

Lab #1 - Getting to know the Miura-ori pattern

ENGN 250 - Introduction to Engineering Design

April 24, 2023

1 Introduction

Origami (in Japanese, “ori” means fold and “kami” means paper) is a traditional Japanese art of paper folding, which has gained popularity around the world as a recreational and educational activity. The use of origami techniques has extended beyond the artistic realm and into scientific and engineering domains, as they offer new ways to solve complex problems, as well as innovative designs for structures and devices. One of the most famous origami patterns is the Miura-ori folding pattern, developed by Kōryō Miura in 1970, which has been applied to various engineering fields such as space exploration, fashion, and architecture (see Figure 1). In this lab, we will explore the Miura-ori pattern and its properties to better understand how we can use such a geometry to create a deployable acoustic panel and exploit the pattern’s unique behaviors.

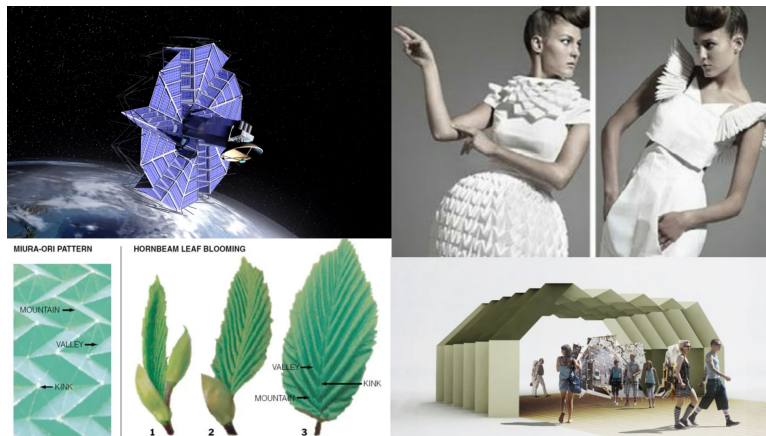


Figure 1: The Miura-ori pattern applied to a deployable solar panel, clothing, and a pavilion. The pattern can also be found in nature in the Hornbeam leaf.

2 Folding instructions

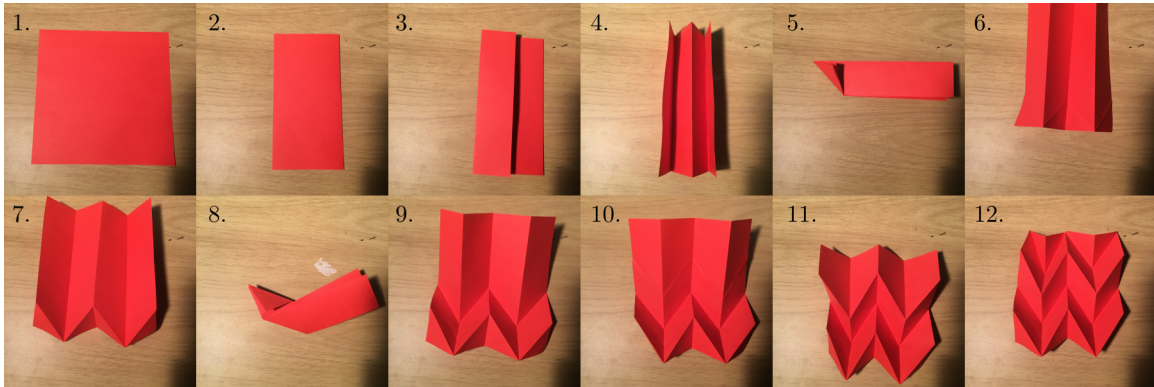


Figure 2: Visual guide to folding the Miura-ori pattern by hand.

The process of folding a Miura-ori model by hand involves creating creases and then popping the creases out so that they form the correct shape. Here are instructions for a simple version of the model:

1. Choose any piece of paper, and cut it into a square.
2. Fold the paper in half horizontally.
3. Fold the sides of the paper to meet the center crease.
4. Fold the paper so that it forms a W-shaped cross-section.
5. Collapse the folds, rotate the paper so that its long side is horizontal and the bottom of the W points upwards, then fold the lower left corner up to the top crease.
6. Unfold the paper. The creases should form a herringbone-like shape.
7. Invert the creases so that they form a mountain-valley-mountain-valley-mountain-valley-mountain pattern from left to right.
8. Collapse the folds again, and flip the tail of the model upwards.
9. Unfold the paper. Again, the creases should form the herringbone-like shape.
10. Invert the creases so that a zig-zag of valley creases moves across the sheet from left to right.
11. Repeat until you have reached the end of the paper.

Folding the Miura-ori pattern by hand requires patience and practice. Don't worry if you wrinkle the paper between creases. Once you have finished making this simple pattern, try a more complex one. For example, you can fold the paper into an accordion pattern (like in step 4) with double the number of creases, making the panels smaller. Additionally, you should try using a different shape of paper (you can make this with a rectangular piece of paper, too) and/or different paper thicknesses. **By the end of the lab, you should have at least three Miura-ori paper models. Bring these to class on Wednesday.**

3 Documentation and reflection

Go to a new sheet in your design notebook (if the notebooks have not arrived yet, write your answers on another piece of paper and copy the notes into the notebook when it comes). You should start by recording the information about your three origami models. Some ways to describe the models include:

- Paper thickness (use calipers to measure this)
- Paper dimensions before folding (use a ruler to measure this)
- Number of panels in each direction
- Sketches of your models

Use the same units for your measurements (SI or US customary).

