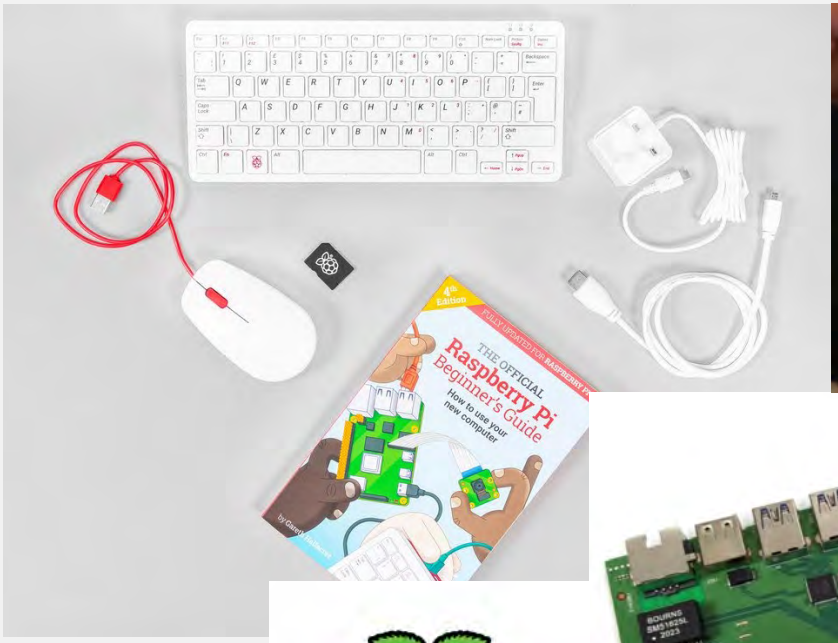
PLAY WITH CIRCUIT-BENDING

electronics introduction: interactive hardware tweaking



Raspberry Pi

TTU Makerspace

+

Raspberry Pi 400/CPX

+

Electronic toys

2025

Sean W Scully

Lead Administrator – TTU Libraries - Emerging Technology

Rhino3D, TinkerCAD, AutoCAD Inventor, Fusion360, Blender, Solidworks
MakeCode, Python, Scratch, C++, C, MATLAB, JS, Assembly, Verilog, Xilinx

General Studies BS – Math/Engineering/Renewable Energy, TTU

MFA, Studio Art - Metals/Jewelry/Enameling, Kent State Univ

BFA, Studio Art - Metalsmithing/Jewelry Design, TTU

AA, Fine Arts, South Plains College

linkedin.com/in/seanwscully

Find me on the First Friday Art Trail, ffat.org, CASP Work Studio H

MAKER SPACE

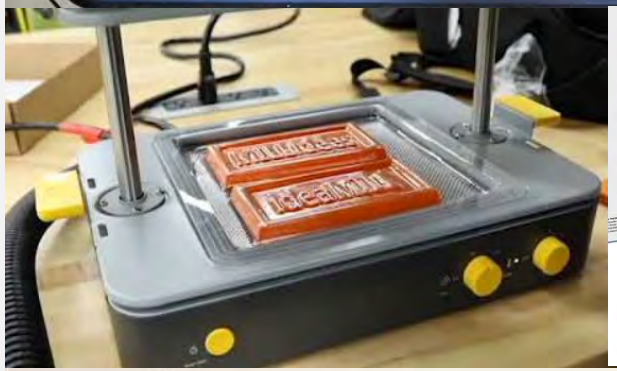
RYAN CASSIDY | SEAN SCULLY | JAKE SYMA | BRIANA MOODY

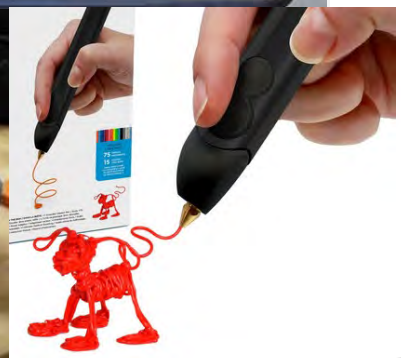
Emerging Technology

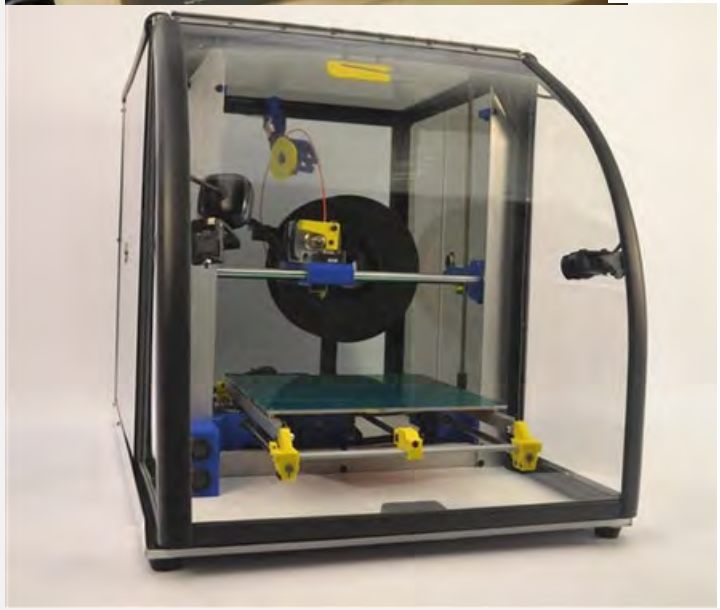
- Makerspace: Main Library, 2nd floor, room 210
- VR Lab: Main Library, 2nd floor, room 201A

