Self-Directed Skill Documentation

Intro to ECSE

Overview

This is your reference document to improve or learn skills necessary for Intro to ECSE labs! I am looking to make this document better through collaboration with you, Fall 2023 students! If you add pdf links or videos that helped you, please insert your name next to them, so I can give you some participation credit for these edits. The ultimate goal is to make this an external, preparation resource for future Intro to ECSE students even before they get to the course. Thanks to the students of the Fall 2022 and Spring 2023 Intro to ECSE classes for their contributions!

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MATLAB Basics and Simulink

- 1. I have completed the MATLAB Onramp Tutorial
- 2. I have completed the Simulink Onramp Tutorial
- 3. I can add two sinusoid waves and show the display using MATLAB Simulink
- 4. I can analytically determine the amplitude, frequency, period and phase shift of a sinusoid
- 5. Find solutions for linear independent equations using the matrix function
- 06. & 7. Import simulation data to MATLAB
- 8. Using a regression Line to simulate the data in MATLAB

Community, Communication, Asking for Help & Helping Others - Be an Active Part of the Learning Community!

- When and how to help, get help, and work together? (PS Probably don't take this one first!)
- 1. I can ask for help from a TA or SA when needed for technical issues, parts, or general question as I complete this Proof of Skills work
- 2. I can HELP someone else OR ask another student for help after I have mastered a skill
- 3. Make Your Portfolio
- 4. I add new information, add a comment or make a correction to the Intro to ECSE Skills documentation in a meaningful way for future semesters

Best Practices for Documentation and Submission on Gradescope

Gradescope Submission

- Submit only PDF files. Image files can be compressed to the point of being unreadable in Gradescope (and then need to be downloaded and opened individually in order to be graded). .docx files always need to be downloaded and opened individually to grade them.
- Submit one PDF per question (not category). This helps us grade more quickly, since we won't be spending time scrolling through your document to find where a particular question is.

Documentation

- Ensure that your schematics and waveforms are easily visible and legible. The background should be white, the lines should be thick enough to see, and the colors of the lines should be high contrast.
- Ensure that you can match simulation outputs to points in the circuit where those results were probed. For example, for a transient simulation, your curves of the voltage vs. time should be labeled AND those labels should correspond to particular points on the circuit (i.e. voltage nodes or voltage drops across components).
- Ensure that you can match experimental measurements BOTH with points in the physical circuit that were probed AND the points in a circuit diagram where those points were probed. That means you'll need to provide a photo of your circuit with all of the components and wires labeled, a circuit diagram of your circuit with the important measurement points labeled, and a label to go with your numerical values to show where in the circuit that voltage was measured.

Preliminary Installation Instructions

Simulations

LTSpice (preferred for Intro to ECSE)
Version 17.1.10
https://www.analog.com/en/design-center/design-tools-and-calculators/ltspice-simulator.html

Can also use any previous version. Whatever works for you!

PSpice or Multisim are also options (instructions not shown here… unless needed)

Experimental Personal Instrumentation Board

(You only need to choose 1!)

M2K Software (Scopy)

ADALM2000 Quick Start [Analog Devices Wiki]

- More information on downloads: Scopy [Analog Devices Wiki]

Analog Discovery Board 2 (Waveforms)

Download WaveForms Software – Digilent

Analytical Computation

MATLAB for RPI students

Full instructions: Matlab Campus-wide Install and Online Resources

Direct link to RPI MathWorks Page: Rensselaer Polytechnic Institute - MATLAB Access for Everyone

TI-89 or TI-Nspire are best for Intro to ECSE (complex matrices!) but students can also use a TI-83 or TI-84.

1. If you want to stick with a TI-83 or TI-84, here's a guide to how to input complex matrices:
   TI 84 PLUS: solving a matrix with imaginary numbers (TI 83 too)

Skill Development Tutorials

Professional Accountability

1. ABET Engineering Student Outcomes (Scroll to Criterion 3, *Student Outcomes*)

Google or use another search engine…there should be 7

Criteria for Accrediting Engineering Programs, 2021 – 2022 | ABET

*Updated link for 2023 GL → Criteria for Accrediting Engineering Programs, 2022 – 2023 | ABET

Joel M.: List the ABET Engineering Student Outcomes.

Comment on one that you are most excited to accomplish while at RPI. Share/discuss with a classmate.

Comment on the one that will be the most challenging for you to accomplish while at RPI. Share/discuss with a classmate.

2. IEEE Code of Ethics

Google or use other search engine "IEEE Code of Ethics"

Joel M.: List the IEEE Code of Ethics

Choose one to write a few sentences about that seems most important to your lived experience or your future experience. Share/discuss with a classmate

Is ethics important for design or not important? We'll discuss it in class too!

3. The DIFFERENCE between Good Failure and Bad Failure

The ECSE Advisory Board asked Prof. Sawyer to do this for you! #1 skill out of the blue! "Teach your students to fail well!" What does this mean? WHY WOULD AN INDUSTRY LEADER WANT YOU TO FAIL WELL?!?! It seems backwards **BUT it is not**. Find strategies to do so….what is your plan to iterate on a design? Find references for the idea behind this statement like the one below:

Advice For Young Engineers: Learn From Failure, Not Just From Success

Joel M.: Write a plan for when your experiment/design doesn't work as planned. (i.e. Who takes responsibility between partners? How do you troubleshoot? How do you design for troubleshooting? etc.)

