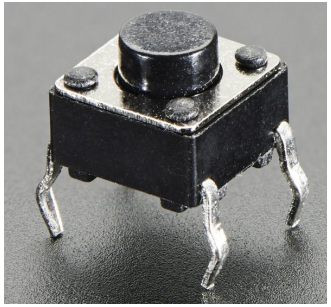
Building a Capacitive Touch Keyboard

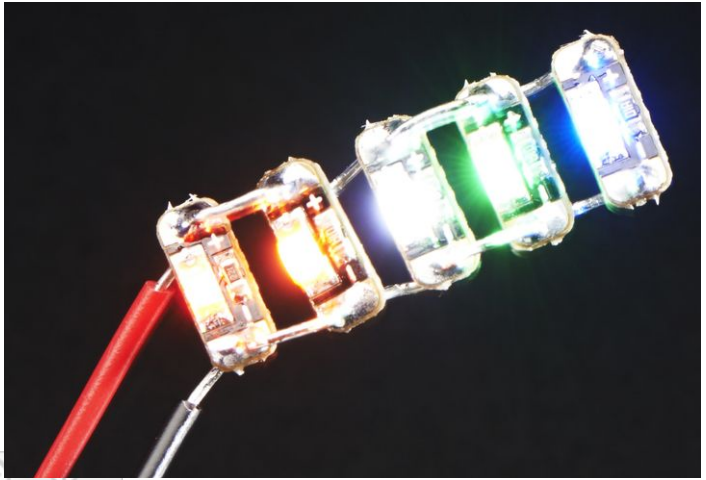
Introduction to Wearable Interfaces with Circuit Playground Express + Make Code

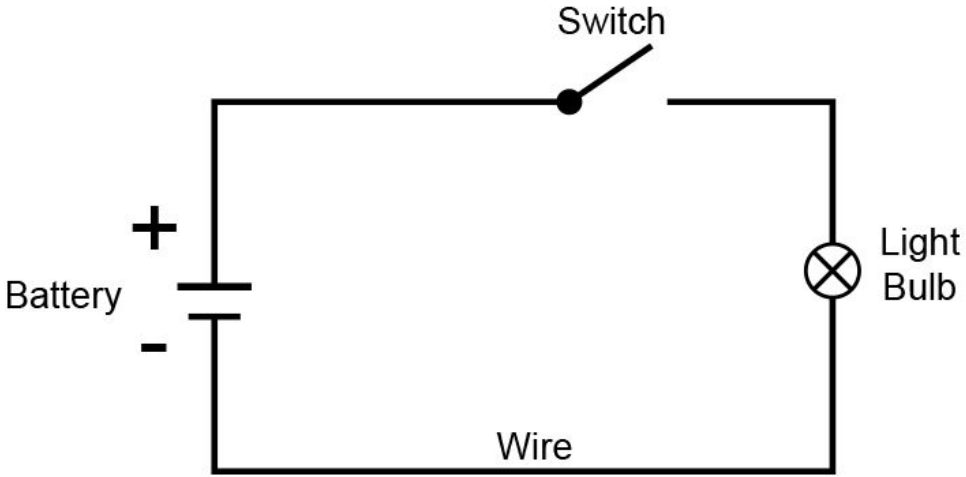
Capacitive Touch vs Traditional Circuits

What's been covered:

- Basic DC Circuit (supply LEDs with voltage)
- Conductivity Tester



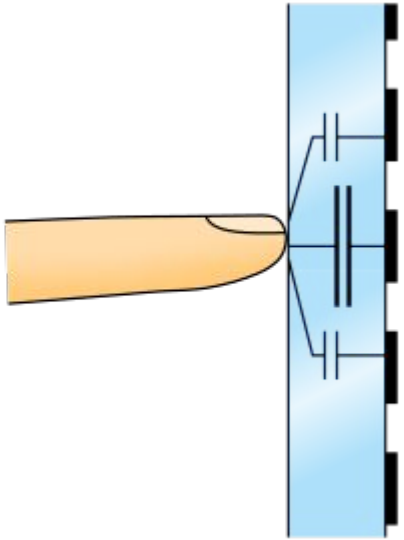




Capacitive Touch vs Traditional Circuits

New: **Capacitance**

Generally Speaking, Capacitance is the *Capacity to hold an Electric Charge.*



Human skin can both conduct and hold electric charge.

Capacitive Touch vs Traditional Circuits

In an AC circuit, where current flow is constantly changing direction, capacitors generate a specific type of resistance called reactance, which modifies the signal wave.

By measuring the change in an AC signal being sent to your Analog Pins (A1-7), you're Circuit playground can sense if a capacitor is connected.

Since you are a capacitor, it can sense your touch!

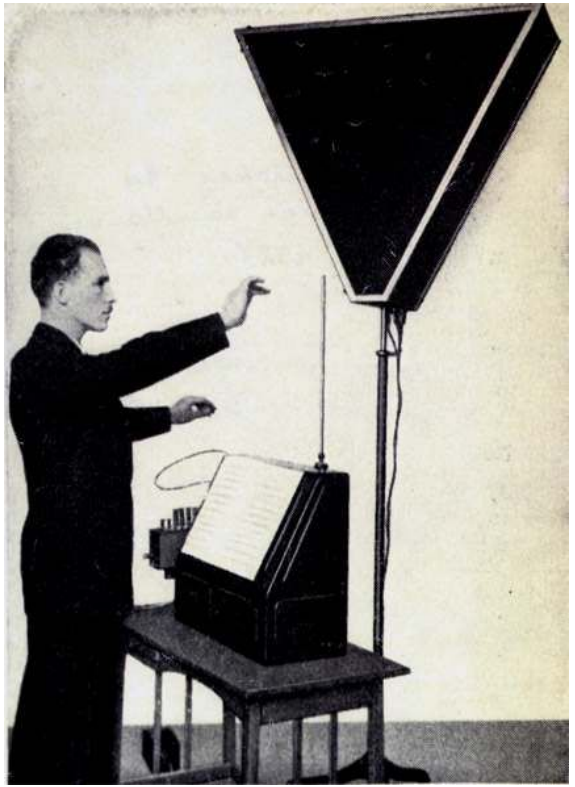
Capacitive Instruments

The original Capacitive Touch Instrument: **The Theremin**

2 Antennas controlling *Pitch* and *Volume* - controlled by proximity

Invented by Leon Theremin during Soviet research into proximity sensors (1920s)

Theramin Demo



Capacitive Touch Instruments

Sensing and Calibrating for change in capacitance through air is tricky- What is much easier is using capacitance to measure if something has been touched.