make@ttu.edu

https://www.depts.ttu.edu/library/make/

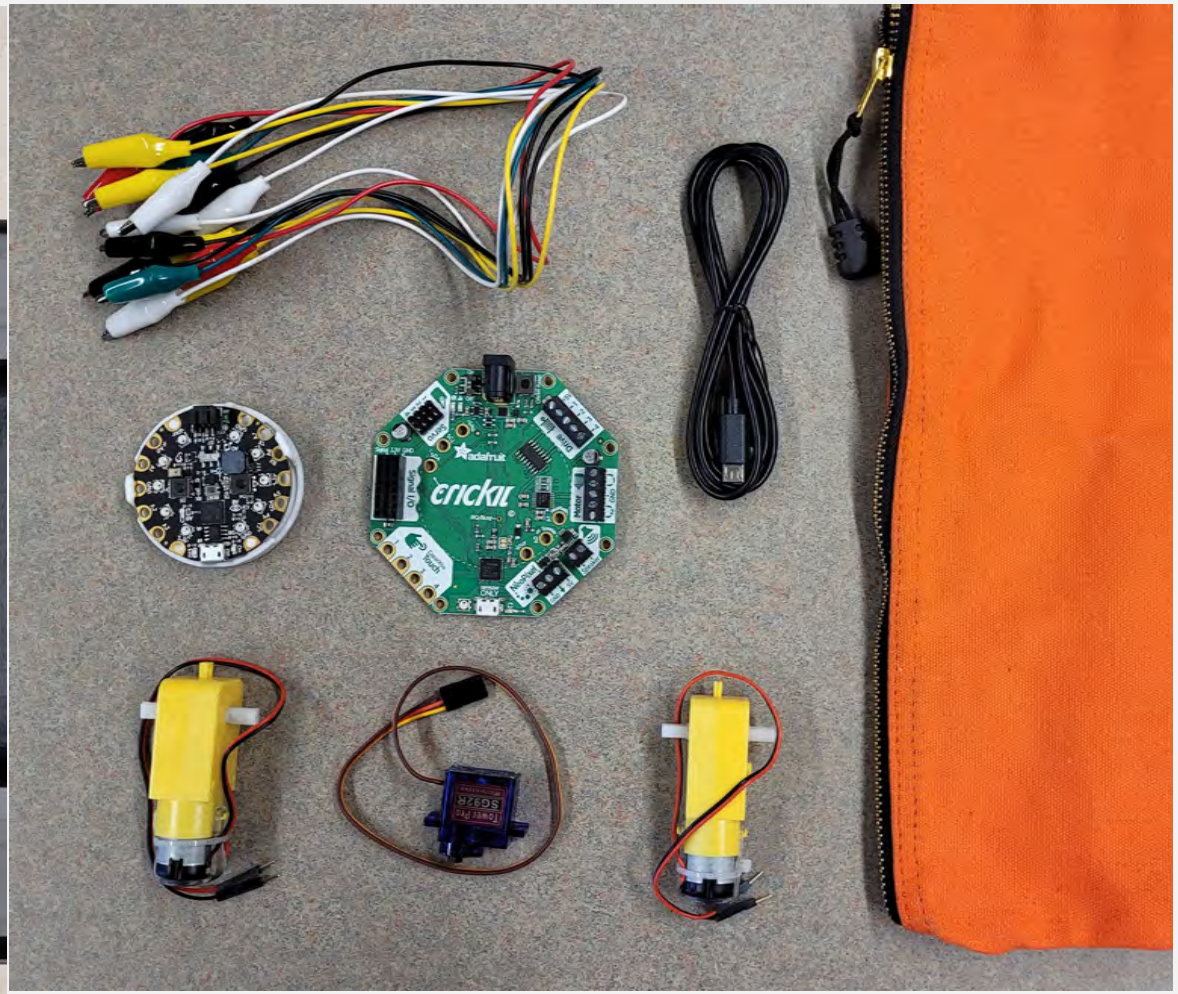






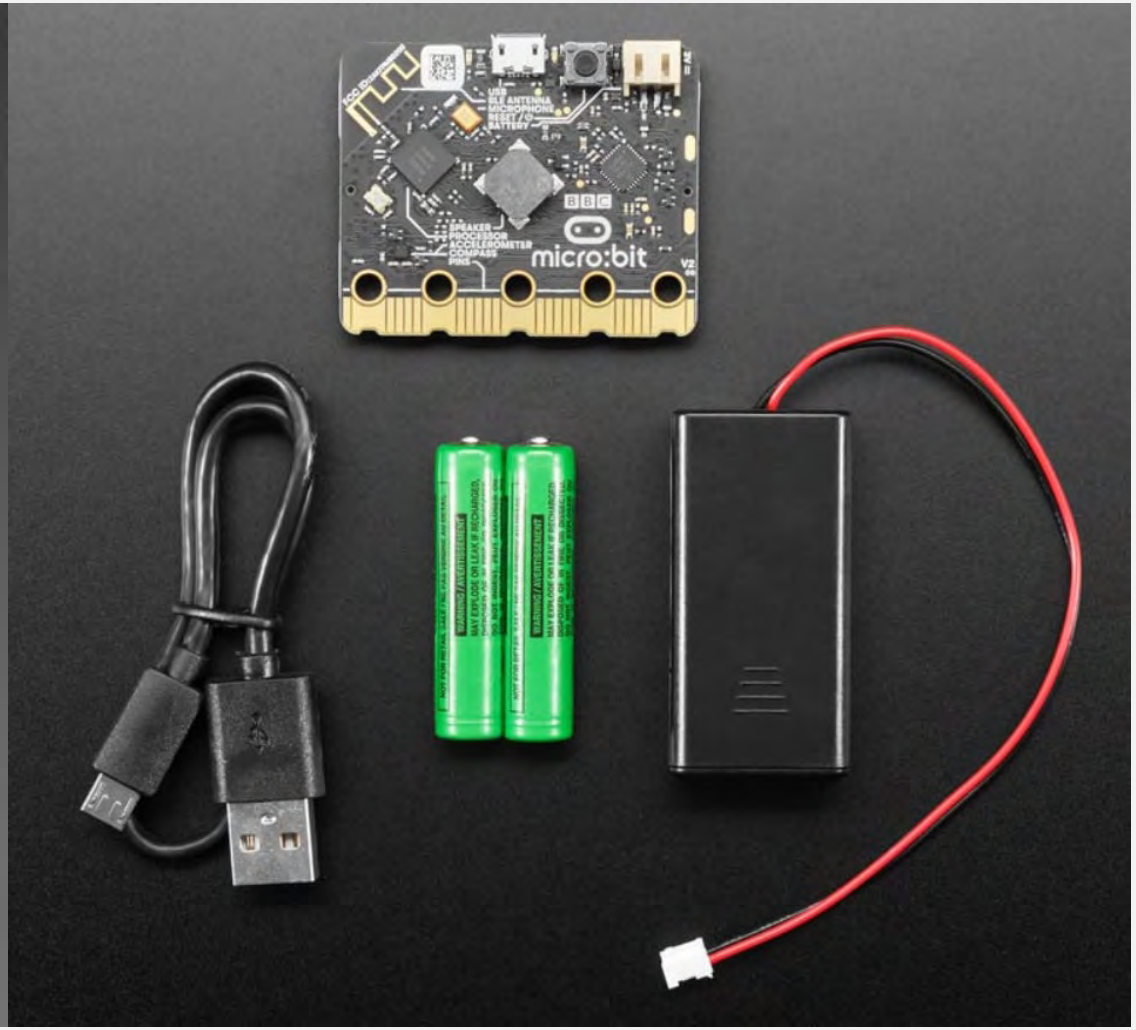
- Cricut Maker/Venture
- Glowforge Lasercutter
- Makyu Formbox
- Matter&Form 3D Scanner
- PolyPrinters 229 & 508
- Ultimaker 3, S7
- Sewing machines

TTU Library's Makerspace *Electro* and *Robo* Kits



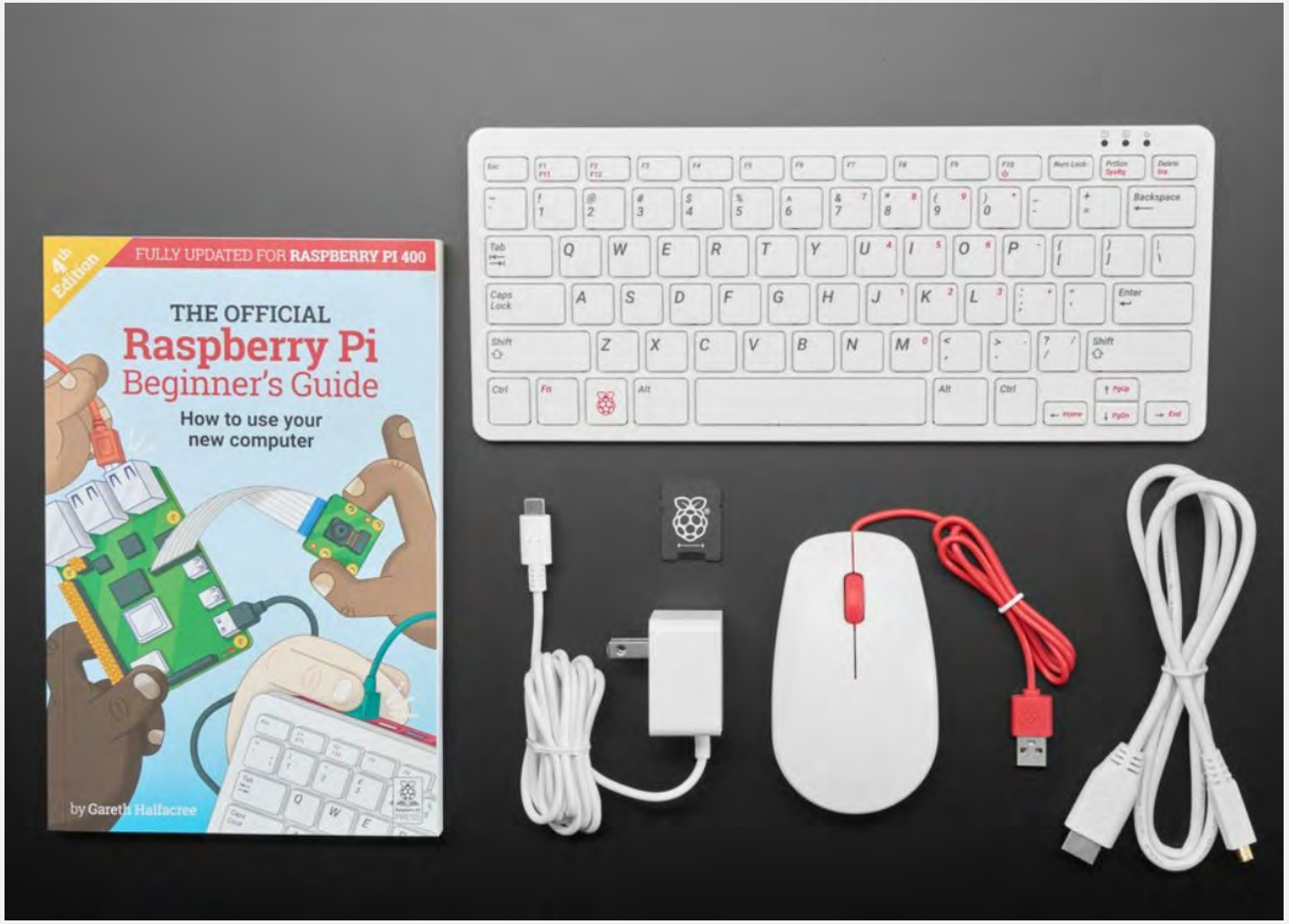
Images of our soldering kit and cpx/crickit kit

TTU Library's Makerspace *CuteBot* and *Micro:Bit v2* Kits



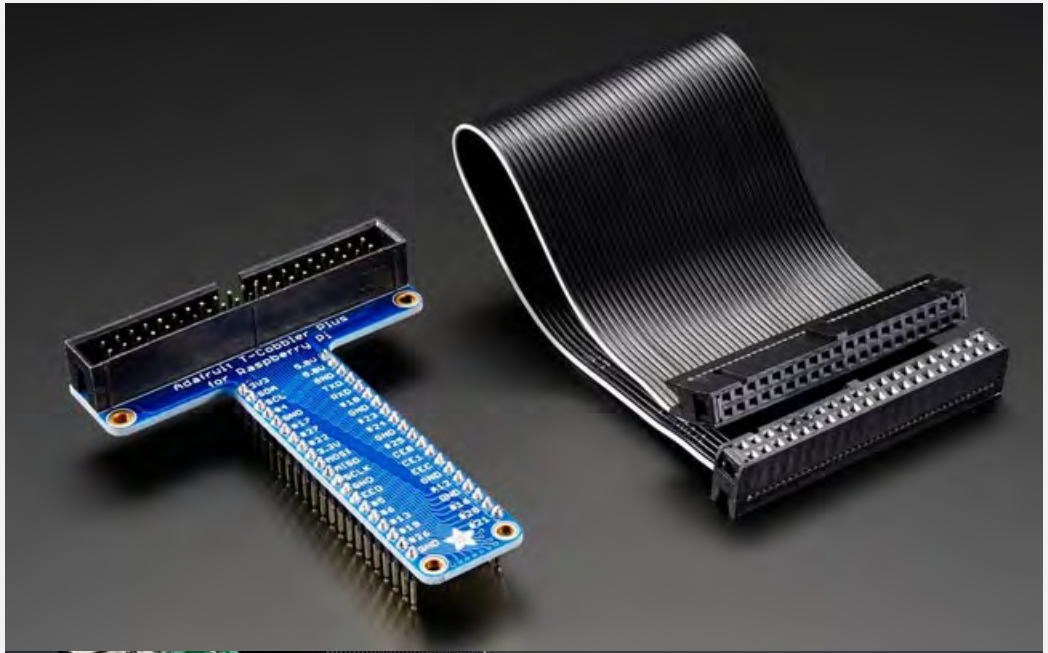
Images of our CuteBot kit and Micro:Bit v2 kit