Additionally, answer the following reflection questions in your design notebook:

1. Describe your experience folding the models. What was difficult about the process? Did you learn any strategies for making the process easier? Are you happy with your final results?
2. What happens when you pull on two corners of the Miura-ori model? Does it behave like a flat sheet would (think about pulling on a piece of flat cloth in the same way). How does this folded model differ?
3. A flat-foldable origami pattern is one that has two (nearly) flat states, one folded and one unfolded. Is the Miura-ori pattern flat-foldable?
4. A rigid-foldable origami pattern is one that can be folded from a flat state to a folded state without bending or stretching the panels between the creases. Is the Miura-ori pattern rigid-foldable?
5. Can you imagine any problems that could arise as the panels between the creases get thicker (think 1 [cm] thick).

Lab #2 - Designing and cutting origami panels

ENGN 250 - Introduction to Engineering Design

April 26, 2023

Introduction

As you may have learned in the last lab, folding the Miura-ori model by hand is a difficult task, and small errors in the folds can appear with ease. In the research world, most origami models are created using computer-guided tools, such as a mechanical cutter that uses a razor or a laser cutter that uses a high-powered laser to cut thin sheets. To use these tools, you must first generate a CAD drawing that shows the cutter where to make cuts in the material. We will use Autodesk AutoCAD and a Universal Laser Systems 75-Watt laser cutter to design Miura-ori panels and cut paper. Our goal is to create the lines that the laser cutter will cut along in the geometry we desire.

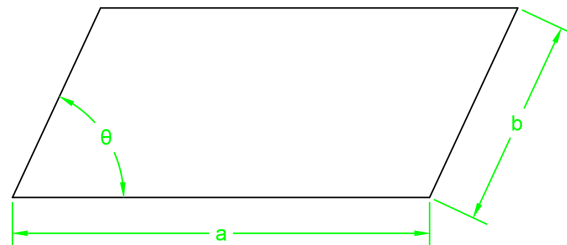
Step 1: Setting up the drawing environment

Before we start creating the crease pattern, we need to set up the drawing environment in AutoCAD. Follow these steps:

1. Open AutoCAD and open the ULSTemplate.dwg file.
2. Ensure that under the “Layers” toolbar in the drop down menu the current layer is “Vector Cut.” This will generate red lines that tell the laser cutter where to cut through the paper.
3. Only the things you draw within the green dashed box will cut, so keep your geometry within these lines.
4. Set the units to millimeters by typing “UNITS” in the command line (white bar at the bottom) and selecting “Millimeters” from the options.

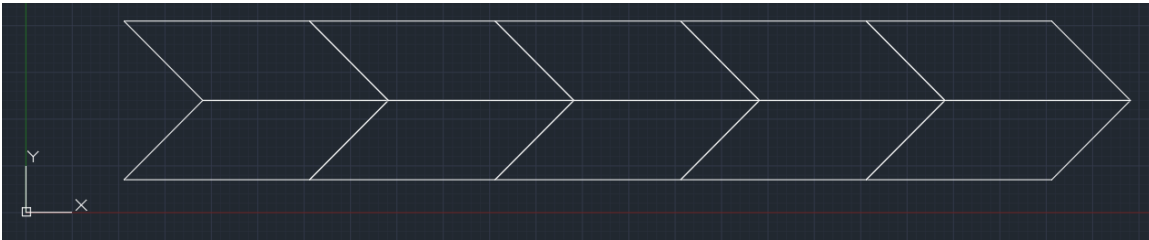
Step 2: Creating the basic grid

The Miura-ori crease pattern is based on a grid of parallelograms with side lengths a and b and an angle of $0^\circ < \theta < 90^\circ$. To start, we will make a Miura-ori pattern with $a = 50$ [mm], $b = 30$ [mm], and $\theta = 45^\circ$. Our pattern will have five panels in the horizontal direction and six in the vertical.



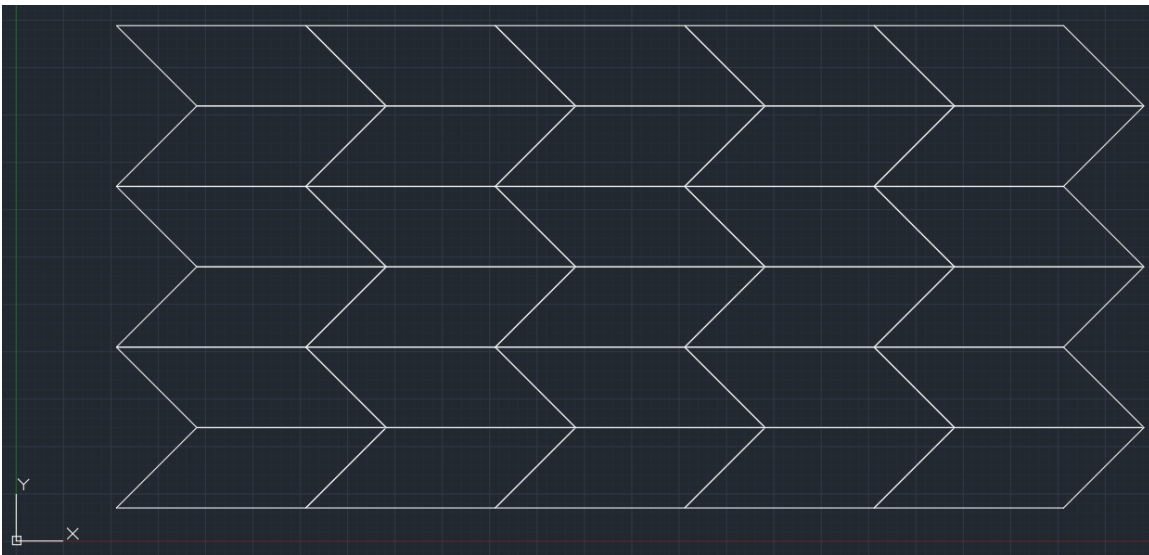
Follow these steps to create the basic grid:

1. Type “POLYLINE” in the command line, select an arbitrary starting point, move the cursor to the right, and type “@50<0” then hit enter to create the bottom line of the parallelogram with a length of 50 [mm] inclined 0° from the horizontal axis.
2. Next, type “@30<45” and hit enter to create the right side of the parallelogram with $\theta = 45^\circ$.
3. Complete the parallelogram by adding the top line with the same length as the bottom inclined at 180° from the horizontal and the left side with a length of 30 [mm] inclined at 225°. Hit the escape key to exit the polyline tool.
4. We can now repeat this parallelogram using the copy tool. Select the parallelogram, then type “COPY.” Choose the lower, left-hand corner of the parallelogram as the base point, then select the lower, right-hand corner to place the new parallelogram. Repeat this until you have a row of 5 parallelograms.
5. Next, select all five of the parallelograms and type, “MIRROR.” Hit F8 to snap to right angles, then mirror the pattern about the vertical axis by selecting two points along this axis. Hit enter.
6. Next, move the new set of parallelograms to the top of the old parallelograms by selecting the new set and typing “MOVE.” Choose the lower-left corner of the new set, hit enter, then select the upper-left corner of the old set.



7. Finally, select all of the parallelograms, and type “COPY” to repeat this row two more times.

You should now have a grid of parallelograms that look like:

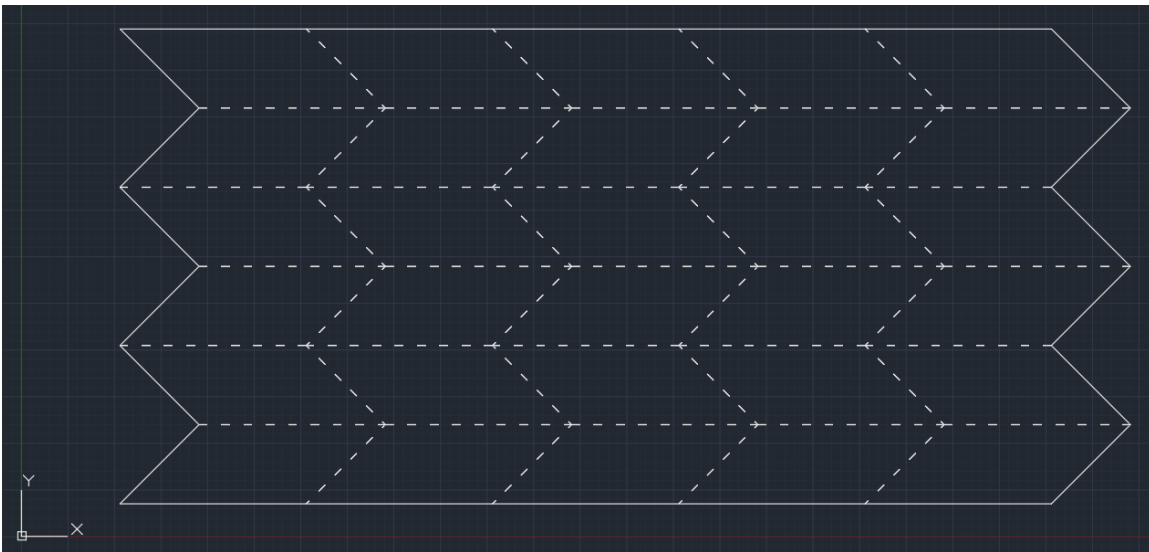


Step 3: Creating the crease perforations

With paper, the easiest way to create a crease is to weaken the sheet along the edges we specify. We can do this by perforating the crease lines with a dashed cut.

1. Select the grid you created, and type “EXPLODE” to break the grid into separate lines.
2. Under “Properties,” select the lowest drop down menu, and select “Other.” A window should appear. Click on “Load,” choose “ISO dash space,” click “OK,” and then “OK” again.
3. Next, select the interior lines that will be our creases. Using the drop down menu, choose the dashed line.
4. The spacing between the creases will likely be too large or small, but we can change this by typing “LTSCALE,” hitting enter, and typing in 0.2, then hitting enter.

You should now have a Miura-ori crease pattern that looks like:



Step 4: Saving the Drawing

Once you have created the crease pattern, it’s a good idea to save the drawing. Follow these steps to save the drawing:

1. Type “SAVE” in the command line.
2. Enter a file name for the drawing and select a location to save it.
3. Click “Save.”

Congratulations! You have now created your first Miura-ori crease pattern. You can now set up the laser cutter and print to it in AutoCAD by typing “PRINT.”

Final task and reflections

You should draw and cut three Miura-ori crease patterns. For each model, use a different value for the size and angle of the parallelogram. Try using paper of different thicknesses. Once the crease pattern is cut, remove the paper from the laser cutter and fold the creases in the mountain-valley pattern you made in the last lab.

In your design notebook, answer the following questions:

1. Start by recording the information about your three origami models. Some ways to describe the models include:
 - Paper thickness (use calipers to measure this)
 - Paper dimensions before folding
 - Number of panels in each direction
 - The side lengths and angle of your parallelograms

Be sure to indicate the units.

2. Describe your experience drawing, cutting, and folding the models. What was difficult about the process? Did you learn any strategies for making the process easier? Are you happy with your final results?
3. How would you compare this process to what you did in the last lab?
4. As we work on our class project, you will need to use thicker materials (e.g., basswood panels or acrylic sheets). How do you see this process being helpful to achieving such a task?
5. With perforated creases, the position of the cuts can impact the shape of the model. How could you redesign your crease pattern so that the cuts do not extend to the edges of the paper? Think about the tools available to you in Inventor (they are similar to the tools in AutoCAD).
6. How does the size and shape of the parallelograms impact the folding of the panel?

Understanding the client's goals

ENGN 250 - Introduction to Engineering Design

April 28, 2023

Instructions

As a class, work on the following tasks. Everyone should record the results of each step starting on a new page in their design notebooks. The tasks build off each other, so follow them in order, rather than split up the work into sub-groups. Feel free to use the blackboard and/or sticky notes to help you formulate your ideas.