Capacitive & Wearable Instruments

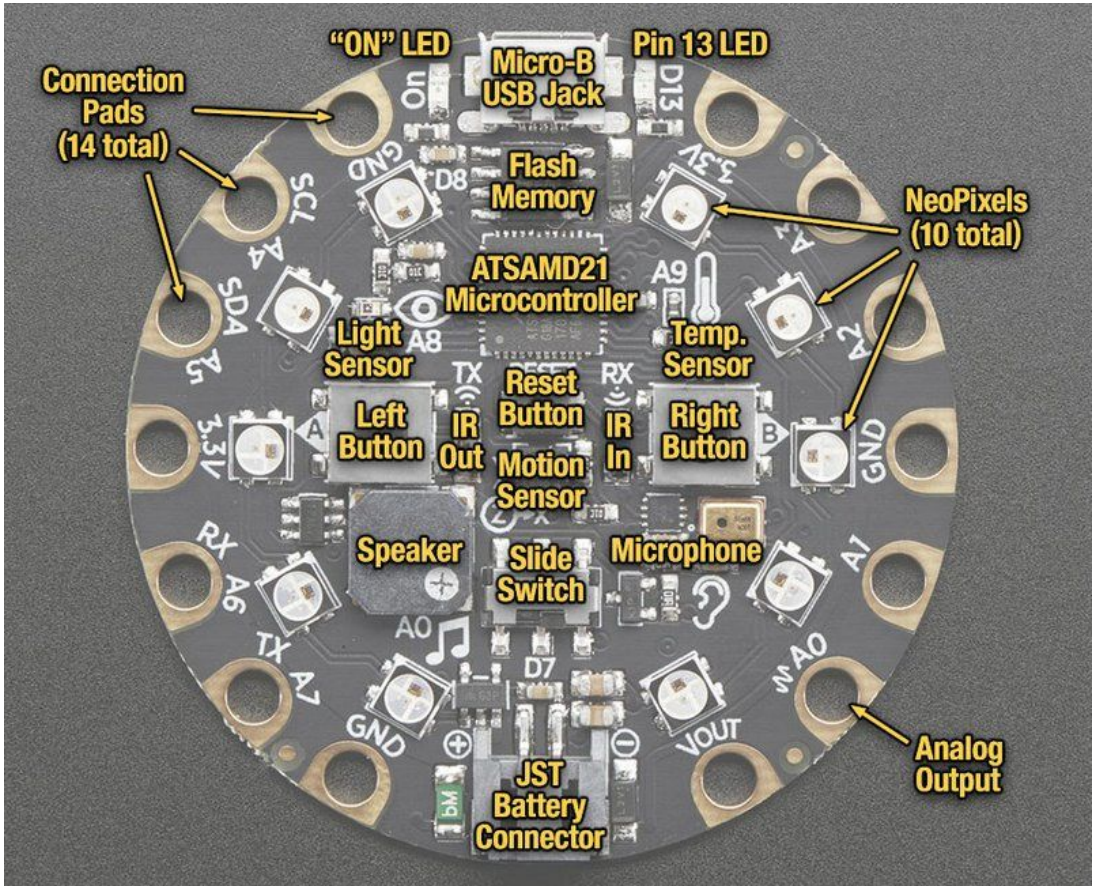
DIY and Commercial Wearable Instruments and audio/visual controllers are more accessible than ever - your Circuit Playground incorporates a large variety of sensors that you can mobilize

Keep these concepts in mind when designing your interface

Chromhatic Demo

Onyx Ashanti

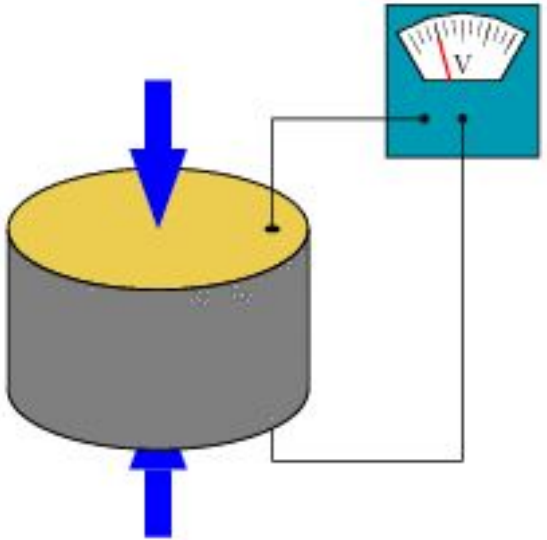
Circuit Playground Inputs & Outputs



How Circuit Playground Makes Sounds

Piezoelectric Speaker - Buzzer made of crystal or ceramic that experiences strain (deforms) when subjected to electric current.

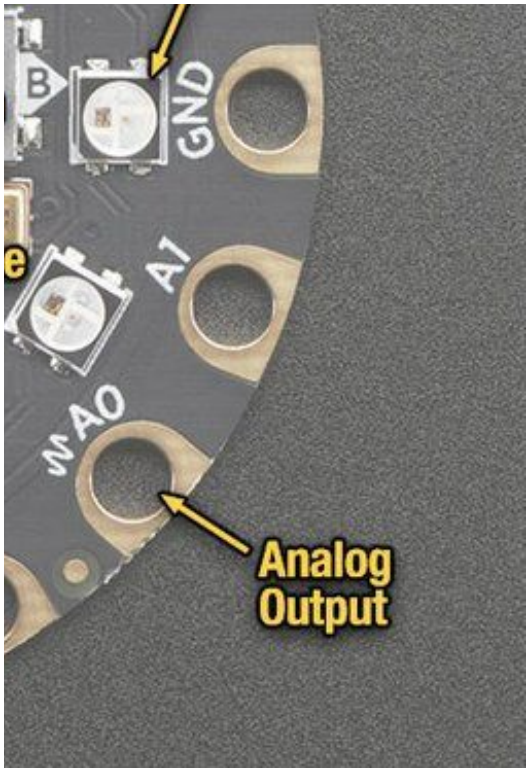
- Best at higher frequencies (can't replicate Mid-low range)
- Durable - resistant to blowout
- Isn't great at replicating complex audio signals



How Circuit Playground Makes Sounds

Audio Out Channel → A Mono Channel that allows you to connect a pair of headphones directly.