Joel M.: What is your plan for when a Quiz or Exam is tougher than expected?

Joel M.: What is your plan for if you feel overwhelmed (time management approaches, who do you go to?)

4. Draft of 4-Year Plan of Study

******* new 2027 link https://eng.rpi.edu/students/advising/welcome***

https://rpi.app.box.com/s/545h5tk7Welcome, Class of 2027! | School of Engineeringnq6mk2v5h67sgmns0z4oif6g (link to template for class of 2027 Erik U)

Make a draft of my Plan of Study according to your own personal interests at the moment. Write/fill in a draft of your 4-Year Plan of Study excel spreadsheet. You will have to do this before your SAM (student-advisor meeting) with your Hub advisor, which will likely happen in the spring. Where do you find 2026 Curriculum templates for all majors? Where will you find Program templates and more detail about Navigating ECSE?

ECSE 2026 curriculum checklist

2027 Excel Templates

HASS Core Program: School of Engineering Requirements

HASS Core Requirements for Engineers

ECSE Senior Capstone that would be interesting to look at

QuACS great way to see potential schedule

RPI Course Catalog and RPI Program List

The SoE First-Year Advising Hub

DegreeWorks (found in the Student Menu on SIS) is very useful for seeing graduation requirements, your progress towards your degree, and information on all the majors offered by RPI.

Are you unsure about your path? No problem, pick one and go through the exercise! Investigate any path you want to, but fill out a full Plan of Study!

Suggestions from former Intro to ECSE students!

- I strongly recommend creating multiple 4-year plans that follow different major templates in the case that you are considering multiple majors. This is also a GREAT OPPORTUNITY to satisfy your SAM requirement by also completing your HASS worksheet and declaring your HASS Pathway! Definitely book a meeting with your advisor to discuss any progress you make on this when completing this proof of skill!
- A 4-year plan is very important, because engineering is a subject that requires lots of different kinds of skills. With a 4-year plan, we can better organize the limited time we have to get enough required skills while we are at RPI.
- It's a good idea to research about the most important courses in your 4-Year Plan, to see if adjustments need to be made to take those courses earlier or later.

- It is very important to note what courses each integrative pathway consists of. A list of integrative pathways and their requirements can be found here: RPI Program List.
- Make a table or flow chart of courses and their prerequisites so one course doesn't delay your 4-year plan.
- If you have any specific questions, you should schedule a meeting with an advisor at the SoE First-Year Advising Hub. They are very kind and will answer any and all the questions you have.
- It's ok if you don't know what your interests are currently. You can always go back and change things after exploring each 'field' until you find something you like.

5. I can begin to prepare for my future internship or job search on RPI's Handshake portal.

Employers search for students for internship positions and jobs by posting them on Handshake or attending career fairs that you can find on Handshake. There are far more internships with companies open than students applying for them.

Register for Handshake here: https://ccpd.rpi.edu/handshake

Name three career-oriented things that students can do via Handshake.

Choose a company that you would be interested in doing an internship with or working for – why does this company interest you?

Search for the company you chose by clicking on the "Events" tab, then clicking on "Employer". Will that company be at any upcoming events listed on Handshake? If so, which ones?

6. MAX LEVEL PROOF OF SKILLS: I can clearly document and compare a calculated, simulated, and experimental result to answer the question “Is this right?” for myself?

As an engineer, you are responsible for the correctness and integrity of your own work. Unlike in classes, once you start working, there will be no one to check for you if your work is “right” or not - you will need to learn a set of skills to do this for yourself. This is not only important for your own reputation, but has ethical considerations which we’ll also discuss in class. You will learn how to answer the question “Is this right?” for yourself in this class and we will practice it throughout the semester through something called a “Proof of Concept”.2

So, how do you answer the question “Is this right?”. You will need to provide multiple sources of convincing proof that your design or experiment is technically sound and is in line with accepted engineering practices. In this course, we will call the documentation that proves that your work is “right” a “Proof of Concept”. Each lab this semester will guide you in applying lecture concepts to hands-on problems to gain practical experience with electrical and computer engineering fundamentals. Once you have had practice with these concepts via the lab instructions, you will then have to ***prove*** that you’ve mastered these concepts by completing a “Proof of Concept” for each. The concepts you need to prove are listed at the end of each section of the labs. Your collection of Proofs of Concept for a lab is what you will hand in as your “lab report” to be graded by the course staff (if you are doing an Omega Exploration, you will also have to submit additional documents).

So, how do you prove that you’ve mastered a concept? The procedure consists of four main types of documentation (***you must include all four pieces of documentation to receive full credit for a Proof of Concept!***):

1. **Mathematical Analysis**: This is where you will start. Mathematical analysis means using the theoretical engineering tools (such as circuit analysis) you have learned to hand-calculate important quantities that you expect to measure in your system/circuit, such as voltages and currents.
    - The documentation for this step should include a diagram or schematic of your system/circuit, relevant hand-calculations for all important quantities, and any important assumptions or estimates that you have made for your system/circuit.

2. **Simulation**: This is the second step. You will need to create a schematic of your system/circuit in a simulation software such as LTSpice or Simulink and run a simulation to demonstrate that your mathematical analysis is correct. You will do this by making a 1 to 1 comparison between the quantities you calculated by hand in the mathematical analysis and the results of the simulation for those same quantities. If both sets of quantities agree, you may proceed to experimental verification of the concept. If not, check through your simulation and mathematical analysis for errors.
    - The documentation for this step should include the schematic or diagram of your system/circuit in the simulation software and a screenshot of the simulation results.