All of the information you generate in this activity will be useful to you when you start writing your final report and will give you some tables and/or figures to explain your design process.

Original problem statement

The acoustic properties of the rooms I teach in are awful. There is often an echo bouncing around the room or a droning sound from an HVAC fan. I want an origami-inspired panel that can improve the acoustic properties of a room that I can take with me to different classes. Since each room is different, I want the device to adapt to the sounds it senses in the room.

Step 1 – Revising the problem statement

Look for any biases or implied solutions in the original problem statement. Note that for this class, you will be required to build an origami-inspired acoustic panel (think of this as a constraint that helps keep the problem simpler). Rewrite the problem statement such that these biases and implied solutions are eliminated and details are clarified. You should be asking Prof. Woodruff questions while working on this.

Step 2 – Categorizing a list of attributes

Using the revised problem statement, start listing attributes of the design. Try to create at least three attributes per person. Then, categorize each attribute as an objective, constraint, function, or means.

Step 3 – Creating an objective tree

With your list of objectives, think about how you can categorize them into levels of abstractness. Starting with the most general objectives, arrange the objectives into an objective tree using the sticky notes. Add any sub-objectives to the tree where appropriate. Remember to avoid adding constraints and functions to the tree.

Step 4 – Ranking objectives with a pairwise comparison chart

Next, you will rank the high-level (most abstract) objectives using a pairwise comparison chart.

Step 5 – Generating metrics for the objectives

With your ranked objectives, create a metric for each one. Decide if the metric will be measurable (a numerical value) or subjective (a qualitative value). Translate the qualitative values into points according to VDI 2225 (described below).

Points	Meaning
0	unsatisfactory
1	just tolerable
2	adequate
3	good
4	very good

Step 6 – Specifying constraints

Finally, identify any constraints applied to the project. List these constraints in your notebook. Think about the context of the project (amount of time and resources we have at W&L) and any safety concerns. Note that for this project, the cost of testing and prototyping must remain below \$2,000.

Lab #3 - Signal processing with an Arduino circuit

ENGN 250 - Introduction to Engineering Design

April 28, 2023

Introduction

In this lab, you will be creating a system that receives sound, performs a Fourier transform, and plots the spectral amplitude of the sound. In its simplest form, a sound can be expressed as a single sine wave with an amplitude, A , and a frequency, f , over time, t :

$$g(t) = A \sin(2\pi ft)$$

This system should be able to tell you what f is for a given sound, since the spectral plot will peak around f .

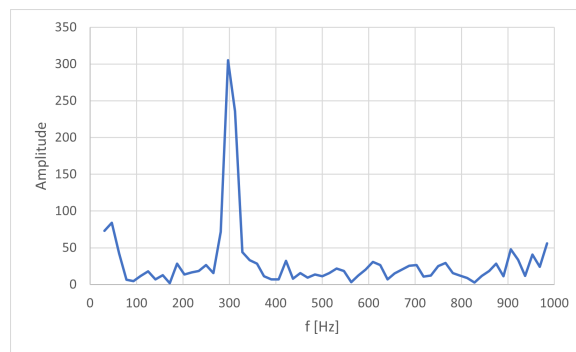


Figure 1: A spectral plot whose peak shows the predominant frequency, f , around 300 [Hz].

Most sounds, however, are made of many sine waves, so a typical spectral plot will have multiple peaks. But, it is important for you to identify the most prominent one as you develop your acoustic panel design.

In teams of three, complete the following steps (I recommend having one person on each team that has taken circuits already). Answer the reflection questions individually.

Building the circuit

Start by building the circuit that will act as a microphone receiver for the sound signal we want to analyze. Because the Arduino can only supply a small voltage to a circuit, you will need to build a more complex circuit design to amplify the signal and send the data to the Arduino memory. You will use a breadboard to build our prototype.

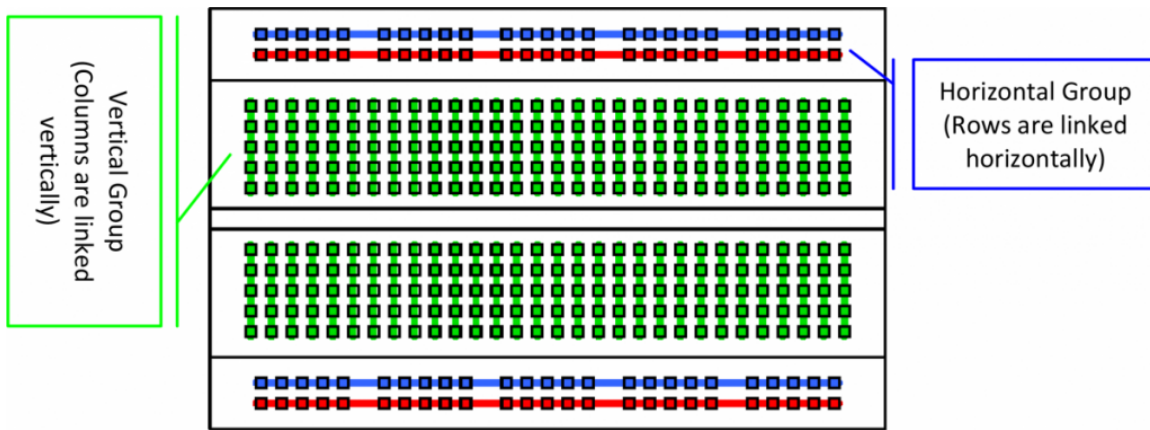


Figure 2: Diagram of a breadboard. Solid lines show which holes are connected to the same metal strip.

A breadboard is a tool that allows you to quickly and easily create electronic circuits without the need for soldering. It works by providing a grid of interconnected holes that you can use to insert and connect electronic components, such as resistors, capacitors, and LEDs.