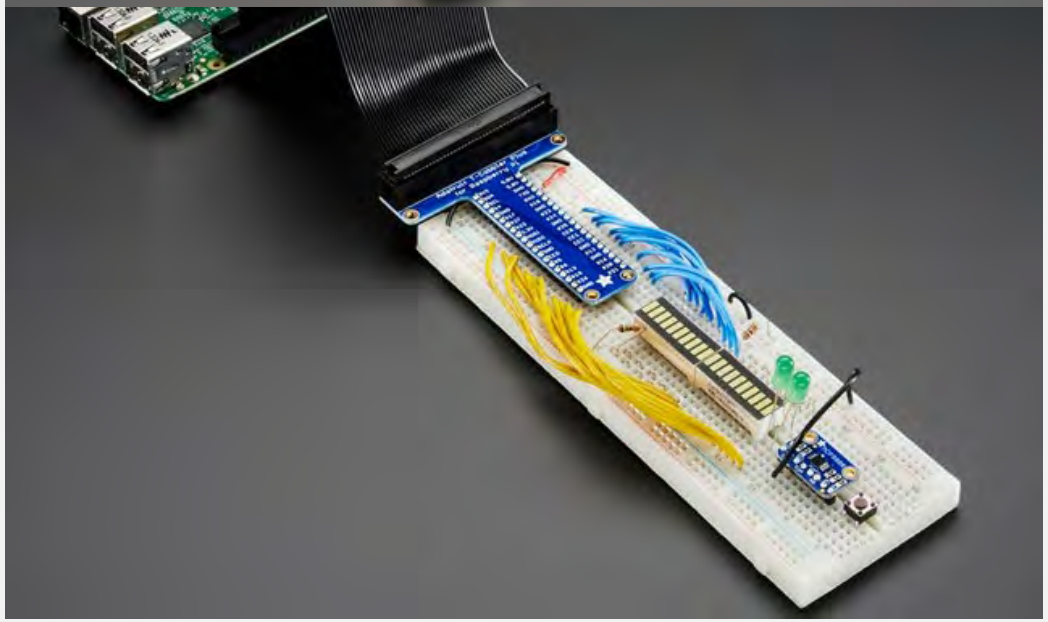
TTU Library's Makerspace *Pi-400* and *Pi-Zero W* Kits

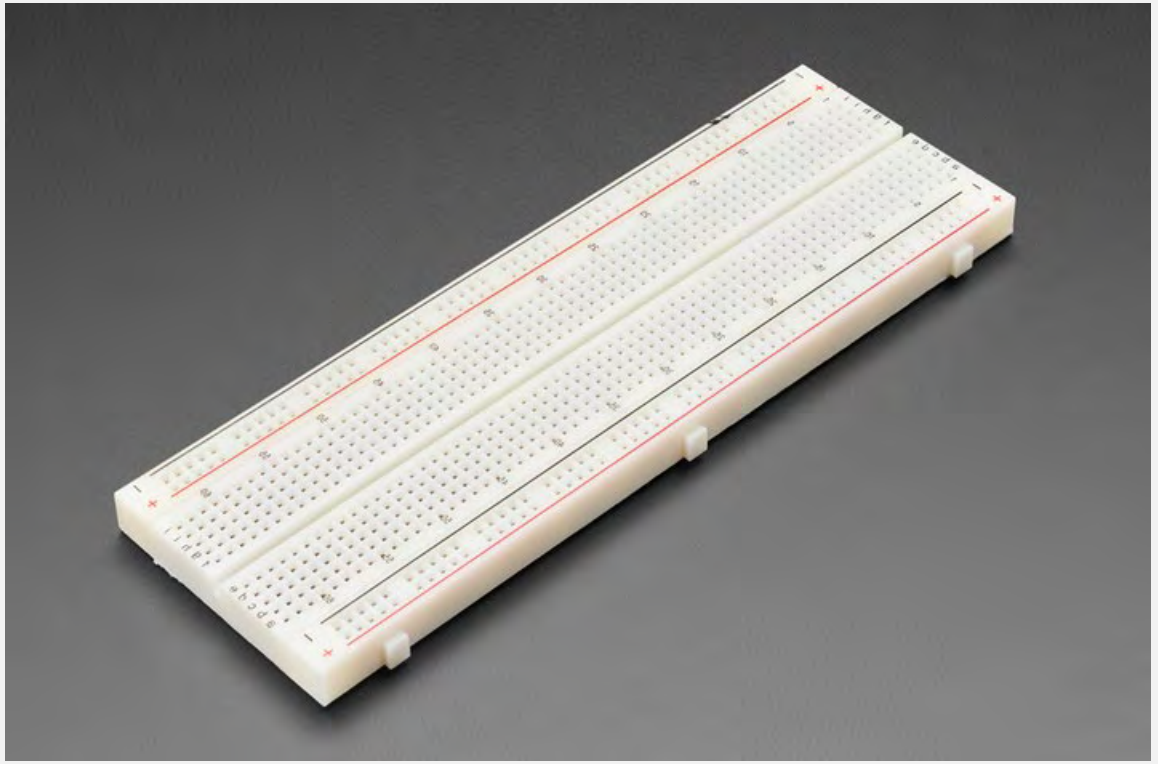


6 kits of each is available: recommend supplying your own microSD card (minimum size: 8Gb)

TTU Library's Makerspace *Pi – Interface* Kits







6 kits of each is available, one for every Pi-400

- Pi T-Cobbler Plus
  - GPIO Breakout - Pi A+, B+, Pi 2/3/4, Zero
- Full Sized Premium Breadboard
  - 830 Tie Points

TTU Library's Makerspace *iFixit* Kits

6 kits of each is available, one for every Pi-400

- all kinds of screwdriver tips, 64 total
- larger kit has spudgers and plastic pryers

what is Circuit-Bending?

- art of creatively modifying the circuits of electronic devices, such as children's toys
- produces unexpected and innovative sounds

why Circuit-Bend?

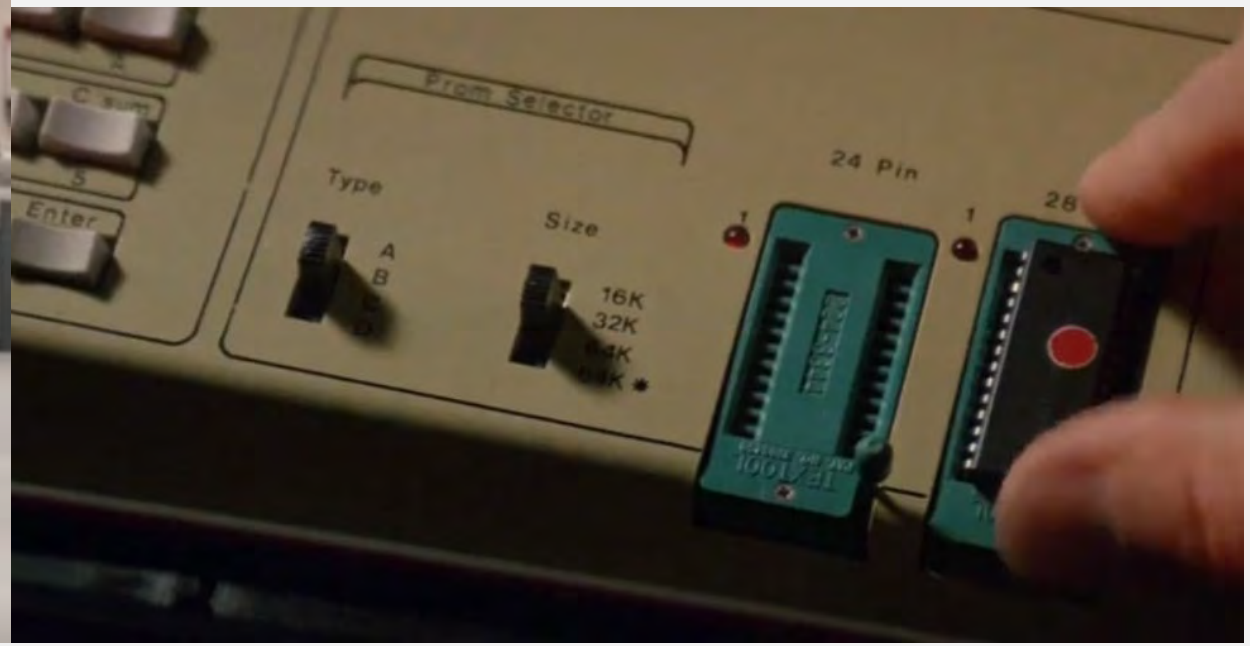
- allows us to creatively transform ordinary toys into unique musical instruments
- promotes experimentation and exploration in the world of electronics

Circuit-Bending philosophy

- realm of electronics
  - *experimentation*
  - *curiosity*
  - *play*
- repurposing /modifying existing device
  - *challenge traditional notions of technology/creativity,*
  - *fostering a spirit of innovation/discovery*
- intersection of art/technology/DIY ethos