- *Important*: the schematic and simulation results *must* have labels that are consistent with what you called them in the mathematical analysis - this is necessary to be able to compare the two sets of results.

3. **Experimental Measurement**: This is the third step. You will build your system/circuit on a breadboard, then use your instrumentation board (i.e. your MK2 or Analog Discovery 2) to make measurements of the important quantities from the mathematical analysis and simulation of the chosen concept. If these measurements agree with what you calculated in the mathematical analysis and simulation steps, congratulations - you've done the steps to show that your work is "right"! If your measurements disagree with the mathematical analysis and/or the simulation results, check your circuit for errors.
   - Documentation for this step must include a photo of your system/circuit and photos or screenshots of the measurements themselves.
   - *Important*: the photo of your system/circuit and measurement results *must* have labels that are consistent with what you called them in the mathematical analysis and simulation steps - this is necessary to be able to compare the three sets of results.

4. **Comparison and Discussion**: A short comparison of the results of the mathematical analysis, simulation results, and experimental measurements. Discuss or speculate on anything that could cause the results to differ between the three steps of proving the concept.

Note on quality documentation: Since the documentation you provide with your Proof of Concept is the ***proof*** that you've done your work properly (both in this course and as an engineer in general), you will be graded on the quality of your documentation. Be sure that your documentation (handwriting, schematics, plots, photos, labeling, etc.) is clear and legible and that you've labeled all parts of your schematics and results sufficiently, so that the mathematical analysis, simulation, and experimental results can be directly compared with each other. If your documentation cannot be understood, it's of no use to anyone!

You may need to wait until Lab01 starts to fulfill this skill or you can skip ahead to Lab01 to choose a circuit to fulfill this objective. You can also manufacture your own question or simple circuit, then calculate, simulate, measure, and compare/discuss to complete your Proof of Concept.

A template that you should use for Proof of Concepts can be found here: Proof of Concepts Template

Here are some examples of Proofs of Concept of different levels of quality:

- Excellent Example from ECSE-1010
- Example with Room for Improvement from ECSE-1010

Circuit Simulation Skills

LTSpice (preferred for Intro to ECSE)

Introductory Guides when needed:	
License Agreement for Spice Models | Analog Devices	Linear Technology – 53 page pdf – I'd say for students beyond a beginner stage
LTspice Tutorial | The Complete Course	Simon Bramble – Website with 6 part tutorial for intermediate level students for reference
ECSE 1010 - Intro to LTSpice	Mahmood Hameed - Intro to ECSE Introduction to LTSpice video
How to Save LTspice schematics and plots	How to put schematics and plots into your reports or Word document or PowerPoint (changing axes, using cursors). GREAT for understanding how to place simulations into reports with clarity….
LTSpice: Installing & Configuring LTSpice on Mac OS X	use this video to help set up LT spice on mac and make it easier to build circuits as the interface on mac is much more different to the one on windows.

For those on Mac here is a quick Intro to LTSpice for Mac users: LTSPICE Tutorial For MAC
vLTspice : Easy Installation on MacBook Air with M1 chip

Another helpful video: https://www.youtube.com/watch?v=FEGT5dUpdrc

Goals while accomplishing the Circuit Simulation objectives

Notes on Creating a Well-Labeled Schematic

(FOR FULL CREDIT, YOUR SUBMISSIONS FOR EACH SECTION MUST INCLUDE THE FOLLOWING WHERE APPLICABLE)

1. **Changing schematic and plot background to white**
   - Schematic and plot background Schematic and plot settings in LTspice
   - Additional simple plot background video: How to Change the Background Color of Plot/Graph in LTspice to Any Color!
2. **Change the schematic and plot line thickness and color**
   - Pen thickness to make schematic lines thicker: Schematic and plot settings in LTspice
   - Plot line thickness: Schematic a-nd plot settings in LTspice
3. **Label simulation output clearly with circuit component names**
   - Annotate plot lines within LTSpice on plot Schematic and plot settings in LTspice
   - Significant figures: Undocumented LTspice - LTwiki-Wiki for LTspice
   - You can also annotate by copying and pasting in PowerPoint, Word, or another program then adding labels
   - Using cursors to get exact numbers for your output plot How to Save LTspice schematics and plots
   - Video showing how to copy and paste a plot and schematic into a report: Exporting LTspice Data
   - Once a simulation has been run, you can left click on the wires to label the voltage values that they have (DC operating point analysis).
4. **Show the most relevant part of the simulation by altering time and voltage parameters or scale**
   - Zooming in on a plot How to Save LTspice schematics and plots

Additional tips and resources from former Intro to ECSE students:

- A list of Useful Hotkeys for LTSpice can be found here

- A Guide Containing Commands for building and analyzing LTSpice Circuits
- One helpful shortcut is Ctrl+R, which will rotate components in LTSpice. For example, if you would like to rotate a resistor, you can use Ctrl+R before you place it down to reorient it.
- A time-saving tip is to place all the circuit components first and then connect everything with the wire. LTSpice will automatically place the wires in the right spots, so there is no need to place a circuit element and then manually connect the wires to the other elements each time

1. Operation Point DC Analysis:

I can use operation point dc analysis to find voltages across a resistive circuit (Must be two or more resistors, hint: to do something useful to you, try to simulate a homework or class problem!)