Does not have internal amplifier, requires additional circuit to amplify through speakers (see softspeaker workshop)

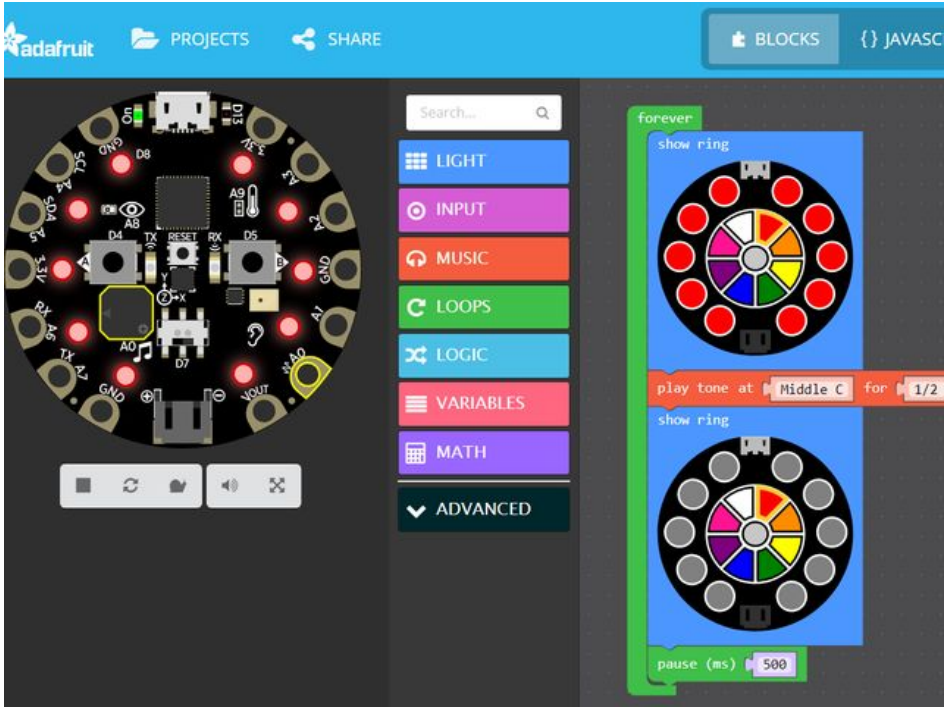


Part II: Programming your Interface

Make Code Review

makecode.adafruit.com

- Events
- Loops
- Logic
- Lights
- Variables



Setup Code / First Test

Activity:

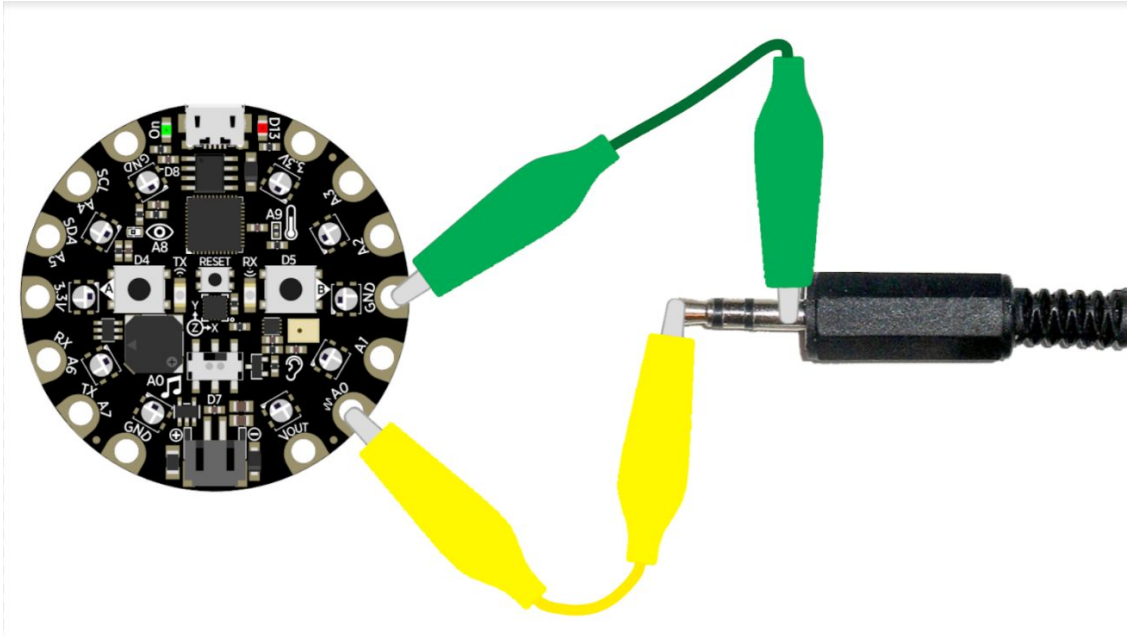
Write a program that sets Volume to Maximum and plays a single note when A1 is touched. Calibrate at startup

Goal:

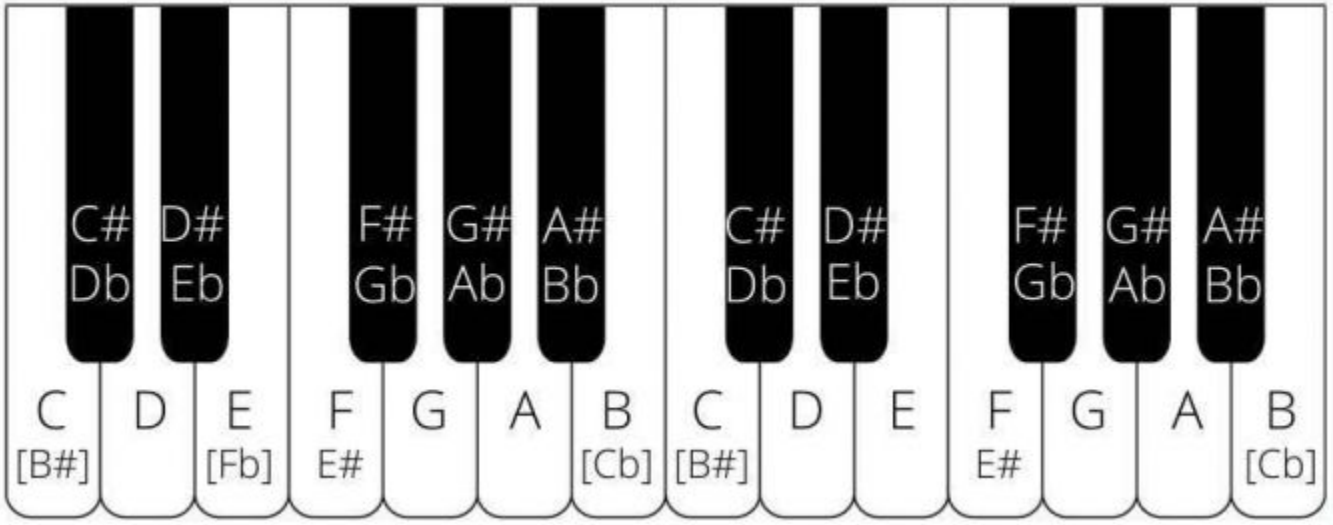
Confirm you can load code onto board, piezo is audible & capacitive touch is working.

