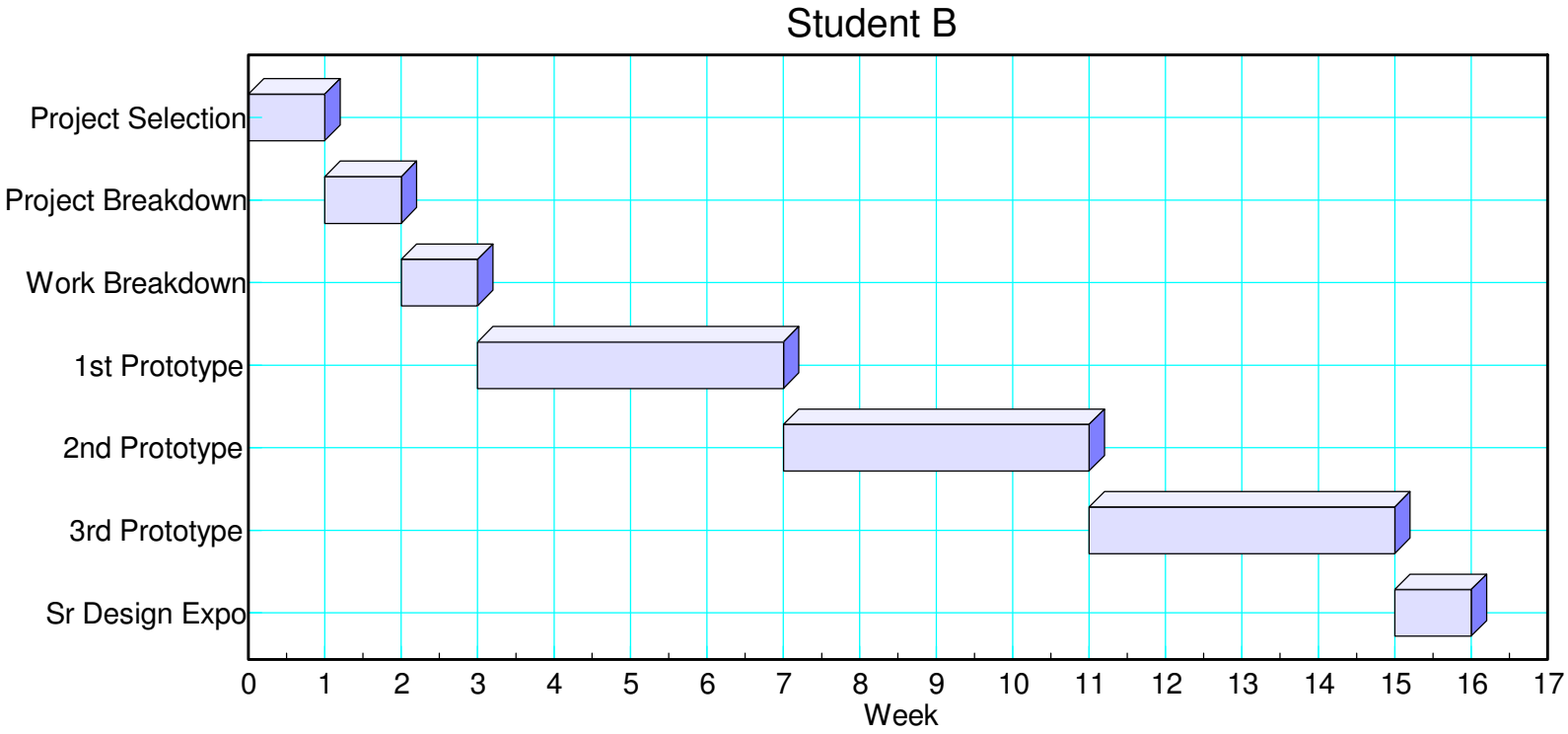
Gantt Chart with Waterfall

- Tasks = Technical Challenges
- Also demonstrate knowledge of ECE



Gantt Chart with Agile

- Develop a prototype
- Keep improving it
  - Adding more features
  - Demonstrating knowledge of ECE



OneNote with WaterFall

- Section = Student A / B / C
- Pages Contain both your task as well as knowledge of ECE

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 List 4 advanced ECE topics you'll apply in your tasks List 2 ECE tools you'll use to validate your work
	Task #1	Document work on task #1 *while applying knowledge of ECE (hw4)*
	Task #2	Document work on task #2 *apply another advanced ECE topic (hw5)*
	Task #3	Document work on task #3 *apply another advaned ECE topic (hw6)*
	HW8: ECE Tools	Demonstrate mastery of two ECE tools *usually done in previous sections*

OneNote with Agile

- Section = Student A / B / C
- Pages Contain iterations & knowledge of ECE

OneNote Section	Pages Within Section	Content
Student B	HW3: Work Breakdown	Role in Project Major Activities (technical challenges) Tasks to complete in ECE 403 Gantt Chart for ECE 403
	Iteration #1	Get something to work *while applying knowledge of ECE (hw4)*
	Iteration #2	Improve your design *while applying more knowledge of ECE (hw5)*
	Iteration #3	Improve your design *while applying even more knowledge of ECE (hw6)*
	ECE Tools *homework #8*	Demonstrate mastery of two ECE tools *usually done in previous sections*