- See PDF: LABORATORY 1: LTSpice/Analog Discovery Introductory Intro to ECSE
- You can make a simple 2 resistor circuit aLABORATORY 1: LTSpice/Analog Discovery Introductory Circuitss shown in A1 or use a homework or class problem.

Tips from former Intro to ECSE students:

- Using Function Lock (if your computer has it) makes it easier to place multiple wires using the F3 button on your keyboard, instead of holding down the Function button while pressing F3. To turn on function lock, hold down the function button and then press escape. (This works on my ThinkPad, so hopefully it works for you as well)
- Alternatively, you can change the hotkeys by going to Tools -> Control Panel -> Drafting Options -> Keyboard Shortcuts.
- MacOS users: LTSpiceMacUI (Using LTSpice on a Mac) Time 3:39….need to go to VIEW-> Spice ERROR Log, if you want to show the other .raw file too you can but not necessary…but change the background color!
- Joel M.: MacOS users: For Spice Directives (such as operating point analysis) right click on an empty part of your circuit or press “s” on your keyboard to open the spice directive menu. From he4:31
- re, you can type in text or you can right click on the text box and select “help me edit”, which will pop up a super useful menu.
- Simple video explaining DC Analysis in LTspice
- Additional video for an Introduction to LTBasic DC Analysis with LTSpice

2. Nodal Voltages

I can label and identify Nodal Voltages in a circuit. (creating a well labeled schematic!!)

- See PDF: Lab09-1010: Nodal Voltages

Tips from former Intro to ECSE students:

- How to Label voltages Labeling Voltages
- Make sure labels are connected to the circuit otherwise the value may not display.
- Video on nodal analysis: Circuit Analysis With Current Sources
- On page 2 it explains how to label nodes Beginner's Guide to LTSpice.

3. Transient Analysis with Sinusoidal Source

I can use transient analysis with a sinusoidal source to measure voltage across and current through ONE resistor in a resistive circuit (total resistor count in the circuit must be two or more)

- How to set up a transient simulation: LTSpice tutorial on transient and AC analysis of RC circuit
- The above example is for an RC circuit but you can change to a completely resistive circuit. Additionally, zoom functions are briefly covered in the analysis of the output graph.

Tips from former Intro to ECSE students:

- Another Sinusoidal Source Video: LTSpice - Sine Source
- Another Transient Analysis Video: ECSE 1010 - Transient Analysis in LTspice

4. Parametric Analysis (vary resistance over range of values)

I can step through parameters with parametric analysis to repeatedly measure voltages as I vary my resistance over a range of values

- See PDF: https://sites.ecse.rpi.edu/~ssawyer/Intro to ECSESpring2022_all/Labs/Unit1/Lab02.pdf
  In section A1, parametric analysis is explained for a bridge circuit. You can instead use a simple two resistor circuit, homework or class problem.

Tips from former Intro to ECSE students:

- Make sure to have one of your resistors set to {x} and then add a step function by typing "s" when in LTSpice. The pdf below will give you an example function. This will m
- take the resistor value variable and change so you can graph voltage as it changes. Also make sure to add ".op" in the top right, then change the run command after you run it to .op and hit ok. Lastly, click the wire after your variable resistance to see a changing graph
- The link provided leads to an easy to follow video explaining parametric analysis in LTspice: https://www.analog.com/en/education/education-library/videos/5579239884001.html
- Here is another link to tutorial on parametric analysis from Haley Olson:

  https://youtu.be/Sjw_-xMn-vU?si=RL_nqfNjXclqNiBp
- LTSpice - Voltage Controlled Switch - YouTube Basic video for the Entry Level teaches how to set and measure the voltage.

5. AC Analysis (frequency response of RC or RL circuit)

I can use AC analysis to find the frequency response of an RC or RL filter (hint: find a filter with or without an op amp, we'll understand how this works later!)

- AC analysis of an RC circuit: LTspice: AC Analysis. Note: the blue text in the video can be made by using the comment function which is the Aa key.

Tips from former Intro to ECSE students:

- Another video that gives more descriptive instructions on finding the frequency response of an RC circuit

Experimental Measurements and Personal Instrumentation Skills

Tips for Using a Breadboard

- Best breadboard explanation for beginners ***with menu in description:*** How to Use a Breadboard
  - Most important for this class: 2:40 breadboard rows and columns 3:08 power buses (rails) 3:56 which holes are connected?

- Additional resources on breadboards .
  - What is a Breadboard?
  - Breadboards for Beginners
  - Breadboarding Tips and Tricks
  - simple explanation of using a breadboard/

- Conventional color coding for wires:
  - Power - red leads and wires
  - Ground - black leads and wires

Tips for Using a Multimeter

- How to use a Multimeter (for beginners): How to Use a Multimeter - YouTube
  It's a little long, but it has good information on how to measure voltages through a circuit on your breadboard, how to find current, and more.
- How to Use a Multimeter & Electricity Basics | Repair and Replace
  It's a little shorter (a little less in-depth), but it has labeled chapter sections

Goals while accomplishing Experimental Measurements and Personal Instrumentation objectives

(FOR FULL CREDIT, YOUR SUBMISSIONS FOR EACH SECTION SHOULD INCLUDE THE FOLLOWING WHERE APPLICABLE)

1. I can use consistent color coding of wires when I build circuits on my breadboard to aid in troubleshooting (a photo of the circuit must be included). Wire color conventions: red = power; black = ground. Otherwise, just be consistent!