Using Headphones

- Reduce Volume to 50-70% (120 - 200) in code
- Tape together audio channels if necessary



Notes (Frequencies)



440 hz for A above Mid C is common tuning

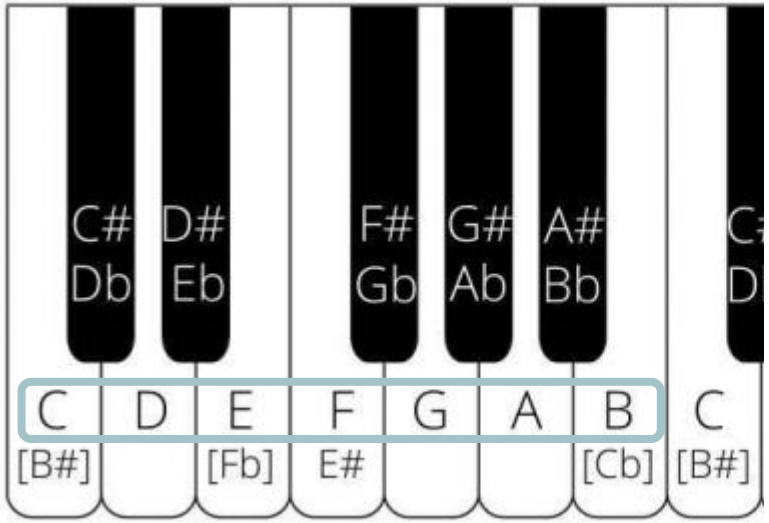
Remember, piezo sounds best with high frequencies

Build a Simple Scale

Activity:

Map Each Note to a Analog Pin (1-7), Starting with Middle C. Remember to calibrate at startup

Goal: Be able to play your Circuit Playground

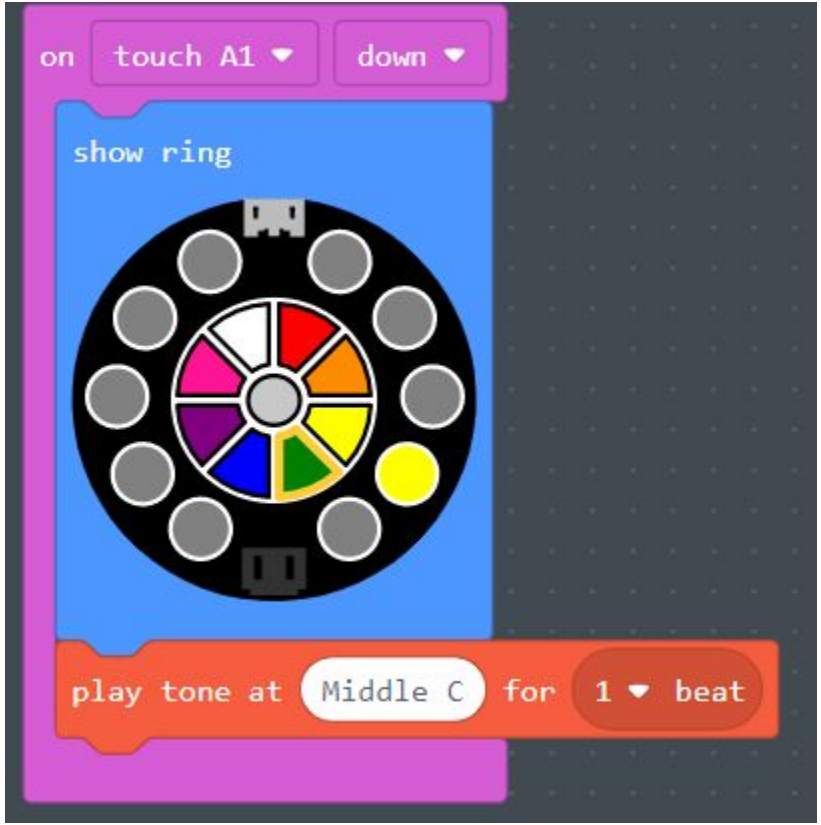


Add Indicator Lights

Activity:

Map Each Note to an LED position & Color & add a volume switch

Goal: To Make troubleshooting easier - test button presses silently



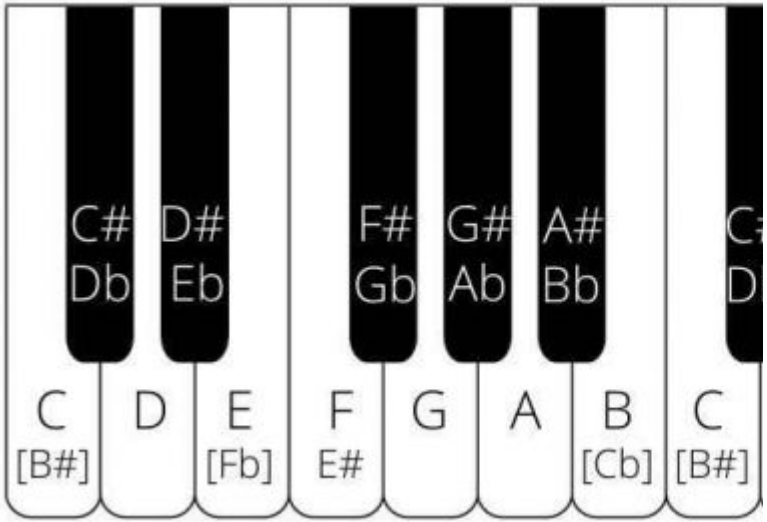
Add Missing Notes / Secret Tunes

Activity:

Find another input to program High C to (not capacitive)