Task 1 Example: 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. Vf = 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 < gain < 500
- Vbe = 0.7V
- Vce(sat) = 0.36V

Calculations:

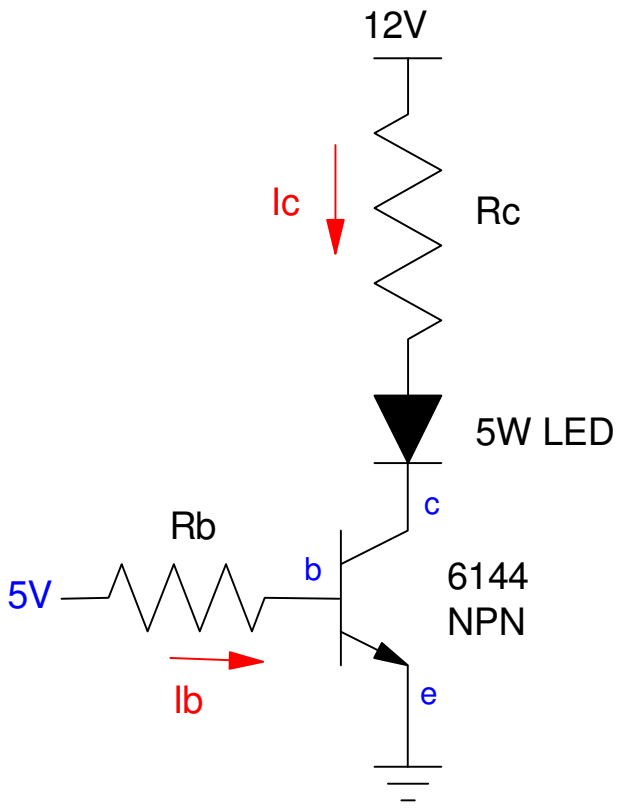
$$R_c = \left(\frac{12V - 5V - 0.36V}{500mA}\right) = 13.28\Omega$$