2. I can "zoom in" to an oscilloscope output by changing the time scale (x-axis) to show important parameters (for example, a sinusoid with 25 cycles would be easier to see if only 3-5 cycles were shown instead!) when needed
   - *M2K*: Scopy Oscilloscope - Setting the Horizontal and Vertical Scales
   - *Analog Discovery 2*: Information on how to rescale the x- and y-axes is found in Section 2.4: Plot Pane Axes

3. I can "zoom in" to an oscilloscope output by changing the voltage scale (y-axis) to show important parameters (for example, a sinusoid with 500mV amplitude would be difficult to see with 5V/div…) when needed
   - *M2K*: Scopy Oscilloscope - Setting the Horizontal and Vertical Scales
   - *Analog Discovery 2*: Information on how to rescale the x- and y-axes is found in Section 2.4: Plot Pane Axes

4. I can change the THICKNESS of my trace lines for easy viewing.
   - *M2K*: scroll down to the bottom of the channel control on the right hand side of the oscilloscope tool and adjust the thickness under "CH Thickness"
   - *Analog Discovery 2*: Information on how to set the thickness of the traces is found in Section 5.3: Plotslin

5. I can change the background color of my oscilloscope output to white and paste in an external document for easy viewing. You can use "print screen" or the "snipping tool" to take a screen capture. Cell phone photos of a computer screen are not considered to be good quality documentation.
   - *M2K*: once you open Scopy, click on "Preferences" in the bottom left of the main window and set the theme to "light".
   - *Analog Discovery 2*: Information on how to set the color theme for the plots is found in Section 5.3: Plots

6. Label the measurement output clearly
   - Measurement values and curves must be labeled so that they can be associated with a particular component or location in the circuit according to a circuit diagram and/or photo of the circuit.

- Measurements on an oscilloscope must be labeled so that time and voltage are easily readable. You can accomplish this by turning on the axis labels in the oscilloscope settings or directly labeleing your times and voltage amplitudes on your oscilloscope plot.

M2K Objectives

Basic M2K Intro

- Intro to the M2K
- M2K Reference Manual
- Additional information/guides on the M2K from RPI's course Electronic Instrumentation
    - Pdf with 、
    - information regarding M2K and Scopy : Tool_M2k_tutorial.pdf - Tyler Lammey

1. Function Generator – DC, Sinusoid, and Pulse Signals

I can use my instrumentation board's function generator to create a DC, sinusoid, and pulsed signal and measure with its oscilloscope directly (hint: no circuit necessary but you need external wires!)

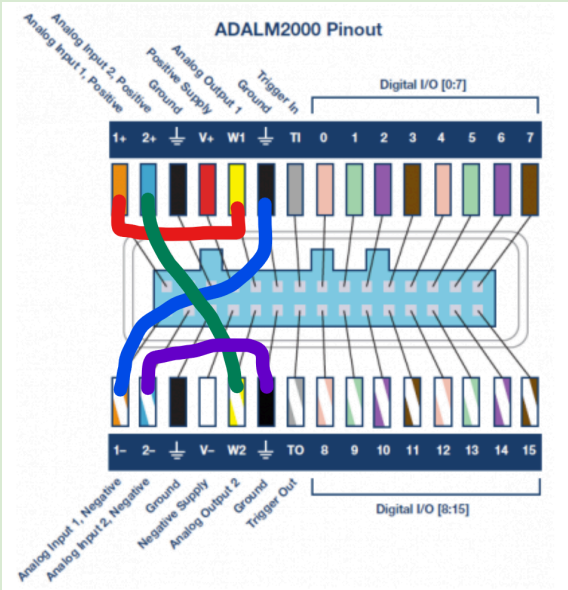
- Using the signal generator in Scopy: Scopy Signal Generator [Analog Devices Wiki]
- Using the oscilloscope in Scopy: Scopy Oscilloscope [Analog Devices Wiki]

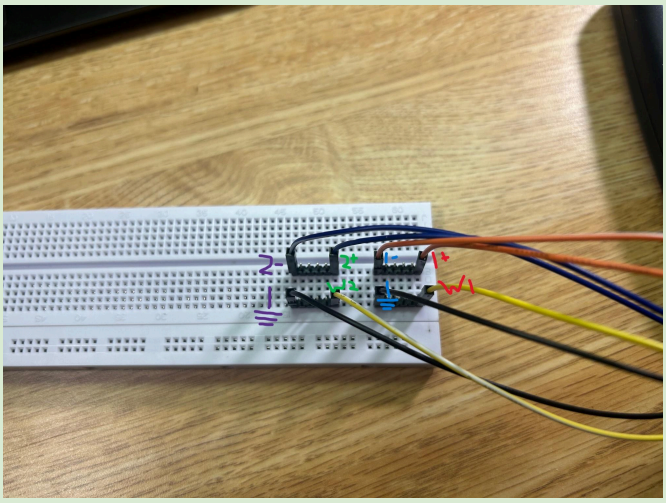
Notes from students:

If your Oscilloscope magically reads n times higher for no apparent reason, check your attenuation, it may have been accidentally changed at some point

Make sure the W1 pinout on the ADALM2000/Analog Discovery 2 is connected to the 1+ pinout and the GND pinout (3rd column on ADALM2000) is connected to the 1- pinout to ensure that the oscilloscope functions correctly in Scopy.