Goal: Full scale keyboard+

Bonus: Make 2 simultaneous key presses trigger a pre-programmed melody



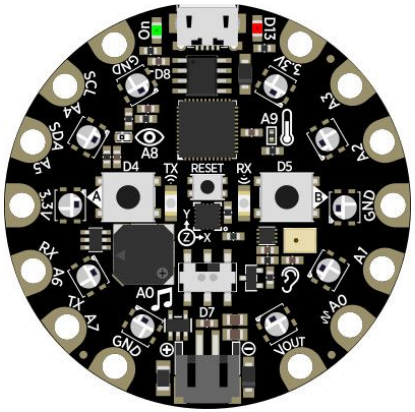
-Free Program Time / 10 min. Break-

Part III: Building your Interface

Methods & Materials

Tools:

- Computer + internet (makecode.adafruit.com)
- Micro USB Cable
- Scissors
- Alligator Clips



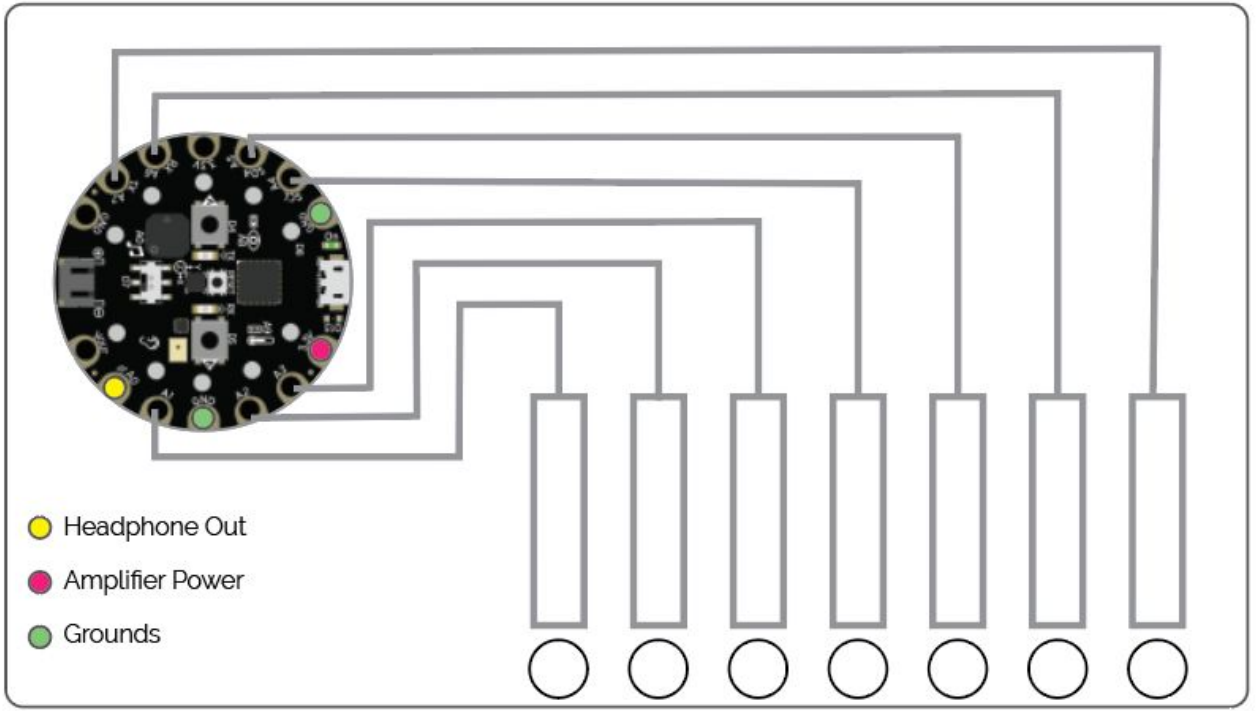
Bill of Materials:

- Circuit Playground Express
- Conductive Fabric Tape
- Alligator Clips (x2)
- Surface Material (Paper Template / Cloth)

Optional Add-Ons:

- Headphones
- Battery Power (AAA Battery Pack w/ JST Connector)
- Conductive Thread / Ink (For more organic layouts)
- Conductive Snaps
- Adhesives
- External Speaker Circuit (See Soft Speaker Tutorial)

Keyboard Interface Activity



Goal: Have a basic instrumental interface for your Circuit P.

Keyboard Interface Activity

Activity:

- Label your keyboard notes.
- Search song+notes to find a song to demo out.

Bonus: Program one of your buttons to play a tune, or play corresponding lights (visual guide)

Goal: Test your instrument

Designing your Own Interface

Design Steps

Free Ideation: Forget tools or materials, What is the experience of using your instrument like?

Full body? Multiple physical styles of interaction? Environmental and human responsiveness?

Crystal Cortez, Impact Mitts

Design Activity

Take some time to think about what kind of interactive instrument (or interactive wearable, more generally) you would like to make.

- Draw a picture, map out points of interactivity, Describe what interaction triggers, what themes you're interested in exploring.

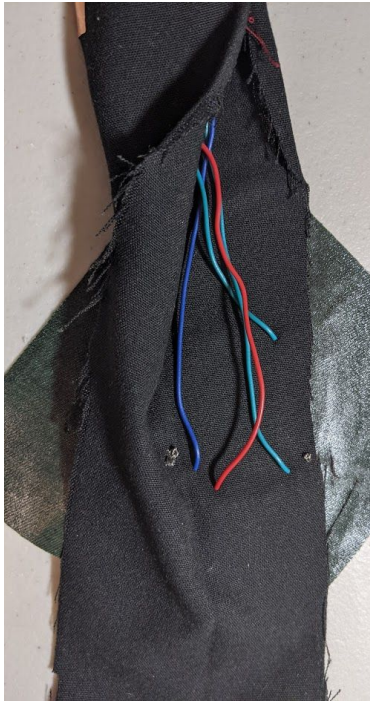
Then, share your ideas with a neighbor.