$$\beta I_b > I_c$$

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

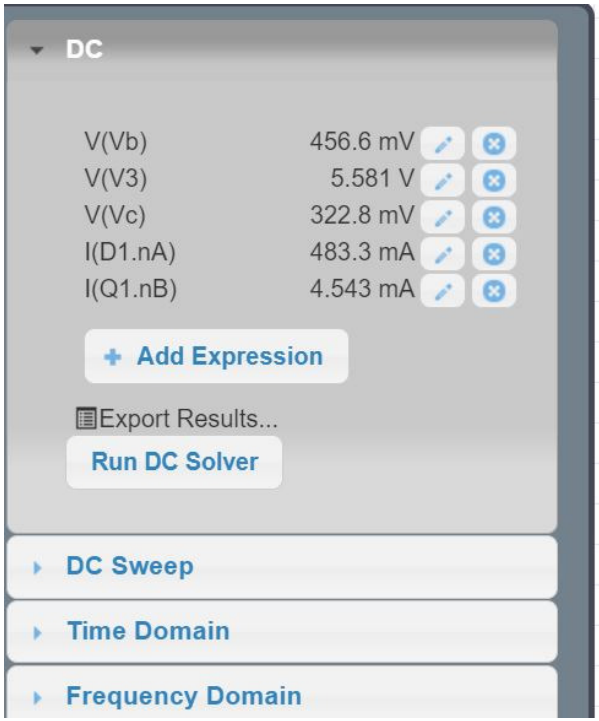
Let Ib = 4.3mA

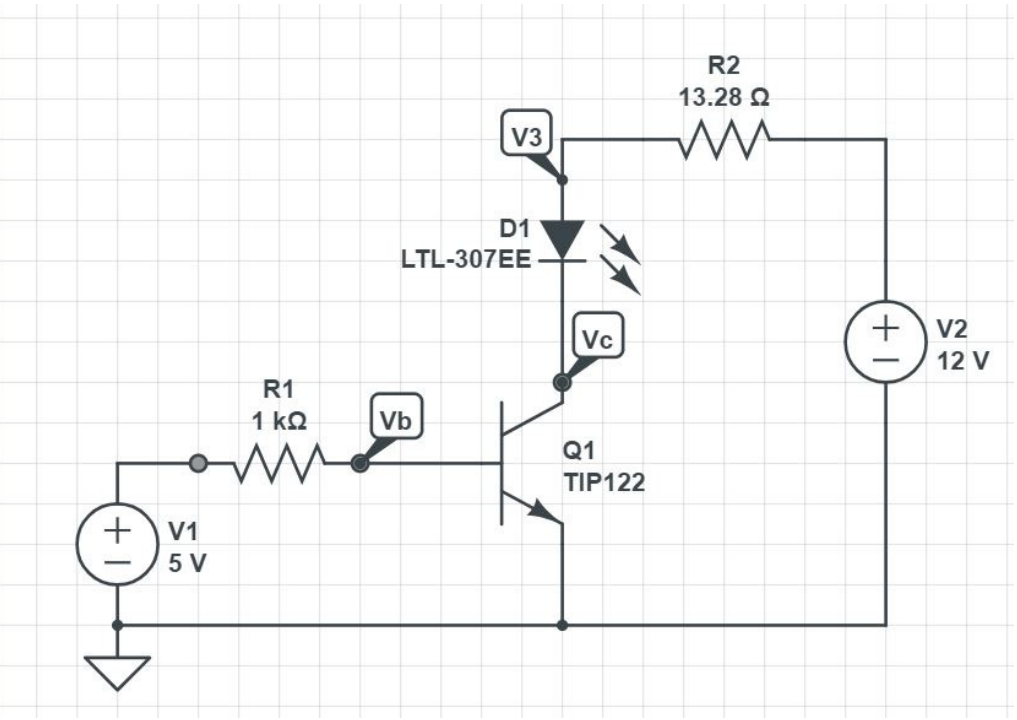
$$R_c = \left(\frac{5V - 0.7V}{4.3mA}\right) = 1k\Omega$$



Simulation:

- Goal: verify your calculations were correct
- Ic = 500mA
- Ib = 4.3mA
- Transistor is saturated (Vce = 0.2V)

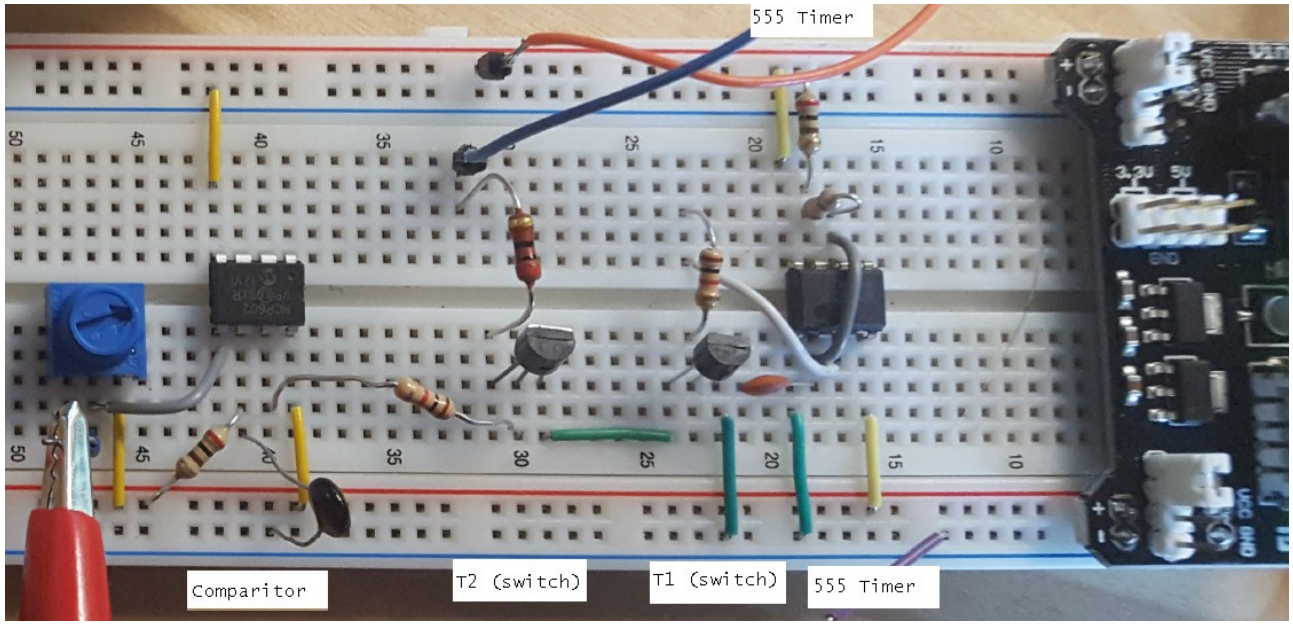




Breadboard:

Goal: Verify calculations and simulations are correct

- Include a photo of your breadboard
- Include measurements
- Demo: Include or link to a video



Summarize Your Work:

- Did calculations match simulation match breadboard result?

	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

Homework #3: Work Breakdown Structure

For each student

- Create a section for you in OneNote
- Create pages
  - Work Breakdown
  - Task #1
  - Task #2

Fill in your WBS

- Role in project
- Major Activities (lvl 3)
- Tasks (lvl 4)
- Gantt Chart

Also note

- 4 ECE topics you'll apply
- 2 ECE tools you'll use

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 4 advanced ECE topics you'll apply in your tasks 2 ECE tools you'll use to validate your work
	Task #1	filled in at a later date
	Task #2	ditto
	Task #3	ditto