Here's a diagram for generating a test signal:





Q1 Experimental Measurements and Personal Instrumentation

Note that the necessary connections are:

Analog input 1, positive → Analog output 1	(1+ to W1)	orange to yellow
Analog input 1, negative → ground	(1- to ⏚)	orange-white to any black
Analog input 2, positive → Analog output 2	(2+ to W2)	blue to yellow-white
Analog input 2, negative → ground	(2- to ⏚)	blue-white to any black

Connections to ground (⏚) are interchangeable; they're all ground.

2. Measure DC Voltage Across One Resistor

I can build a resistive circuit and measure DC voltage across ONE resistor using a DC input source and vary DC voltage at least 3 times (-5V,+5V and any voltage in between) (The circuit must have two or more resistors. Hint: to do something useful to you, try to simulate a homework or class problem! Hint #2: use 1 kOhm resistors)

- Using the power supplies in Scopy: Scopy Power Supplies [Analog Devices Wiki]
- Using the voltmeter in Scopy: Scopy Voltmeter [Anaevices Wiki]
- Another video on using the power supply andScopy Voltmeter [Analog Devices Wiki] voltmeter in Scopy: M2K Power Supply & Voltmeter Functions
- Using the oscilloscope in Scopy: Scopy Oscilloscope [Analog Devices Wiki]

3. Measure DC Current Through One Resistor

I can build a resistive circuit and measure the DC current through ONE resistor using a DC source (OR find another way if needed depending on the board!) (The circuit must consist of two or more resistors. Hint: to do something useful to you, try to simulate a homework or class problem!)

- Using the power supplies in Scopy: Scopy Power Supplies [Analog Devices Wiki]
-
- Although the M2K has many functions, it cannot measure current directly. If you want to measure the current through a resistor, you need to measure the voltage across the resistor and divide by the value of the resistor: I = V / R (Ohm's Law).
- You can do this directly in Scopy by using a math channel in the oscilloscope. Scopy will allow you to define an oscilloscope channel that will plot the value of the measured voltage V divided by a value for the resistor R that you enter. Information on math channels can be found here: Scopy Oscilloscope: Working with Math Channels [Analog Devices Wiki]

4. Measure Voltage Across One Resistor with a sinusoidal input source

I can build a resistive circuit and measure voltage across ONE resistor using a sinusoidal input source (The circuit must consist of two or more resistors. Hint: try to make a sinusoidal source with amplitude 0 to 5V centered at 2.5 V and another from -5 to +5V centered at 0 then document whether your board can accomplish both or only one of these).

- Using the signal generator in Scopy: Scopy Signal Generator [Analog Devices Wiki]
- Using the oscilloscope in Scopy: Scopy Oscilloscope [Analog Devices Wiki]

5. Use the cursor function to show specific measurement values

I can use my cursor function to show specific voltage and time points on an oscilloscope measurement

- Using the oscilloscope in Scopy: Scopy Oscilloscope [Analog Devices Wiki]
- Using cursors to make measurements in the Scopy oscilloscope: Scopy Oscilloscope: Making Signal Measurements Using Cursors [Analog Devices Wiki]

Analog Discovery Board 2 Objectives

Basic Analog Discovery 2 Intro

- Getting Started with the Analog Discovery 2
    - Plug in the Analog Discovery 2 before opening the Waveforms
- Analog Discovery 2 Resource Center
- Waveforms Reference Manual
- Analog Discovery 2 - Digilent Reference
- Additional information/guides on the Analog Discovery 2 from RPI's course Electronic Instrumentation

1. Function Generator – DC, Sinusoid, and Pulse Signals

I can use my instrumentation board's function generator to create a DC, sinusoid, and pulsed signal and measure with its oscilloscope directly (hint: no circuit necessary but you need external wires!)

- Using the arbitrary waveform generator in Waveforms: Analog Discovery 2: Using the Waveform Generator
- Using the oscilloscope in Waveforms: Analog Discovery 2: Using the Oscilloscope

2. Measure DC Voltage Across One Resistor

I can build a resistive circuit and measure DC voltage across ONE resistor using a DC input source and vary DC voltage at least 3 times (-5V,+5V and any voltage in between) (The circuit must have two or more resistors. Hint: to do something useful to you, try to simulate a homework or class problem!)

- Using the power supplies in Waveforms: Analog Discovery 2: Using the Power Supplies
    - Waveforms: Analog Discovery 2: Using the Power Supplies
- Using the voltmeter in Waveforms: Analog Discovery 2: Using the Voltmeter

3. Measure DC Current Through One Resistor

I can build a resistive circuit and measure the DC current through ONE resistor using a DC source (OR find another way if needed depending on the board!) (The circuit must consist of two or more resistors. Hint: to do something useful to you, try to simulate a homework or class problem!)

- Using the power supplies in Waveforms: Analog Discovery 2: Using the Power Supplies
- Demo on measuring current with the Analog Discovery 2: Measuring Current
- Although the Analog Discovery 2 has many functions, it cannot measure current directly. If you want to measure the current through a resistor, you need to measure the voltage across the resistor and divide by the value of the resistor: I = V / R (Ohm's Law).
- You can do this directly in Waveforms by using a math channel in the oscilloscope. Waveforms will allow you to define an oscilloscope channel that will plot the value of the measured voltage V divided by a value for the resistor R that you enter. Information on math channels can be found here: Math Channels in Waveforms

4. Measure Voltage Across One Resistor with a Sinusoidal Input Source

I can build a resistive circuit and measure voltage across ONE resistor using a sinusoidal input source (The circuit must consist of two or more resistors. Hint: try to make a sinusoidal source with amplitude 0 to 5V centered at 2.5 V and another from -5 to +5V centered at 0 then document whether your board can accomplish both or only one of these).