Design Steps

Material Collection and Experimentation:

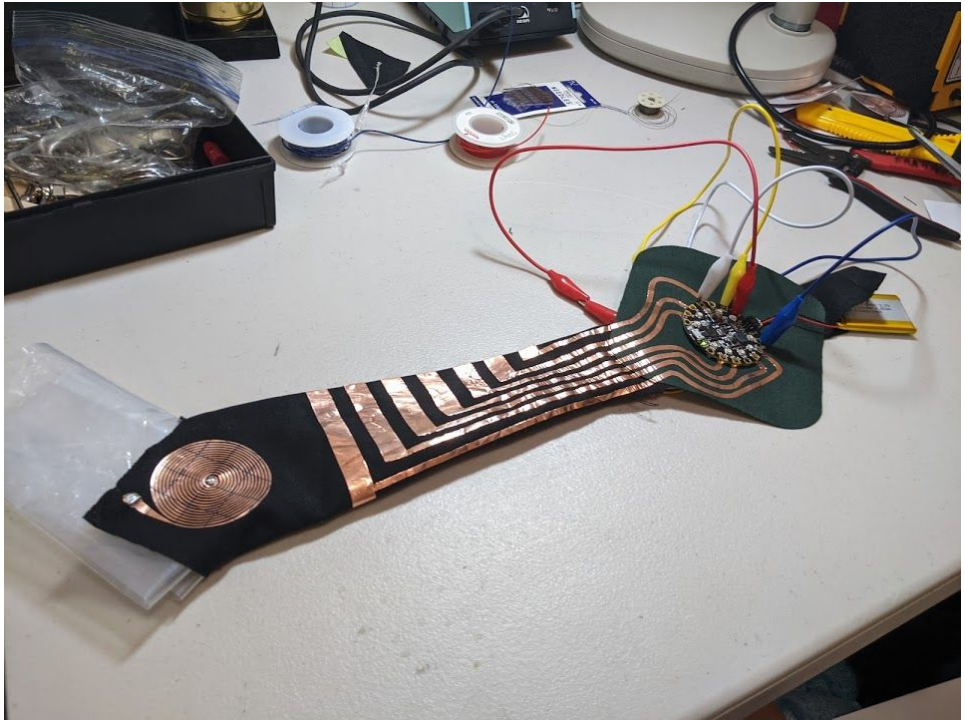
Think in terms of:

- Base materials - structure of instrument
- Connectors - both electrical and physical
- Buttons/triggers - material and geometry
  - **Least predictable, most useful to explore**
- Support elements (battery holder, non-conductive sewing, etc)



Capacitance Testing

All conductors generate some reactance, which is why you need to calibrate you circuit to ignore the conductive materials you've attached to your pins to serve as buttons.



Capacitance Testing

The capacitance of conductive materials is influenced by both material type and geometry - consider this when designing your circuit.

If you have a very small baseline capacitance, it will be very sensitive to movement and contact - and will be triggered easily. This may be desirable depending on your intent.

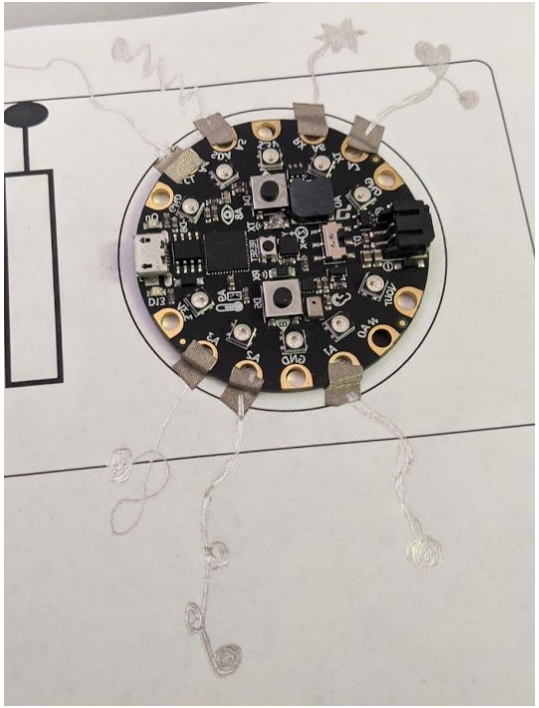
Capacitance Testing Activity

Activity: Test our your conductors!

Try experimenting with conductive ink pens, see if you can create a no-contact trigger for your sound system.

Planning on running conductive thread down your sleeve? Test the length of wire, test moving the wire - does it trigger how you want it to?

Goal: Identify trigger mechanisms that you like/find interesting.



Design Steps

Identifying Sensor Layout:

What sensors do you need, where do they need to be, so they can be interacted with?

Planning a Sensor Layout

How you wish to wear and interact with your keyboard will determine the layout of your project.

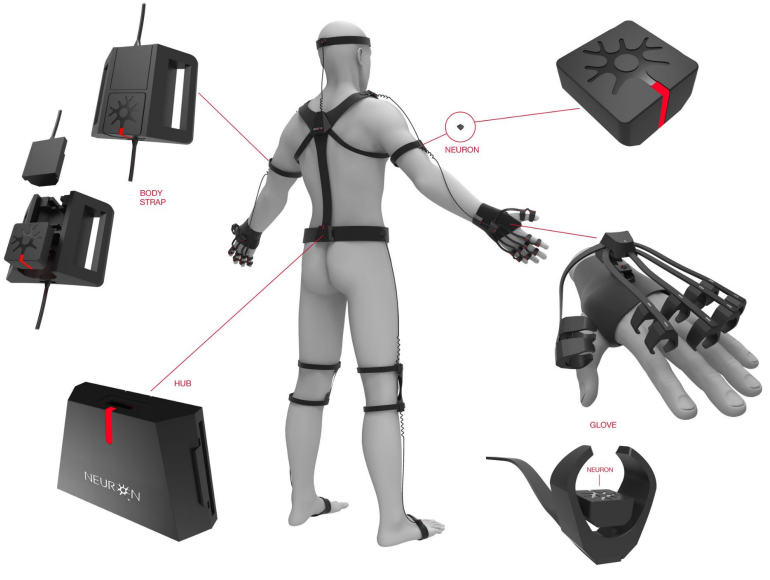
Questions to ask yourself:

- How much control do you want?
- Do you want to have full control over which note is being played?
- Do you want to trigger sounds as your move?
    - Your experiments with materials should inform how to