The holes in a breadboard are connected by a series of metal strips underneath the surface of the board. The strips are arranged in rows and columns, and are usually labeled with letters (A-J) and numbers (1-30) to help you keep track of where you're connecting things.

To use a breadboard, you simply insert the leads of your electronic components into the appropriate holes, making sure that they're making contact with the metal strips underneath. You can then use jumper wires to create connections between components.

The power and ground (negative) rails on the sides of the breadboard are used to provide power to your circuit. You will connect the Arduino 5 [V] power supply to the rails, and then use jumper wires to connect the rails to the appropriate components in your circuit.

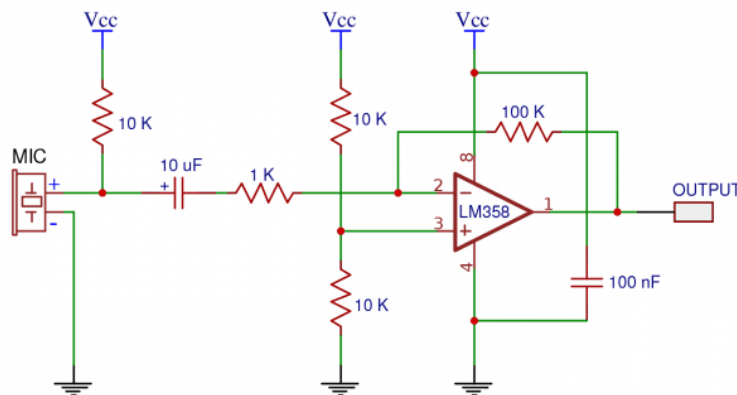


Figure 3: Circuit schematic (don't worry if you do not understand what this means yet).

Collect the following components for your circuit:

- Arduino Uno
- Breadboard
- Jumper wires (x8)
- Resistors

- 100 [kΩ] (brown-black-yellow-gold)
- 10 [kΩ] (x3) (brown-black-orange-gold)
- 1 [kΩ] (brown-black-red-gold)

- 10 [μF] (larger, blue)
- 10 [nF] (smaller, blue)

• Capacitors

- LM358 op-am (black rectangle with eight pins)
- Electret microphone (steel cylinder with black top)

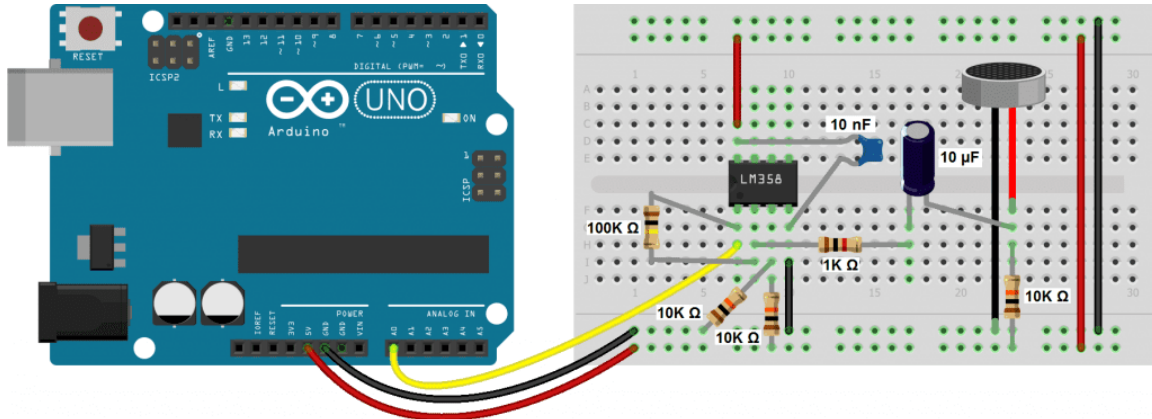


Figure 4: Circuit setup. Note that red wires indicate positive and black wires indicate ground. The op-amp should be oriented such that the circular notch is to the left.

Insert the circuit components as shown in the circuit diagram. Note that the resistors and capacitors are non-polarized, so it does not matter which direction you place them. However, the op-amp and microphone are polarized, so be sure to place them such that the positive terminal points to the positive rail and the ground terminal points to the ground rail.

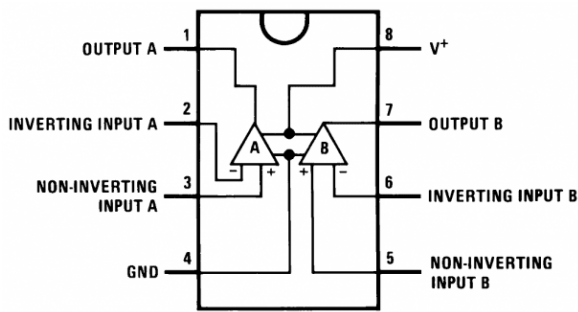


Figure 5: Op-amp diagram. Note the location of the circular notch.

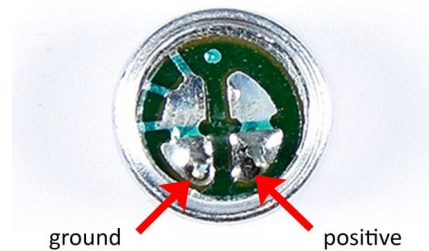


Figure 6: Electret microphone with positive and ground (negative) terminals shown.

Be sure that none of the metal wires in your circuit are touching each other. Also, make sure the red wire on the Arduino is in the 5V slot, the black wire is in the GND slot, and the yellow wire is in the A0 slot.

Writing the Arduino code

With the hardware assembled, you may now create the code required to run the Arduino circuit. I recommend using a Windows computer for these steps. One member of your team should install both the Arduino IDE 2.1.0

(<https://www.arduino.cc/en/software>) and the PuTTY installer (<https://putty.org/>) on their computer. Once that is completed, open the Arduino IDE.