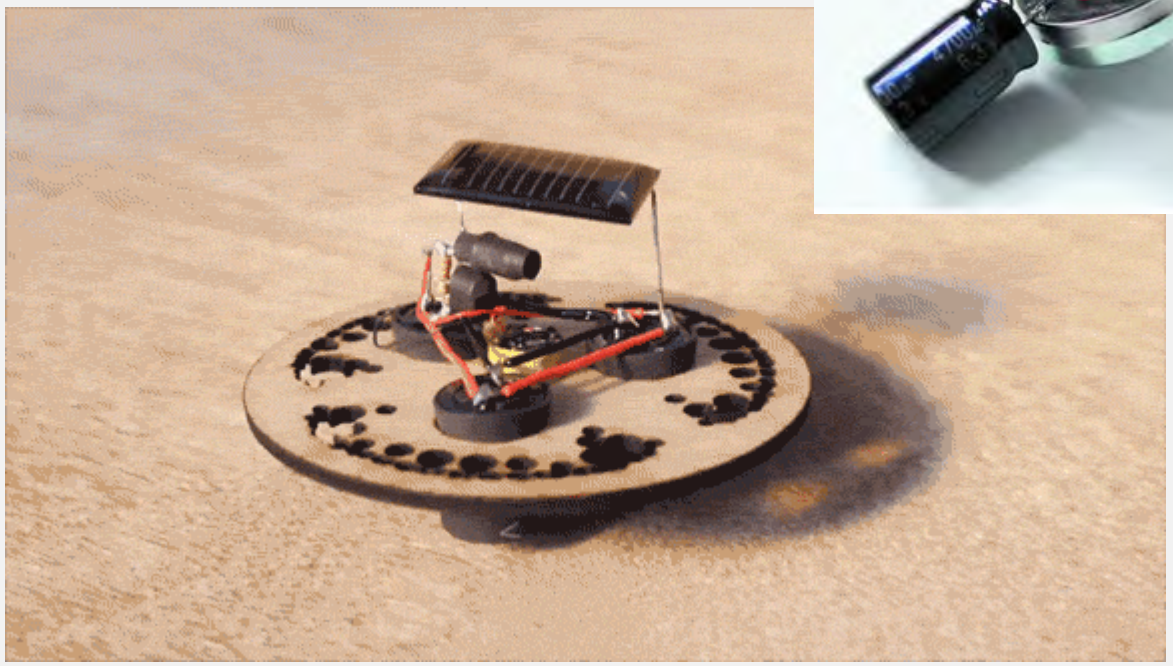
computing – eras, 1980s

- *Superman 3* (1983) VS *Real Genius* (1985)



robots – eras, 1980s-2000s

- *Johnny5* (1986-8) VS BEAM robotics (1988-2002)



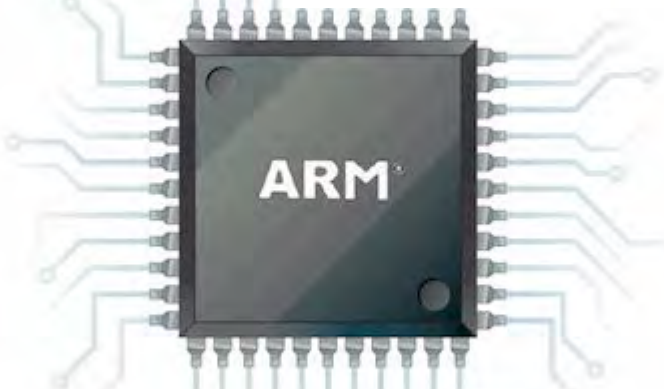
computing – eras, 1990s-2000s

- *Hackers* (1995) VS *The Matrix* (1999)

computing – eras, 2010s

- *CHAPPIE* (2015) VS CircuitPython + ARM chips (2017)

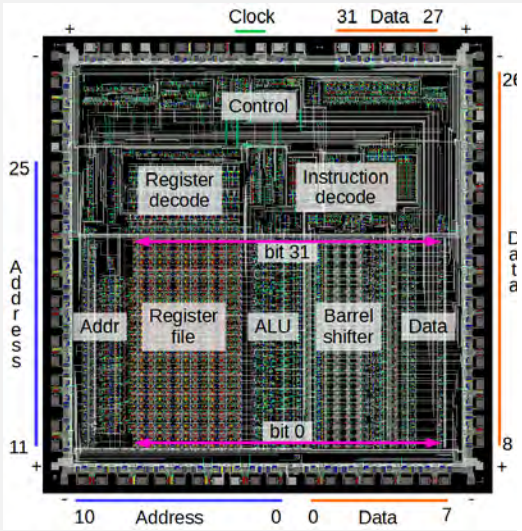
ARDUINO

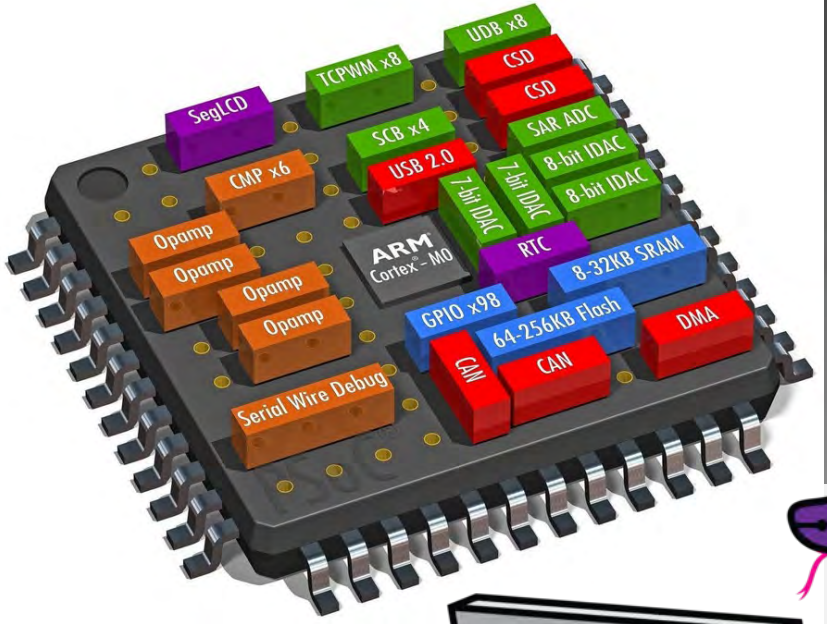


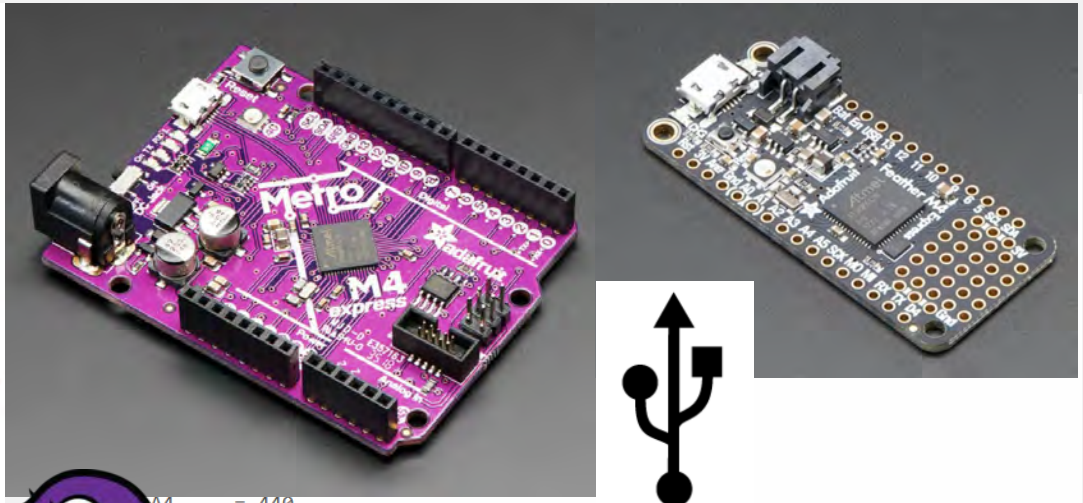
Raspberry Pi

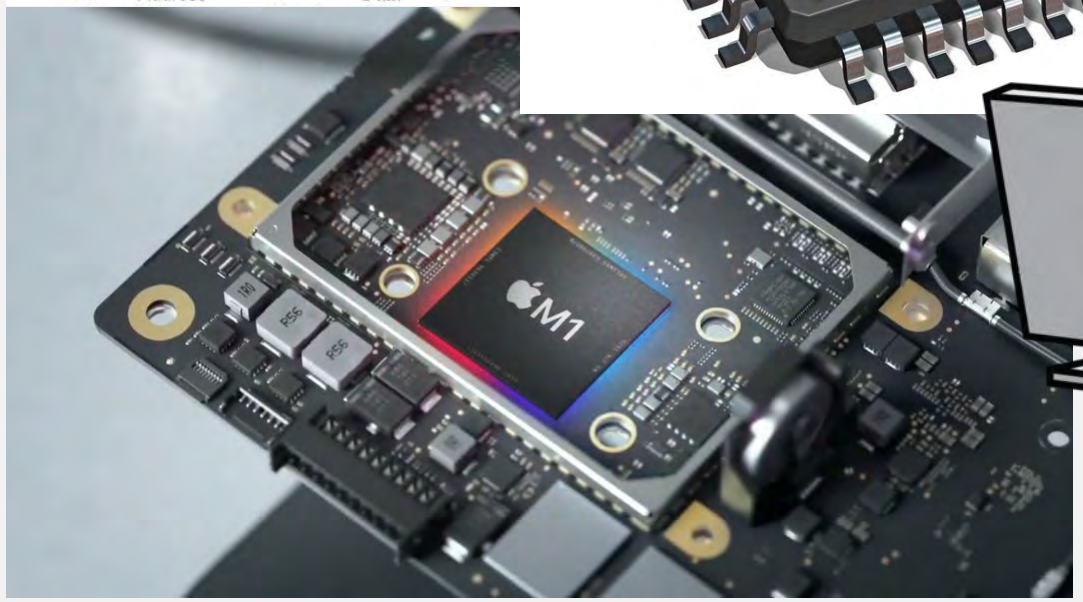
Hardware differences – Structure, Purpose