Fabrication

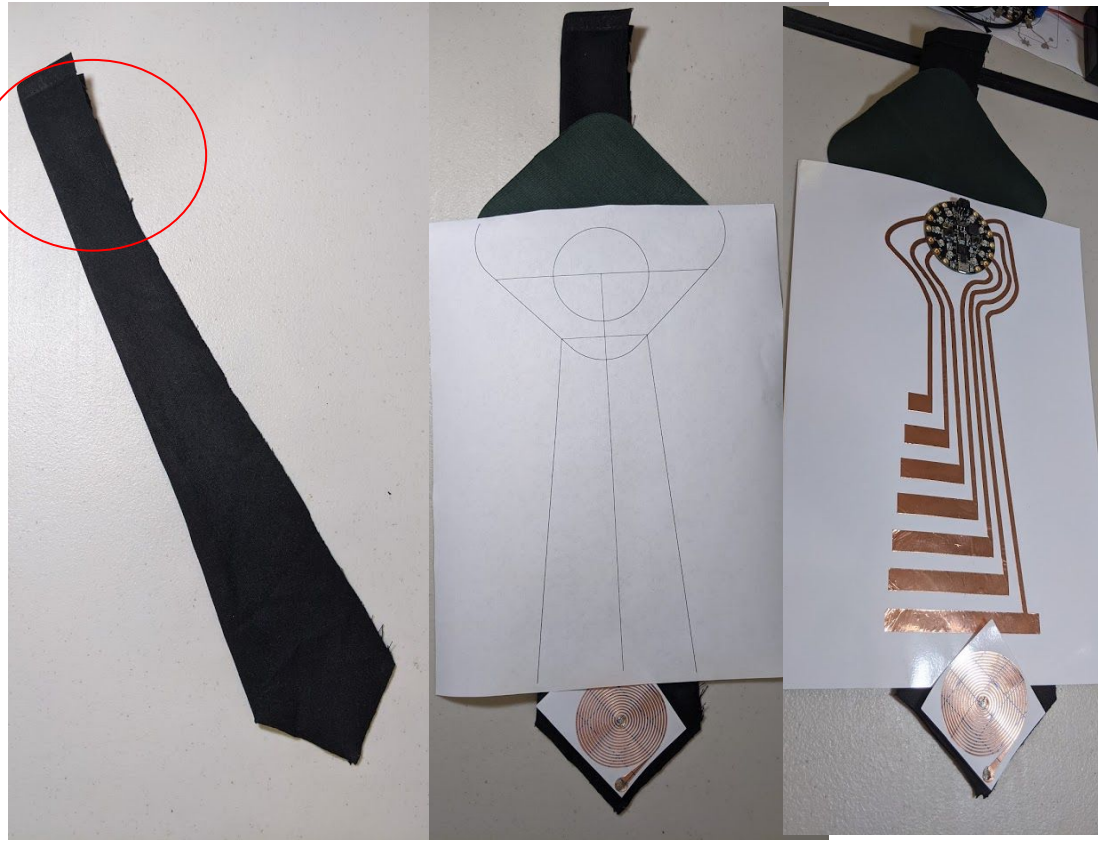
Final Layout

Designing Final Layout:
Now that you know what kind of interactions you want & what materials you are using, consider the final layout of your instrument.



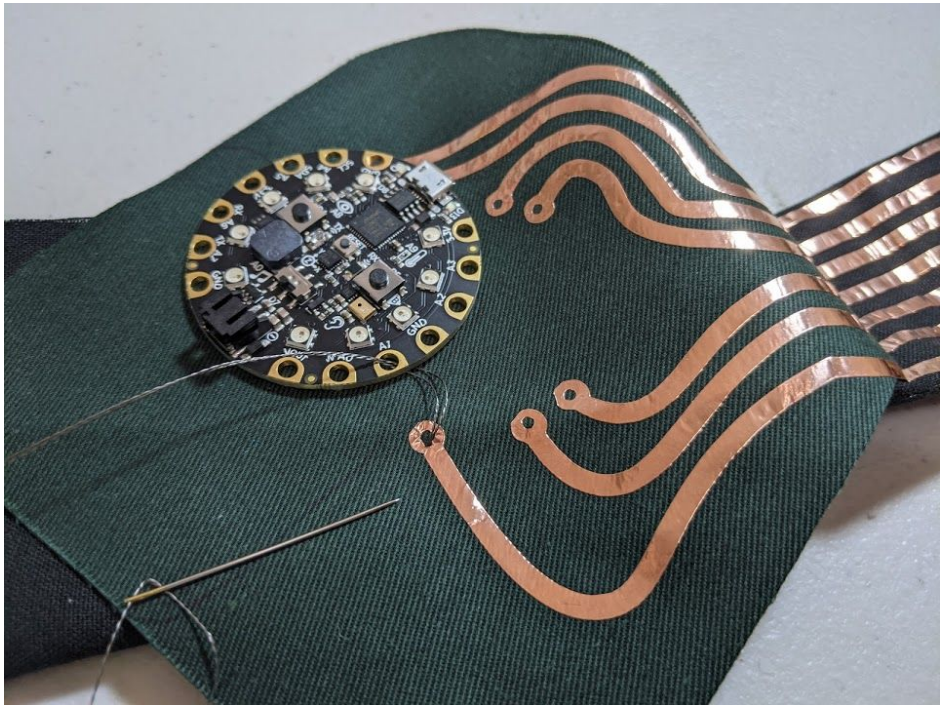
Planning a Layout - Leave Room

Conductive Paths can take up a lot of space, depending on what techniques your using, *make sure there is room for them your design.*



Tips: Making Connections

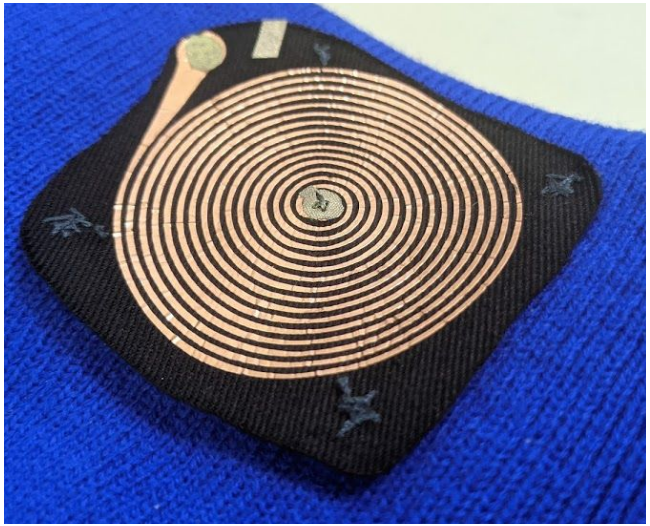
Secure Connections are very important - changes in connection strength can trigger sensor. If you can, consider soldering tape joints and other circuit junctions (*Check out Tomorrow's soldering Demo*)

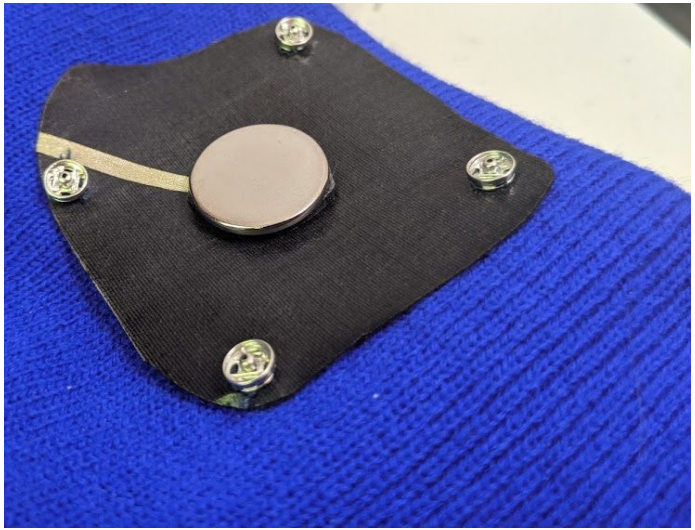


Additional Design Considerations

Is your wearable something that will need to be washed?