- Using the arbitrary waveform generator in Waveforms: Analog Discovery 2: Using the Waveform Generator
- Using the oscilloscope in Waveforms: Analog Discovery 2: Using the Oscilloscope

5. Use the cursor function to show specific measurement values

I can use my cursor function to show specific voltage and time points on an oscilloscope measurement

- Using the oscilloscope in Waveforms: Analog Discovery 2: Using the Oscilloscope
- Making measurements and using cursors in the Waveforms oscilloscope: Measurements and Cursors

MATLAB Basics and Simulink

- Link to certificates: MathWorks My Courses
- MATLAB Download Link: MathWorks Downloads

1. I have completed the MATLAB Onramp Tutorial

Submit certificate to Gradescope

- The MATLAB Onramp Tutorial takes around 2 hours to complete. Make some time to complete it in one sitting if you can! Your progress saves automatically when you close out, so you will not have to restart. You can run the tutorials either through the app itself or in a web browser, which should save your progress everywhere as long as you're logged in. Make sure to take a few breaks to stretch after working for around 15-30 minutes and stay hydrated!
- MATLAB Basic Functions Reference
- MATLAB Cody (Practice with Matlab)

Tips from former Intro to ECSE students:

- Take your time to understand what the code and simulation do for MATLAB and Simulink although simple, try to really remember all the processes and examples you've done in order to complete this sections

For those struggling with the tutorial (IE, not understanding where a certain drop down menu might be, how something works in particular, or would just like to see a more step by step guide) this is a full guide to it. It is all in italian, but it still shows the screen with step by step guides. (753) Calcolo scientifico con MATLAB - Parte 1 - YouTube

2. I have completed the Simulink Onramp Tutorial

Submit certificate to Gradescope

- How to Open the Simulink Onramp in Matlab
- Youtube walkthrough of the tutorial: Simulink Onramp
- Youtube playlist for basics of Simulink (for reference): Getting Started

Tips from former Intro to ECSE students:

- If you don't see a button for Simulink, type 'Simulink' into the command window in Matlab, hit enter, and this should give you an error. Click on the red and underlined 'Simulink' word and it should go through the process to install Simulink as an add-on.
- Downloading Matlab will make the tutorial run much smoother, faster and more stably. You can find the Simulink Onramp tutorial after downloading Matlab by clicking on the Simulink tab in the top center and then the tutorial will be on the left side. If you are having problems with Simulink online such as it randomly closing, download it to your laptop or PC. RPI gives you free access to Matlab.
- *Warning*: do this somewhere with stable Wi-Fi. If you complete a section offline it will not mark that task as done when you go back online.

3. I can add two sinusoid waves and show the display using MATLAB Simulink

- Nice UDEMY Tutorial: Project #1 demonstrates how to display multiple sine waves in Simulink. Can you add them together as well? MATLAB - Simulink Tutorial for Beginners | Udemy Instructor, Dr. Ryan Ahmed
- How to display a sine wave in Simulink: Simulink Basics - Displaying a Sine Wave Signal

Tips from former Intro to ECSE students:

- If your sine wave is not smooth and Simulink still doesn't make it smooth even after increasing the refinement as seen in the video above because your model is not "discrete", follow the steps as seen in this video: Problem with sine wave and triangle signal in Simulink / MATLAB (2015)

4. I can analytically determine the amplitude, frequency, period and phase shift of a sinusoid

Plot a sine wave (it doesn't matter how: Matlab, Simulink, draw one with axes…), then using the plot, calculate and label the amplitude, period, and frequency of the wave. To measure a phase shift, you'll need 2 sine waves.

Finding the properties of a sine wave:

- How to Find the Amplitude Period and Phase Shift of Sine
- Midline, amplitude and period of a function | Graphs of trig functions | Trigonometry | Khan Academy
- Find equation of graph with phase shift

How to Find the Amplitude Period and Phase Shift of Sine

Tips from former Intro to ECSE students:

- For a sine wave: y = a sin(bx + c), |a| = amplitude, 2pi/b = period, c = phase shift; the same is true for cosines
- Quick guide/refresher on how to determine the amplitude and period of a sine wave from a plot: frequency is the inverse of the period, and phase shift is ((x1 - x2) / period) * 2pi.

5. Find solutions for linear independent equations using the matrix function

I can find the solutions for linearly independent equations using the matrix function on my personal calculator (TI-XX) and compare it to the calculation in MATLAB

General information on solving systems of linear equations:

- Matrix Multiplication
- Basics of Matrix Equations
- Solving Systems of Linear Equations Using Matrices (mathsisfun.com)
- Solving Linear Systems Using Matrices
- solutions to linear systems using Reduced row echelon form (to understand how elementary transformations work)

Matlab

- Matrices and Arrays - MATLAB & Simulink
- Solve Linear Equations with MATLAB
- Solve linear equations in matrix form - MATLAB linsolve

Calculators

- Solve a matrix using TI-84
- Using Matrices to Solve Systems of Equations on Ti84 Calculator
- Solve a system of linear Using Matrices to Solve Systems of Equations on Ti84 Calculatorequations using the TI83 - YouTube
- Matrices on TI-Nspire
- Online Matrix Calculator