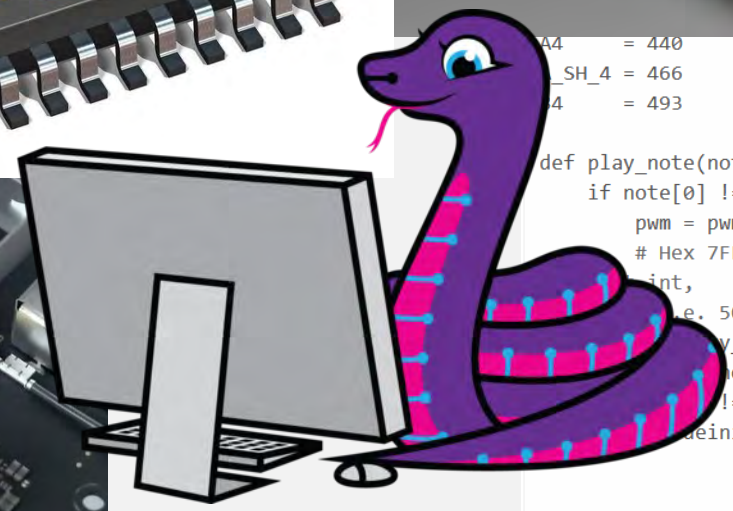
Python – multi-core microprocessors and ARM processors (2010's) – microcontrollers programmable by USB





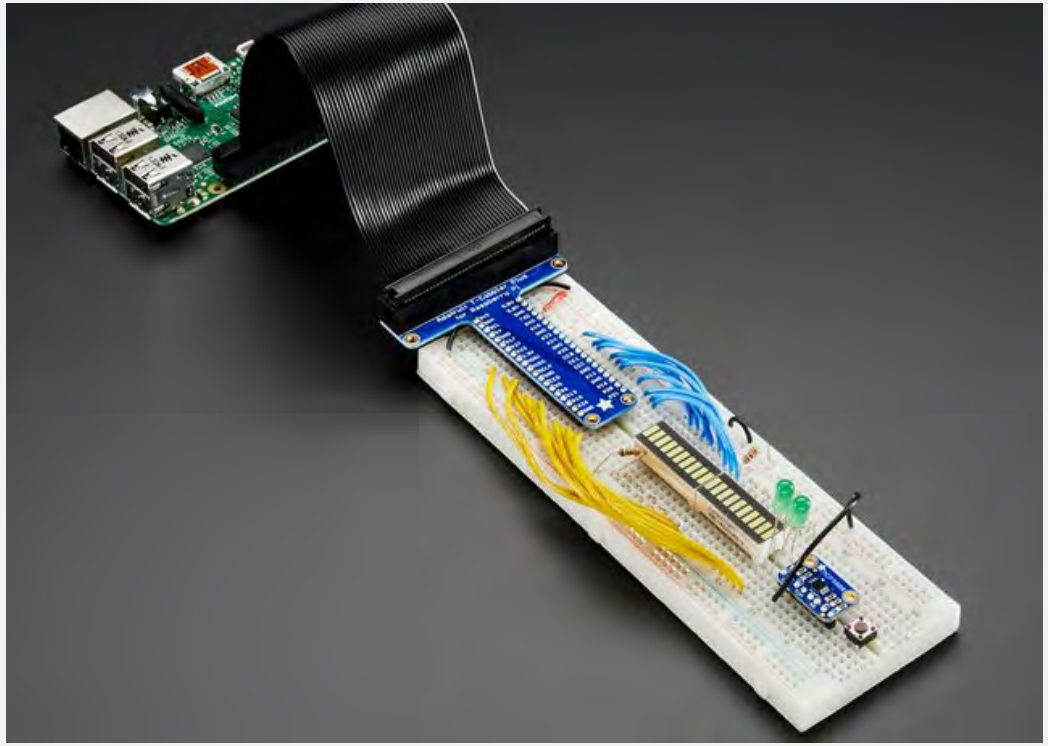


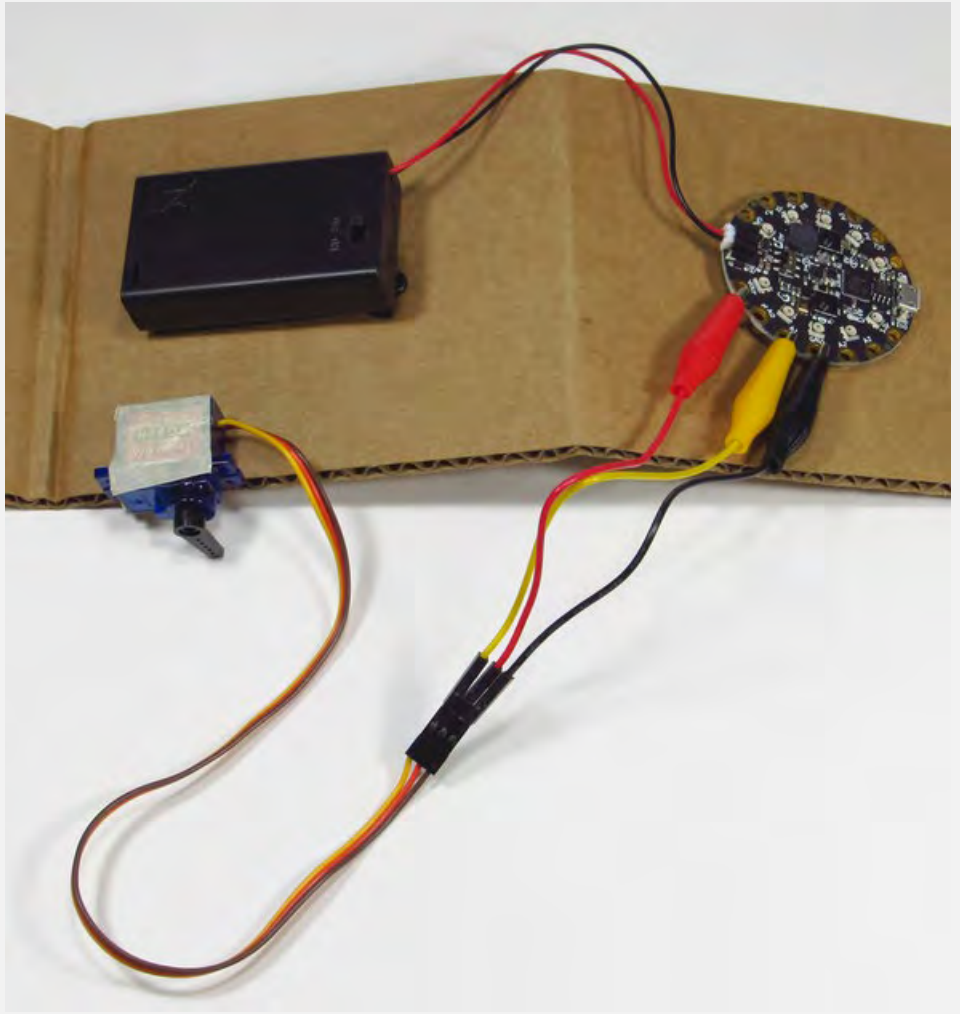




```
A4      = 440
_SH_4 = 466
4       = 493

def play_note(note):
    if note[0] != 0:
        pwm = pwmio.PWMOut(board.D12, duty_cycle = 0, frequency=note[0])
        # Hex 7FFF (binary 0111111111111111) is half of the largest value for
        int,
        e. 50%
        y_cycle = 0x7FFF
        ote[1])
        != 0:
        deinit()


a4_quarter = (A4, 0.25)
c4_half = (C4, 0.5)

play_note(a4_quarter)
play_note(c4_half)
```

TTU Library's Makerspace *Pi 400 or CPX interface*





- Pi T-Cobbler Plus *{above}*
  - GPIO Breakout - Pi A+, B+, Pi 2/3/4, Zero
- Circuit Playground Express (CPX) *{right}*
  - Alligator clip interface for voltage/signal

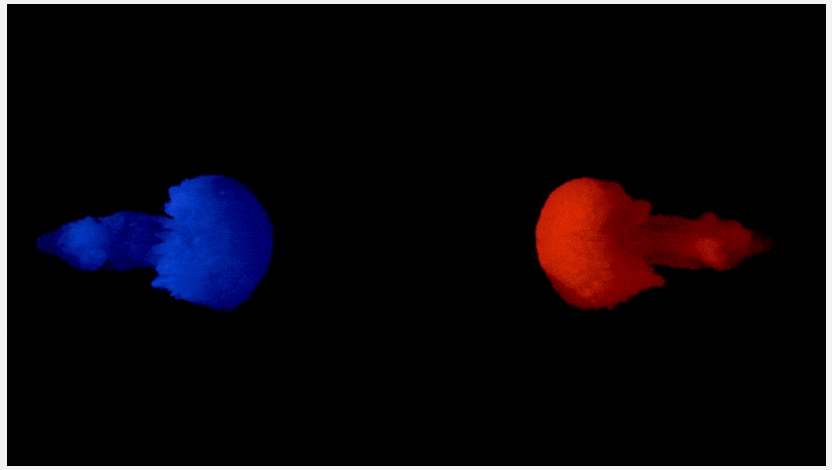
safety first

- unplugging the Toy
  - *before starting any circuit-bending techniques, always unplug the toy from its power source to avoid electrical shock.*
  - *double-check that the toy is completely disconnected from power before proceeding.*
- handling Electrical Components
  - *when working with exposed circuit boards, be cautious around electrical components such as resistors, capacitors, and integrated circuits*
  - *avoid touching these components with bare hands or conductive items, as they may carry a charge or become damaged.*
- proper Tools and Gear
  - *use appropriate tools, such as screwdrivers, pliers, and wire cutters, to open and manipulate the toy's circuit board.*
  - *wear safety goggles and insulating gloves when handling electrical components to protect yourself from potential hazards.*
- by following these safety guidelines, you can enjoy a safe and productive circuit-bending experience.
- remember, safety first!