Make sure electronic components can be removed (Pockets & Snap Connectors)



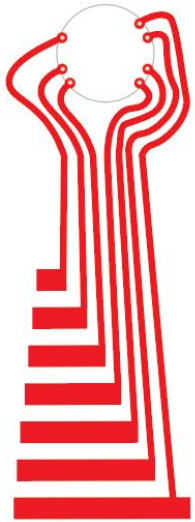


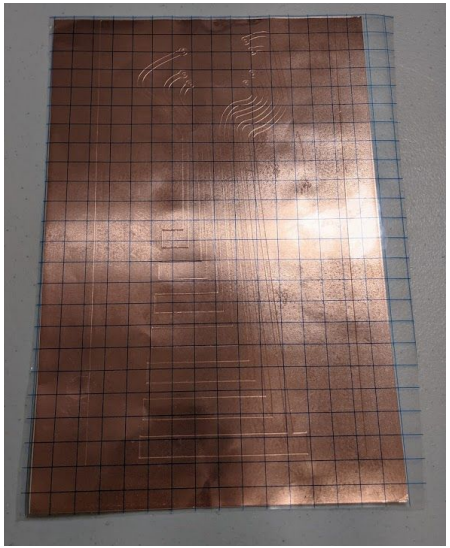
Tips: Build to Last

- Use flexible durable materials around pivot & pinch points (conductive thread, fabric tape, stranded wire).
- Place stiff and fragile materials in locations that *don't* bend (copper tape, solid core wire)
- Solder critical connections
- Mask over regions you don't want to conduct

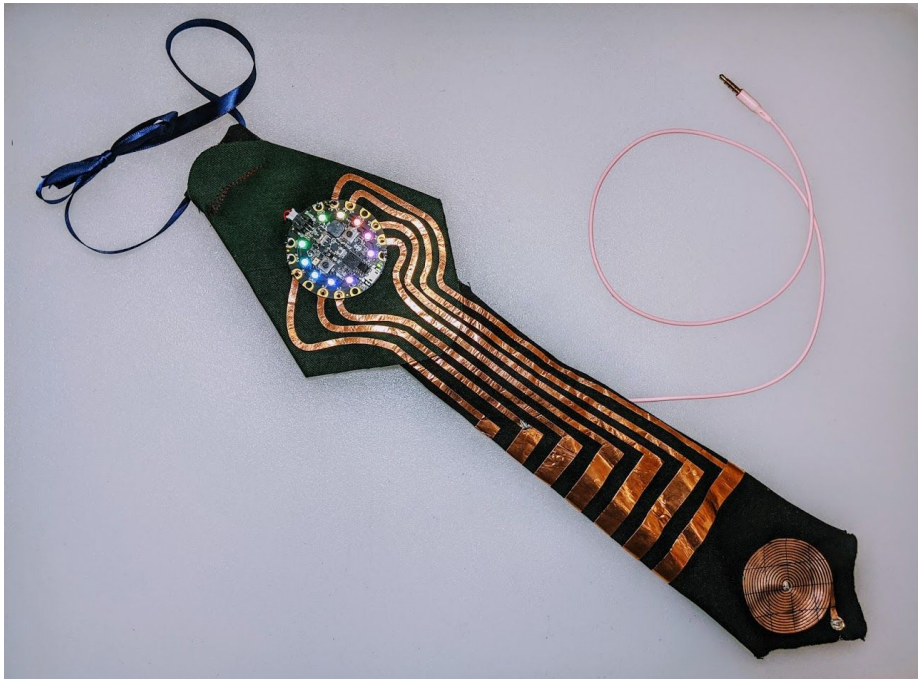
Tips: Advancing your Interface

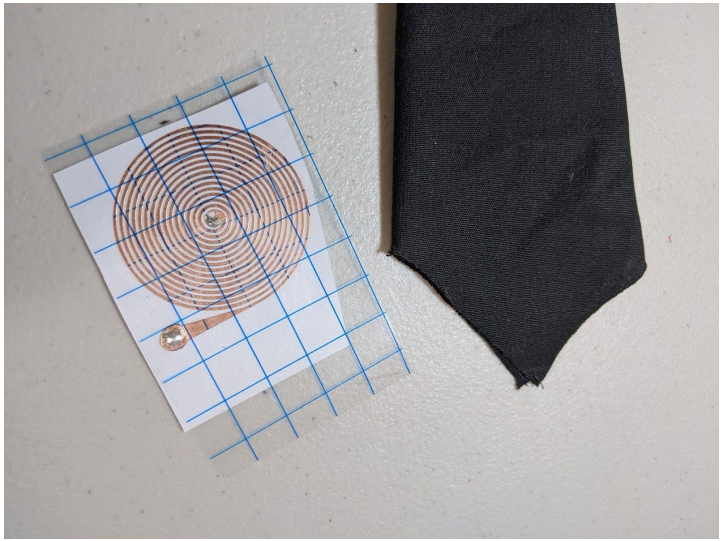
During Afternoon Project Time, you will get additional time to cut out on the vinyl cutter any hand-drawn or vector-drawn circuits - If interested, build with that in mind.





Now...Free Build Time





Tomorrow...Soft Speakers

Advancing your Sound - Beyond

- Circuit Python (can play .wav files)
  - See Guide Here
- Adding an Amplifier (attach or build additional speakers)
  - See tomorrow's workshop
- Specialize you're microcontroller
  - Teensy (Arduino) boards have more capacitive touch pins, stereo out, & an Audio Library + GUI design tool (exports to code).
  - Explore other controller boards + add ons.