06. & 7. Import simulation data to MATLAB

6: I can import simulation data (from LTSpice or equivalent) to MATLAB and plot the function
7: I can import experimental data (from Scopy or Waveforms) to MATLAB and plot the function

- How to Plot LTSpice graph in Matlab | Power electronics using LTspice

Exporting data from LTspice:

- Additional Information on LTspice
- How to Create a Graph in LTSpice

Importing data into Matlab:

- Create table from file - MATLAB readtable
- Use >> T = readtable('data.txt','Delimiter',' ') to read text files delimited by a certain delimiter (comma, space, tab) when opening the data files

Exporting data from instrumentation board software:

- How to export data from the M2K: Scopy Oscilloscope [Analog Devices Wiki]
- How to export data from the Analog Discovery 2: Digilent WaveForms

Tips from former Intro to ECSE students:

- It's best if you complete the LTspice proof of skills first so that you can export your simulation results for this part

8. Using a regression Line to simulate the data in MATLAB

I can use a regression in MATLAB to help define my function

- A very in-depth video on what linear regressions do: Linear Regression, Clearly Explained!!!

Regression and curve-fitting in Matlab:

- Regression Analysis In MATLAB: Regression Analysis in MATLAB
- How to curve fit data in MATLAB: How to curve fit data in Matlab (step by step)
- Supplemental Video: https://youtu.be/CejquWoc210How to curve fit data in Matlab (step by step)?si=9-ed39aOpbizT201
- Another way to fit data: Linear Regression in Matlab - Aashrut Jain
- Chapter 13: Polynomial Curve Fitting in MATLAB
- Important commands for regression lines in Matlab are: polyfit()- creates the slope for the line of regression, polyval()- creates the y values for the line of regression
-

Community, Communication, Asking for Help & Helping Others - Be an Active Part of the Learning Community!

When and how to help, get help, and work together? (PS Probably don't take this one first!)

Our classroom is blended which means you come prepared by reviewing material and we go through problems and activities in class. We also have team assignments, homework problems, and class problems that we'll do in class which should give plenty of opportunities to collaborate, help someone, and get help! You can check answers with simulations for example. Teaching Assistants and Student Assistants can be found on the Intro to ECSE website. Their hours will be posted. In addition, you can find them during lab time.

1. I can ask for help from a TA or SA when needed for technical issues, parts, or general question as I complete this Proof of Skills work

Tell us what you needed help with and who helped you

Tips from former Intro to ECSE students:

- If at a loss for what to do go to the ECSE website for the class and you will likely find everything you need to know there.
- Don't be afraid to talk to a TA or SA, their purpose is to help, and majority of the time, they're able to fix/help with whatever issue you may be having, or clarify something you don't understand.
- When talking to a TA or SA about an issue, try to come to them with a clear question. If you can describe what you are confused about well, the question will be much easier to answer. If you are not understanding a greater concept, try to read documentation regarding the topic before approaching the TA or SA since it is unlikely that they will be able to provide explanations for large concepts given time/resource restrictions.

2. I can HELP someone else OR ask another student for help after I have mastered a skill

Tell us who you helped/who helped you and you talked about

So you did your work ahead of time. Come to class and TEACH/HELP. This will be recognized as participation points. Leadership…is it born or made? If you want to make it, try to help!

Tips from former Intro to ECSE students:

- Try to avoid friends and introduce yourself to new people, perhaps you both have the same question
- Forming study groups with people is a great way to create a sense of community with others in your class. Also, if you get stuck on a problem, borrow someone else's brain because the one you got you there in the first place.
- Brainstorming sometimes might have unpredictable effects, and it will enhance your work in a new way.

3. Make Your Portfolio

Create your portfolio directory in Box or start designing your website and submit a screenshot showing your progress

- Portfolio Examples and Instructions
- Register/request a Box account: Requesting a Box @RPI Account – DotCIO - IT Services and Support Center - Use RPI email to sign up.
- In Your RPI Box Account, you must be under 'Documents' in order to create new folders

Portfolio Sites:

- WebFlow is another great website making tool, free and easy to use
- https://fabrik.io/ Fabrik is a beginner friendly website used to create portfolios
- SITE123 is another website used to make portfolios, which is free and self-explanatory
- You can also create your website using google sites, it has templates and can be very helpful.
- Wix is a great resource to create a website for your online portfolio # the domain does not work unless you have a own website
- github is also another popular website that is geared toward coding portfolios. Very popular for code sharing
    - Creating a repository titled [your username].github.io creates a website with that name that you can freely edit with coding
    - ex) if your username is john123, create a repository titled john123.github.io and github will automatically create a free web domain with the link john123.github.io
- Squarespace is a great place to easily make your portfolio.
- Adobe is another great program you can use to make a portfolio
- Heliohost - Free hosting for portfolio websites.
- Google Sites is also another option if you want something that is completely free and easy to use with no learning curve
- Wordpress can also be used for portfolios

- Here is a good video showing an example of an engineering profile and some important key details that you should add to yours! : https://youtu.be/n6vJL-m3QgU

How to Create an Engineering Portfolio

4. I add new information, add a comment or make a correction to the Intro to ECSE Skills documentation in a meaningful way for future semesters

This document is a work in progress. Add something, write your name next to it, and submit a screenshot of it! Thanks for your help for future semesters…leave a legacy! No matter how small or big…