blue smoke alert

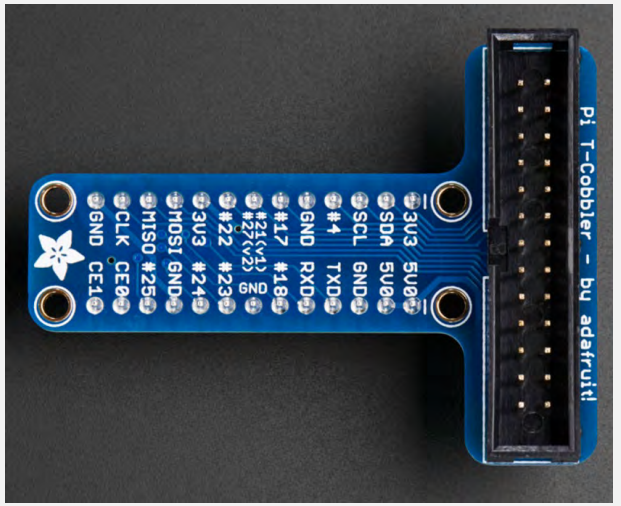
- 3.3 - 5V max
- tips to avoid damaging the toys:

  - *start small:*
    - begin by making small modifications to the circuit board
    - test the effects before making more significant changes
    - understand the impact of each alteration
    - avoid causing irreversible damage to the toy



  - *document and label:*
    - track the modifications you make by documenting the changes
    - label different components on the circuit board
    - helps you troubleshoot any issues that may arise
    - prevents accidentally undoing previous successful modifications

let's get started – version 1



setup Raspberry Pi 400

- *Pi 400 Tour/Teardown*
- *flash a microSD card – links & flasher program*
- *cords & startup*

Open the toy!

multimeter time

Hook up breakout cable to breadboard

- *Pull power from breadboard to use in toy*

play!

let's get started – version 2

setup Circuit Playground Express

- *CPX Tour*
- *Alligator clips & USB power*

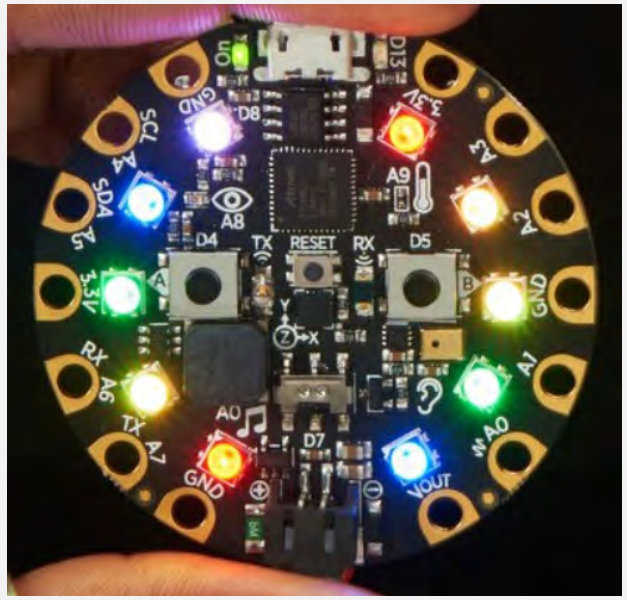
Open the toy!

multimeter time

Hook up alligator clips to CPX

- *pull power from CPX to use in toy*

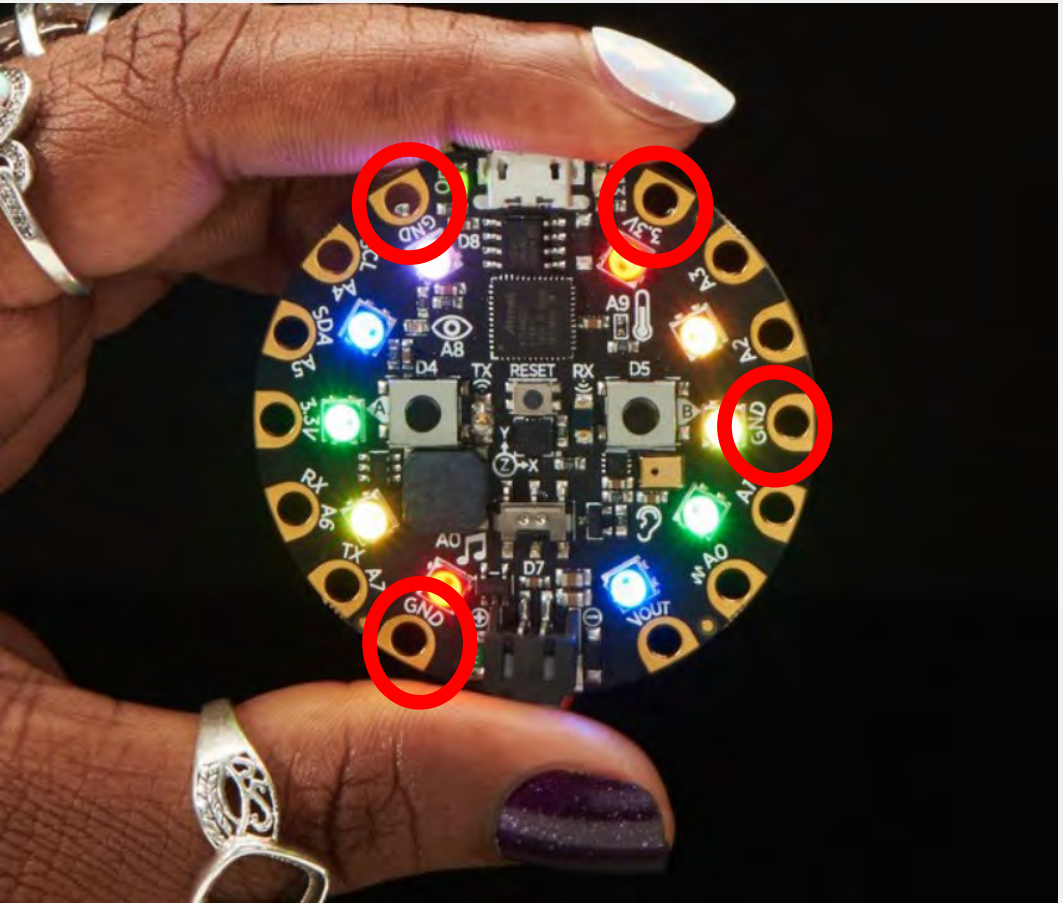
play!



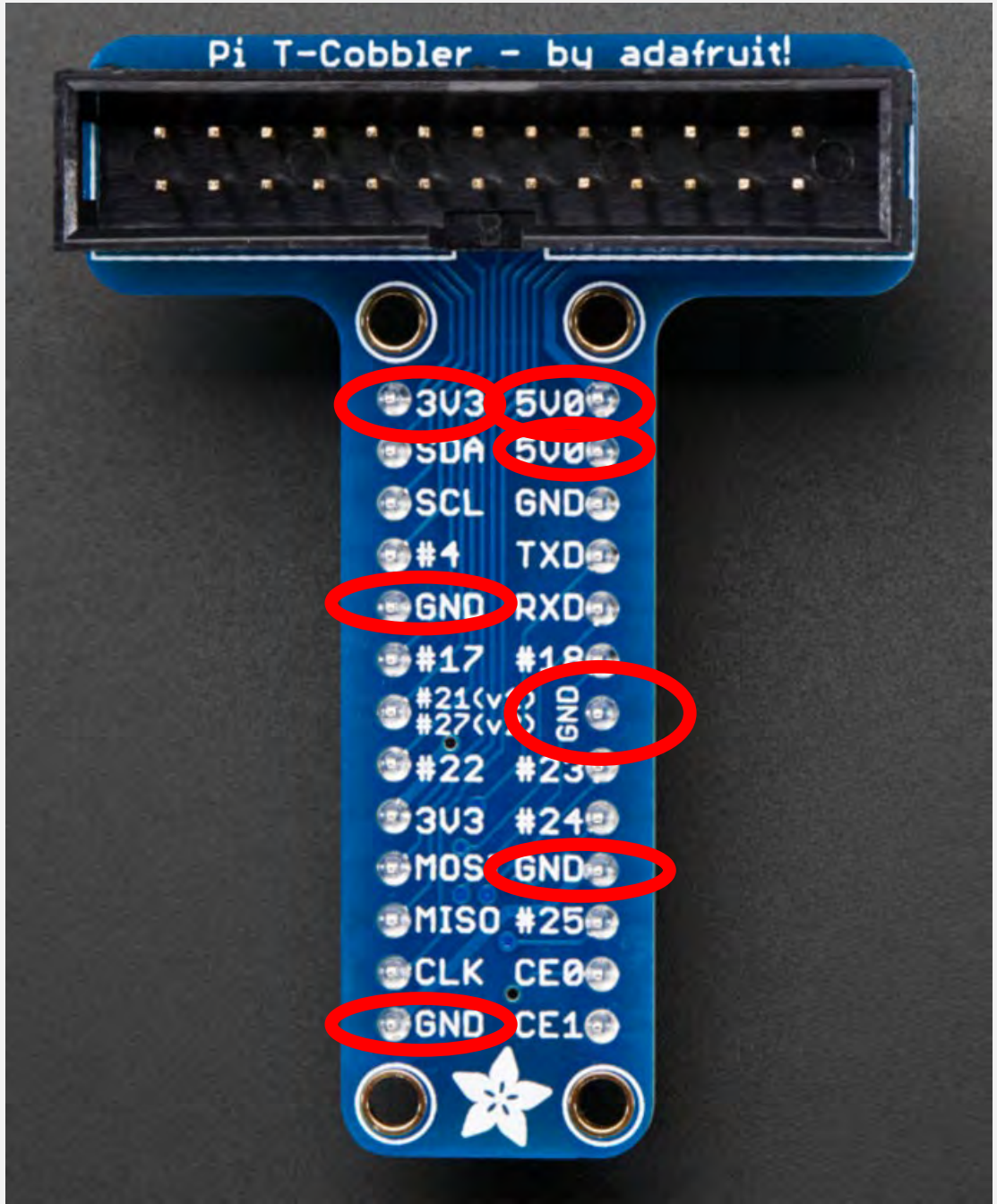
Circuit Playground Express

+

Alligator Clips



VS.



components – 1/3

let's dive into the circuit board of your chosen toy - get ready to discover!