First, you will need to install the a fast-Fourier-transform library to the computer. To do so, go to Tools/Manage libraries. A search bar will appear. Type in “arduinoFFT,” and install the library. Next, you should copy the following code into the editor:

```
1 #include "arduinoFFT.h" //Be sure to install this library before running
3 #define SAMPLES 128          //Must be a power of 2 less than 256
  #define SAMPLING_FREQUENCY 2000 // [Hz], must be less than 10000 and at least twice the highest
    expected frequency
5
6 arduinoFFT FFT = arduinoFFT();
7
8 unsigned int sampling_period_us;
9 unsigned long microseconds;
10
11 double vReal[SAMPLES];
12 double vImag[SAMPLES];
13
14 void setup() {
15     Serial.begin(9600);
16
17     sampling_period_us = round(1000000*(1.0/SAMPLING_FREQUENCY));
18 }
19
20 void loop() {
21     /*SAMPLING*/
22     for(int i=0; i<SAMPLES; i++)
23     {
24         microseconds = micros();
25
26         vReal[i] = analogRead(A0); // Read the A0 port
27         vImag[i] = 0;
28
29         while(micros() < (microseconds + sampling_period_us)){
30             }
31     }
32
33     /*FFT*/
34     FFT.Windowing(vReal, SAMPLES, FFT_WIN_TYP_HAMMING, FFT_FORWARD);
35     FFT.Compute(vReal, vImag, SAMPLES, FFT_FORWARD);
36     FFT.ComplexToMagnitude(vReal, vImag, SAMPLES);
37     double peak = FFT.MajorPeak(vReal, SAMPLES, SAMPLING_FREQUENCY);
38
39     /*PRINT RESULTS*/
40     //Serial.println(peak); //Print out what frequency is the most dominant OR:
41
42     //Print out the spectral plot data (amplitude as a function of frequency)
43     for(int i=0; i<(SAMPLES/2); i++)
44     {
45         Serial.print((i * 1.0 * SAMPLING_FREQUENCY) / SAMPLES, 1);
46         Serial.print(",");
47         Serial.println(vReal[i], 1);
48     }
49
50     //delay(5000); //Repeat the process every 5000 milliseconds OR:
51     while(1); //Run code once
52 }
```

ArduinoFFTCode.ino

With your code finished, connect your computer to the Arduino using a USB cable. Be sure that correct board is selected in the drop-down menu in the upper, left-hand corner of the window. Note the port being used (e.g., “COM3”).

Sending the Fourier analysis data to a CSV file with PuTTY

Unfortunately, there is no straight-forward way to plot a spectral plot in the Arduino IDE. Thus, we must use PuTTY to run the Arduino code and save the data to a CSV file. To do so, open PuTTY. Set the parameters on the Session screen to those seen here. Write the port that your board is connected to. Mine is on “COM5,” but yours might be different.

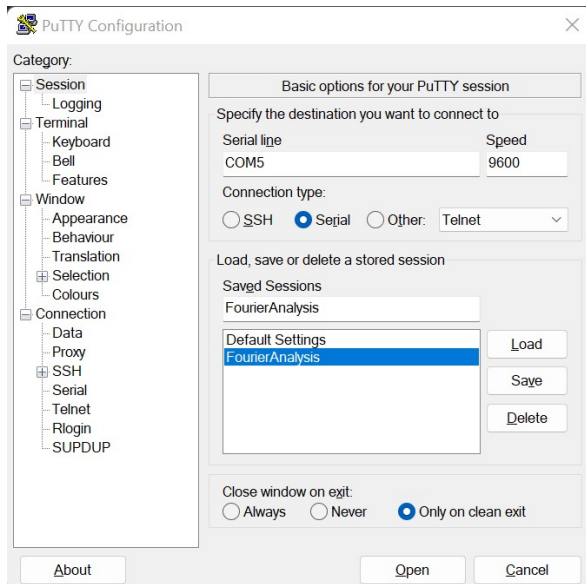


Figure 7: Session settings.

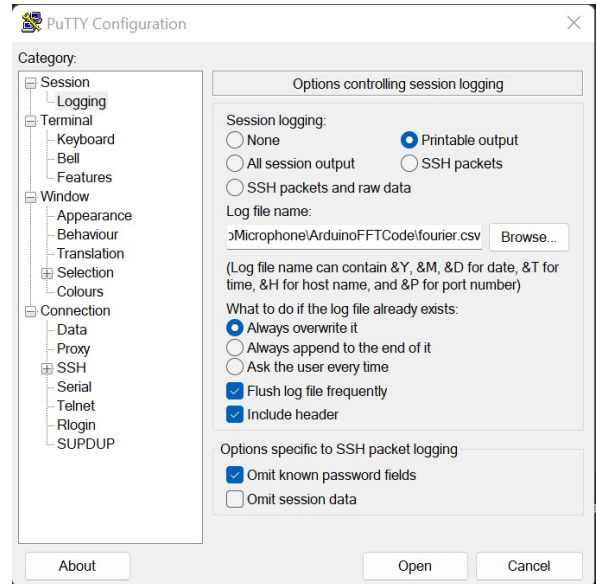


Figure 8: Logging settings.

Next, go to the Logging tab on the left-side of the window. Set the parameters to what you see here. Note that you will need to choose your own save location. Be sure that the file ends with “.csv”

Finally, go back to Session tab, and define a name for the Saved Sessions. Click Save. This will allow you to load the parameters again without having to re-enter them all by hand.

Making sure that the serial monitor is not open in the Arduino IDE, you can click Open in PuTTY. A list of numbers should appear in a new window. These will be saved in the CSV file. Open that file where you saved in in Excel and plot the data as a scatter plot connected with lines. You should see a spectral plot (it will not have a single peak yet).