- Resistors:
  - *regulate the flow of electrical current in a circuit.*
  - *changing the resistance value of a resistor, you can alter the pitch or volume of the sounds produced by the toy*
- Capacitors:
  - *store and release electrical energy in a circuit.*
  - *modifying the capacitance value of a capacitor can create delay effects, add resonance, or introduce interesting glitches to the toy's sounds*
- Integrated Circuits (ICs):
  - *the brain of the toy, controlling its functions and sound generation.*
  - *experimenting with different ICs or modifying their connections can drastically change the toy's behavior and create new sound patterns*

components – 2/3

- Switches:
  - *allows you to introduce on/off controls or trigger special effects in real-time*
  - *switches can be used to modulate sound parameters, create loops, or activate hidden features in the toy*
- Potentiometers:
  - *also known as pots, are variable resistors that allow you to manually adjust parameters like pitch, frequency, or modulation speed in real-time.*
  - *adding potentiometers to the circuit, you can create interactive and customizable sound controls*
- Diodes:
  - *control the direction of electrical current flow in a circuit.*
  - *adding diodes in strategic locations, you can create unique distortion effects, clipping sounds, or feedback loops in the toy's output*

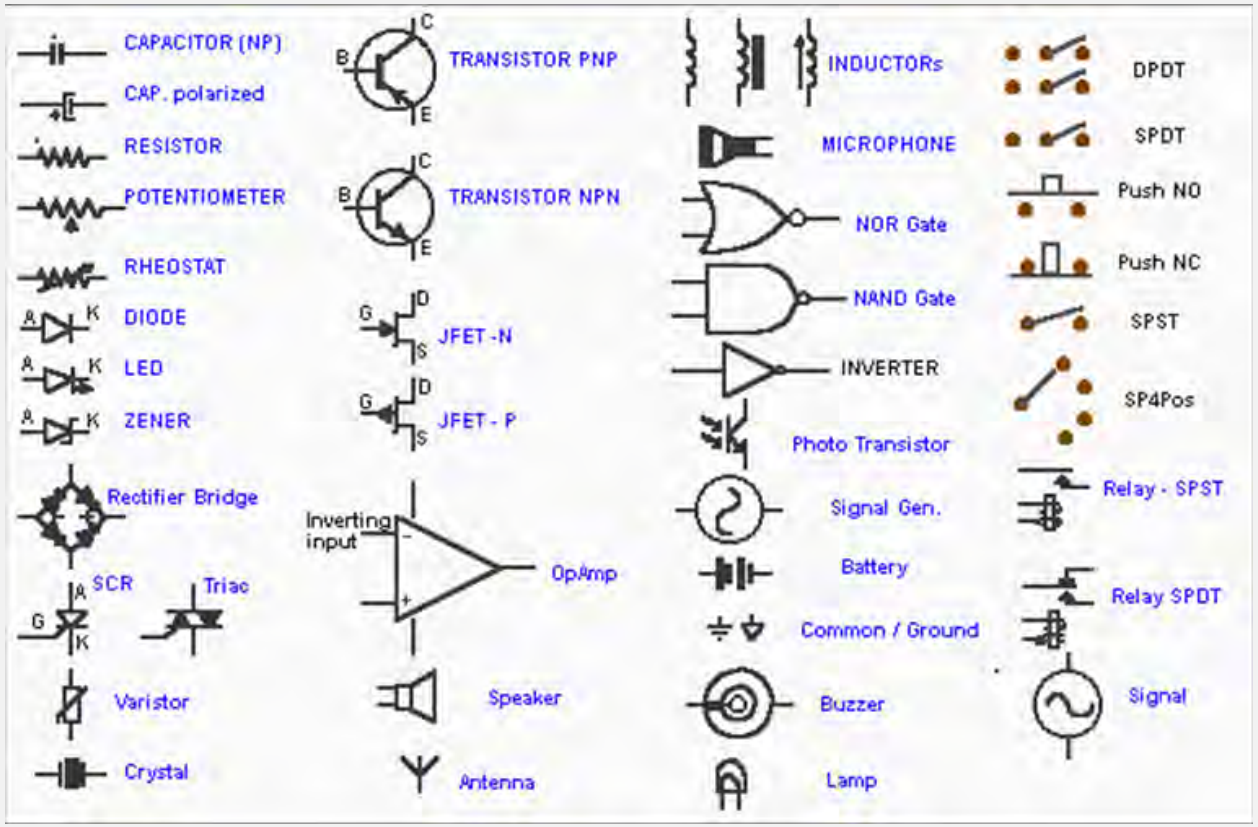
components – 3/3

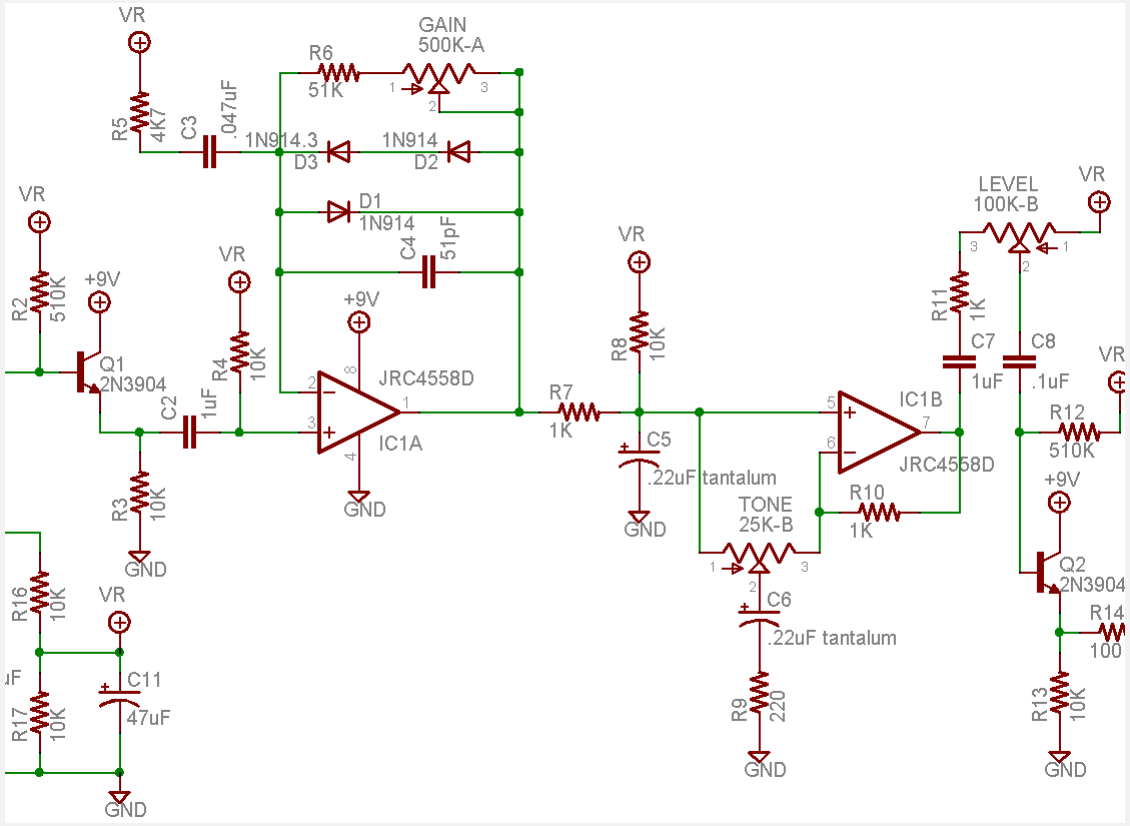
- Transistors:
  - *amplify or switch electronic signals in a circuit*
  - *modifying the transistor configuration or biasing can produce overdrive effects, envelope shaping, or voltage-controlled modulation in the toy's sound output*
- LEDs:
  - *Light Emitting Diodes (LEDs) are not only visual indicators but also interactive components in circuit-bending*
  - *by connecting LEDs to the circuit, you can create visual feedback or use them as triggers for sound modulation effects in real-time*
- Speaker Modifications:
  - *experimenting with connections, impedance, or placement can dramatically alter the toy's sound output.*
  - *try adding external speakers, changing the speaker's polarity, or using the speaker as a microphone for unconventional sound manipulations*

electronics tutorials

- Collin's Lab – playlist of simple shorts on how various components and processes work.
  - *https://www.youtube.com/watch?v=KoSatCnclhE&list=PLjF7R1fz_OOU08_hRcayfVZSmTpBCGJbL*
- Adafruit's Circuit Playground – playlist of Alphabet-based videos on how electronics work – *aimed at kids*
  - *https://www.youtube.com/watch?v=k5Sf0GwWBEs&list=PLjF7R1fz_OOXWHQhEVEI5Jqf18TQRr5Hu*
- Handmade electronic music : the art of hardware hacking (important text in circuit-bending):
  - *https://www.nicolascollins.com/handmade.htm*
- tim hunkin – Secret Life of Machines – remastered & a brand new series!
  - *https://www.youtube.com/@timhunkin1*