Code testing

Test your code to see if it is able to identify a known sound wave. Along with the tuning fork, there are pure tone generator apps on your phone’s market place or online (e.g., <https://www.szynalski.com/tone-generator/>). With these apps, you can generate a sine wave sound signal for a given frequency. Choose a frequency and play the sound near your microphone. Open PuTTY again, load the session you saved, and hit open to re-run the code. Plot your CSV data in Excel, and you should see a peak near that specified frequency. You can also play around with other sounds to see what frequencies are most prominent. Be sure to close the CSV file each time you run the code (it will not overwrite if you keep Excel open).

Notes on the constraints of the code

The main limitation of this system is its available memory. Because the Arduino can only store so much data at a time, the maximum sampling frequency and sample rate are constrained. Theoretically, a higher sample rate and sample frequency will lead to a higher range of detectable sound frequencies, but this does not pan out in practice. For instance, try setting the sample rate to 256 and the sampling frequency to 5000. What happens?

According to the Nyquist-Shannon sampling theorem, the maximum frequency that a discrete system can interpret from a continuous signal is one-half the sampling frequency. Thus, there is an upper limit on the detectable sound frequency. Since there is a constraint on the sampling frequency, there must be a constraint on the maximum frequency that is detectable, and some important frequencies may be excluded from the analysis.

Additionally, there will always be white noise coming from external sound sources, such as an HVAC fan, wind brushing up against a building, or people talking. Thus, the system will never detect just one pure frequency. This explains the ripples in the spectral plot, which represent other frequencies in the room that are less loud.

Reflection questions

On a new page in your design notebook, respond to the following questions:

1. In fewer than five sentences, summarize the work you did in this lab, including the objective, the methods used, and the result.
2. Between building the circuit and testing the software, what was the more enjoyable task? Explain why.
3. What was the most challenging part of this lab? Explain your thinking.
4. Plotting the spectral results in Excel was a matter of convenience. How could you use MATLAB or Python to automatically generate the plot for you?
5. If you were designing the actuation software, how would you use this code to send a signal to the acoustic panel to reduce the amplitude of the most prominent frequency?

Functional analysis

ENGN 250 – Introduction to Engineering Design

May 1, 2023

Instructions

Your goal is to develop design functions, create function-means trees for each function, and establish performance specifications for the acoustic panel problem as a team. Design functions are the desired outcomes that a product or system should achieve (they often take the form of active verb + noun). Function-means trees are a tool for organizing and mapping the relationships between the design functions and the means for achieving them. Performance specifications are the measurable criteria that will be used to evaluate the success of the project.

Step 1 – Create a black-box schematic

Start by identifying the inputs and outputs of the acoustic panel design, placing them at the left and right of a black box sketch, respectively. Reformulate these inputs and outputs as basic functions of the design. Sketch this black-box schematic in a new page in your design notebook.

Step 2 – Perform a literature review

You have been provided some scientific articles about how robots and origami systems have been actuated and designed in the past. Divide these articles among yourselves, skim the text, and identify different potential means for achieving the basic functions you identified in Step 1 (if you have any questions about the means, ask Prof. Woodruff). Note these means in your design notebook (you do not need to include everybody's identified means, just your own).

Step 3 – Generate a function-means tree

Starting with the basic functions identified in Step 1 and everyone's identified means found in Step 2, create a function-means tree for each basic function. A good method is to write the functions and means on sticky notes and arrange them on the blackboard. Once your team is finished, record this tree in your design notebook.

Step 4 – Generate a list of performance specifications

With your identified functions, create performance specifications that specify performance levels that each function must demonstrate to be successful. Record your results in a function-performance specs table in your design notebook (see Table 6.4 on page 90 in the text for an example).

Lab #4 – Forming teams

ENGN 250 – Introduction to Engineering Design

May 1, 2023

Introduction

Your objective for this lab is to create a team charter that sets group norms and expectations as you work on the term project together. As engineers, you will often work in teams to solve complex problems. Developing a team charter can help your group establish a shared understanding of your goals, roles, communication strategies, and expectations for working together. A team charter can also serve as a tool for resolving conflicts and maintaining accountability throughout the project.

Instructions

1. As a team, discuss and agree upon the following elements of your team charter:
 - (a) Purpose: What is the purpose of your team? What is your shared goal for the term project?
 - (b) Roles and responsibilities: What roles will each team member take on (both in the full team and within each of the three sub-teams: Panel design, actuation hardware, and actuation software)? What are the responsibilities associated with each role?
 - (c) Communication: How will your team communicate with each other? What tools or platforms will you use? How often will you meet?
 - (d) Decision-making: How will your team make decisions? What process will you use to resolve conflicts?
 - (e) Accountability: How will your team ensure that each member is contributing equally to the project? What consequences will there be if someone fails to meet their responsibilities?
 - (f) Norms: What are the norms or ground rules that your team will follow? For example, how will you handle missed deadlines or incomplete work?
2. Write a team charter that includes all of the elements you discussed in step 1. Your charter should be no more than two pages long.
3. Someone in the class should submit your team charter on Canvas before midnight tonight. You will include this charter as an appendix in your final report.

Assessment guidelines

As I review your first draft of the charter this week and grade your final draft in the end-of-term report, I will be looking for:

- Clarity and completeness of the purpose, roles and responsibilities, communication, decision-making, accountability, and norms sections (40%)
- Consistency and coherence of the team charter as a whole (30%)
- Demonstration of critical thinking and reflection on team dynamics (20%)
- Grammar, spelling, and formatting (10%)

Morphological and best-of-class charts

ENGN 250 – Introduction to Engineering Design

May 3, 2023

Instructions

As a team, your goal is to generate alternative designs and assess their ability to meet the project constraints and objectives. Results from this activity should give you insight into what design your team should choose as you begin detailed design and fabrication.

Step 1 – Generate a morphological chart

With your function-means trees, create a morphological (morph) chart that communicates the design options available to you. For now, do not worry about feasibility. Record this chart in your design notebooks.

Step 2 – Categorize design feasibility

Looking at your morph chart, identify the means that can be combined to create a feasible design solution. List these solutions underneath your morph chart. Additionally, identify a few combinations that are infeasible and briefly explain why such a design is not practical/possible.

Step 3 – Generate a best-of-class chart

With you list of feasible design solutions, create a best-of-class chart that assesses the design's ability to meet the constraints and satisfy the objectives. Remember that any design that does not meet the constraints should be discarded and the solutions that do meet the constraints should be ranked for each objective, where 1 is the best solution, 2 is the second best, et cetera. Record this chart in your design notebook.

Step 4 – Assess your options

Recalling that the best-of-class chart does not necessarily tell us what design solution will be optimal, review your synthesis of the design solutions. In your notebook, identify a solution that you can argue will best meet the client's needs. Justify your answer using your best-of-class chart and a holistic analysis of the solution from your own point of view. Remember to be critical of all solutions, weigh your options, and discuss your thinking openly with the team.

Lab #5 – Final design choices

ENGN 250 – Introduction to Engineering Design

May 3, 2023

Introduction

Your objective for this lab is to begin the process of implementing the class's chosen design. Using the tools we learned and created in class, you will decide as a team the design solution you will work on for the rest of the term. You will then produce preliminary documents that describe and critique your design.

Instructions

1. In your sub-teams, discuss the design solution that you have chosen. Be sure everyone is on the same page and that any hesitations or concerns are verbally expressed before moving on. If there are any conflicts, attempt to understand the underlying desires of each team member and find a solution that can satisfy those desires, if possible. You should talk with Prof. Woodruff if there is an impasse or knowledge gap preventing movement forward.
2. Each sub-team should start documenting the details of your chosen design in your design notebooks. A good approach to this is to:
 - Write a brief description of the design
 - List the functionality that the design offers
 - Identify the important features of the design (parts, codes, interfaces)
 - List the materials you think you will need to begin fabricating your design
 - List the tools/technology you think you will need to begin implementing your design (e.g., laser cutter, water jet, 3D printer)
 - Sketch the design (a sketch of the physical design or a flowchart explaining a process), pointing out the main features of the system
 - List any uncertainties you have about the design and any obstacles you anticipate will appear
3. When other sub-teams finish, work together to identify any important interfaces between each group (e.g., how the panel will connect to the actuator or how the code will send a signal to the actuator). Make sure that the designs you have chosen will be compatible, and make any adjustments to your design as needed.
4. Send a scan of your work to Prof. Woodruff via email (only one person from each sub-team needs to do this). The purpose of this is to start purchasing material for the project.

Work breakdown structure and calendar

ENGN 250 – Introduction to Engineering Design

May 5, 2023

Instructions

Your goal is to generate a work breakdown structure and calendar both within your sub-team and within the whole team. These tools will be useful as you begin focused work on your project, letting you recognize if you are falling behind or if your goals are too extreme. Record the results from each step in your design notebook.

Step 1 – Establish team deadlines

As a full team, identify the due dates of the class deliverables, and establish a deadline for each sub-team to meet. Be sure to leave time for sub-teams to work together to fix any interface problems.

Step 2 – Create a sub-team work breakdown structure

Within your sub-team, create a work breakdown structure for your sub-team's portion of the project. This should include all of the tasks that need to be completed in order to successfully complete your portion of the project, and should be organized in a hierarchical structure.

Step 3 – Assign tasks and estimate resources needed

Assign tasks to each team member based on their strengths and interests. Make sure that each task has at least one team member responsible for completing it. Additionally, estimate the time and resources required for each task, including any materials or equipment needed.

Step 4 – Create a schedule

Using your work breakdown structure and estimates, create a schedule for your work over the next two weeks. This should include specific deadlines for each task, keeping in mind the deadlines set for the entire team. For this class, you do not need to create a Gantt chart, but you can use a simple calendar layout to point out when tasks and deliverables are due for your sub-team.

Step 5 – Review and revise

Consult with the entire team and Prof. Woodruff to make sure you considered all tasks and have set reasonable deadlines for completing those tasks. To do so, copy your work breakdown structure onto sticky notes, and put them on the board, drawing lines between task levels. We will go over the structure together.

Labs #6-11 – Team meetings

ENGN 250 – Introduction to Engineering Design

May 5-17, 2023

Introduction

For the remainder of the course, you are required to work independently with your teams on the class project each lab period. Over the next two weeks, I encourage you to put in consistent effort, refining your design and ensuring that all team members are actively contributing.

Each day of lab, your objective is to reflect on your progress so far and ensure that you are on track to complete your part of the project. You will submit a brief reflection on the work you have done to date, outline your plans for the remaining days of the project, and prepare a short presentation to keep everyone up to speed.

Deliverables

Each team member should write a progress report in their design notebook, detailing the work completed thus far, any obstacles encountered, and how they have been addressed. Explain your plans for continuing the work in the next few days. Use sketches to help explain your work, and be sure to include how your individual efforts have fit within the overall project. Finally, consider the lessons we have learned in class, specifically about the design process. How has your understanding of the process evolved with each day?

Additionally, each sub-team will give a short presentation that summarizes your previous work at the start of each lab session (you should include your response to the prompt above in your presentation). The presentation should be informal and conversational (no need to create a PowerPoint presentation, unless you feel it would be useful).

Grading

This assignment will be graded based on the following criteria:

- Clarity and completeness of the progress report;
- Insightfulness of individual reflections;
- Evidence of consistent effort.

You should also use the team peer assessment rubric to help you judge your own work and identify any weak areas you can improve upon.

Remember that this course is intended to let you practice decision making and project management – it's your project, and I want you to own your work and be proud of your progress. As such, I encourage you to work together to solve problems. Of course, I am always available and eager to step in if you are stuck and need advice. Good luck, and I look forward to seeing your progress!