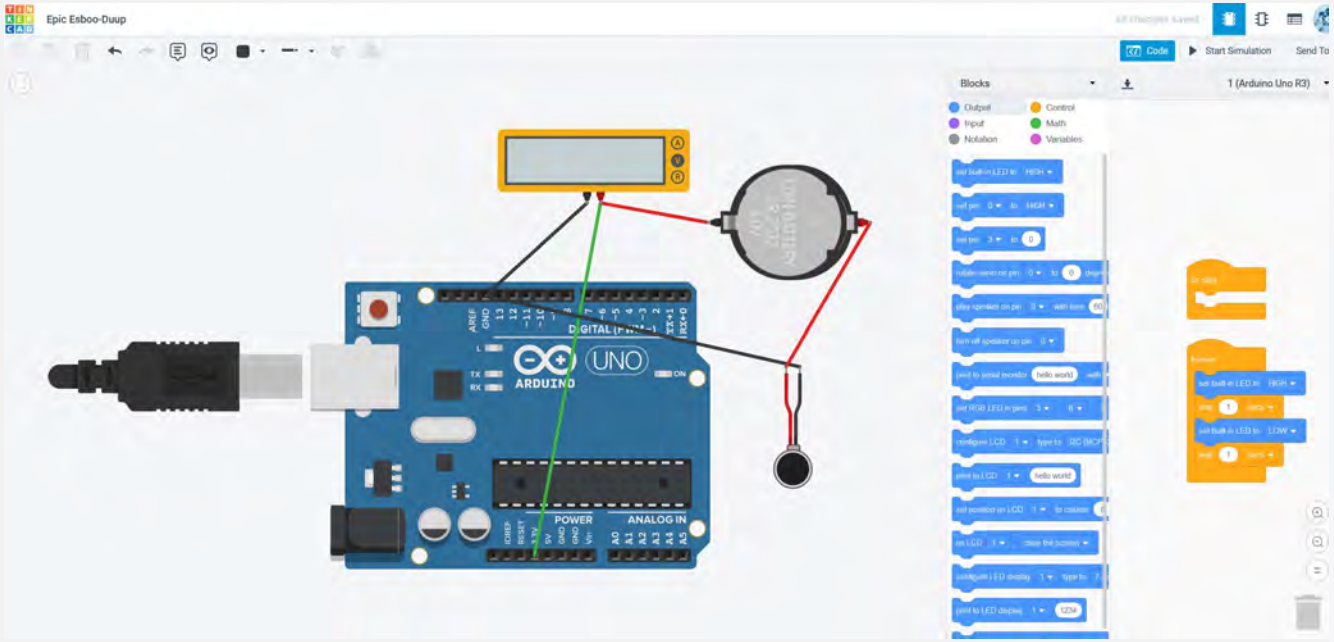
components symbols / schematics

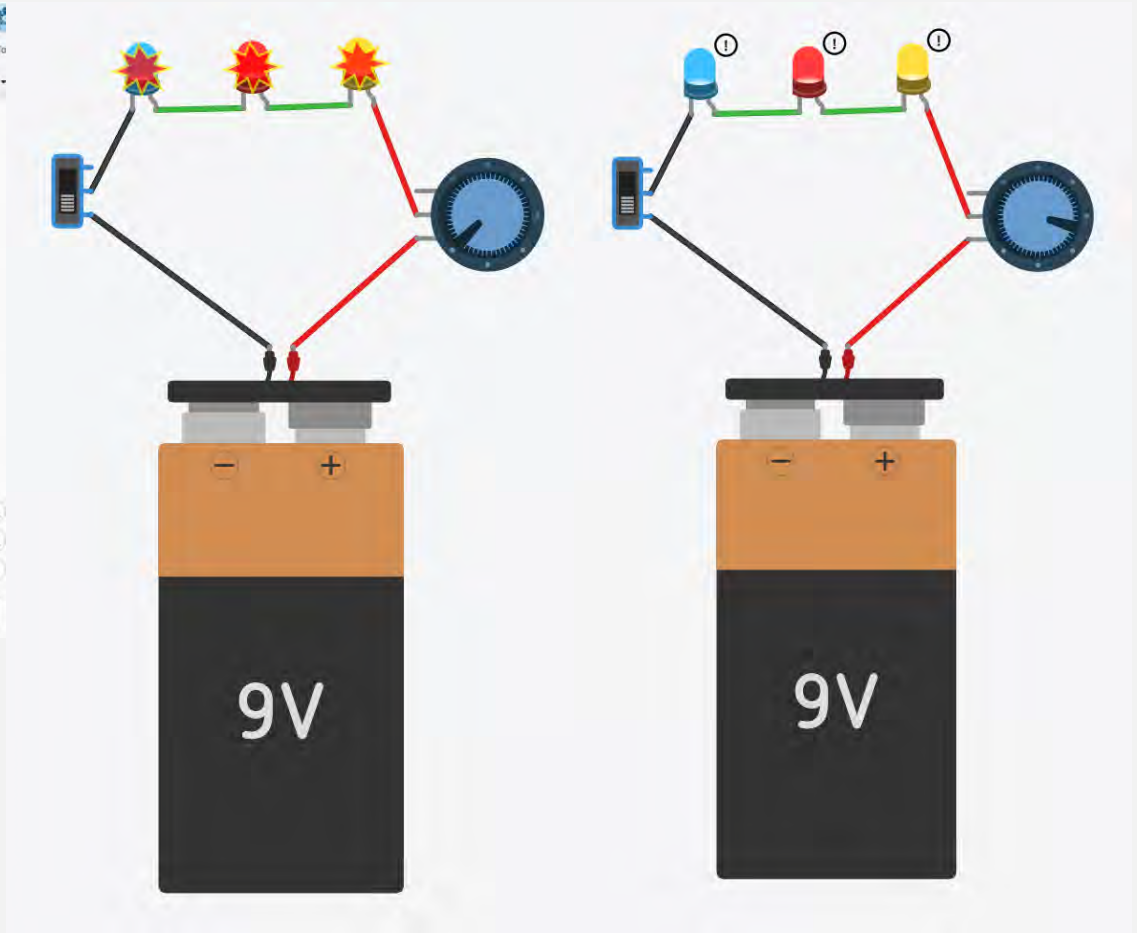


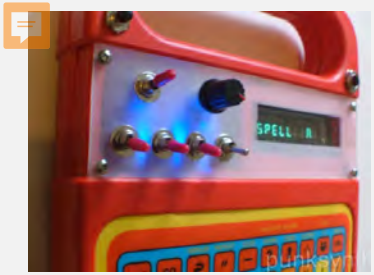


Electronics + TinkerCAD

simulate your project



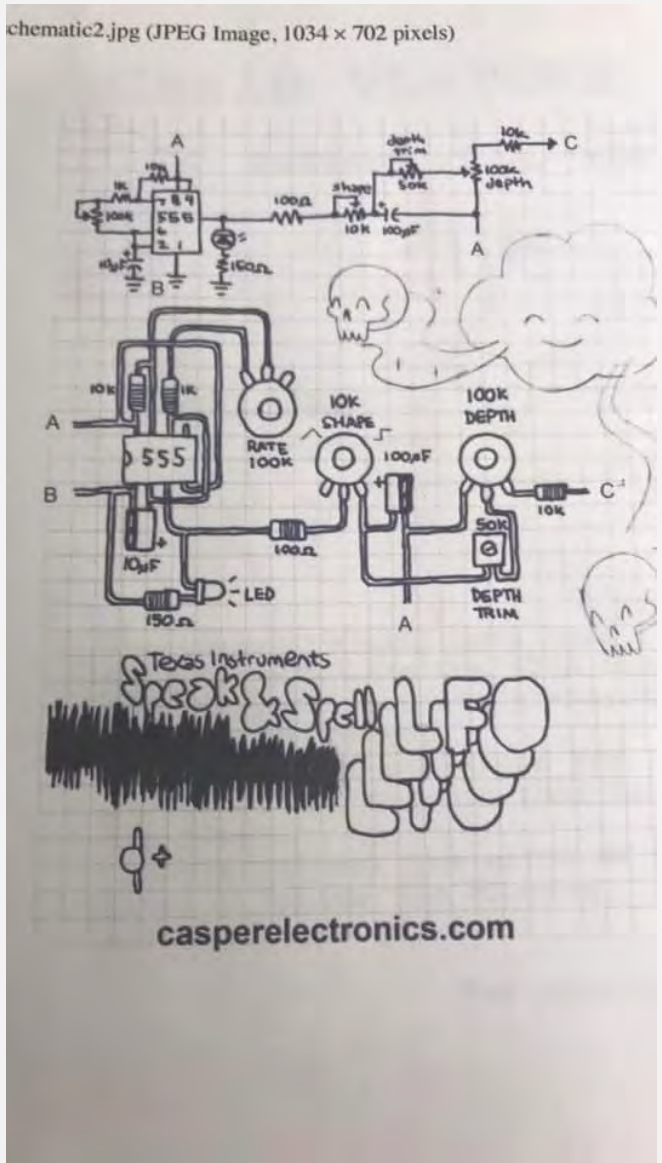


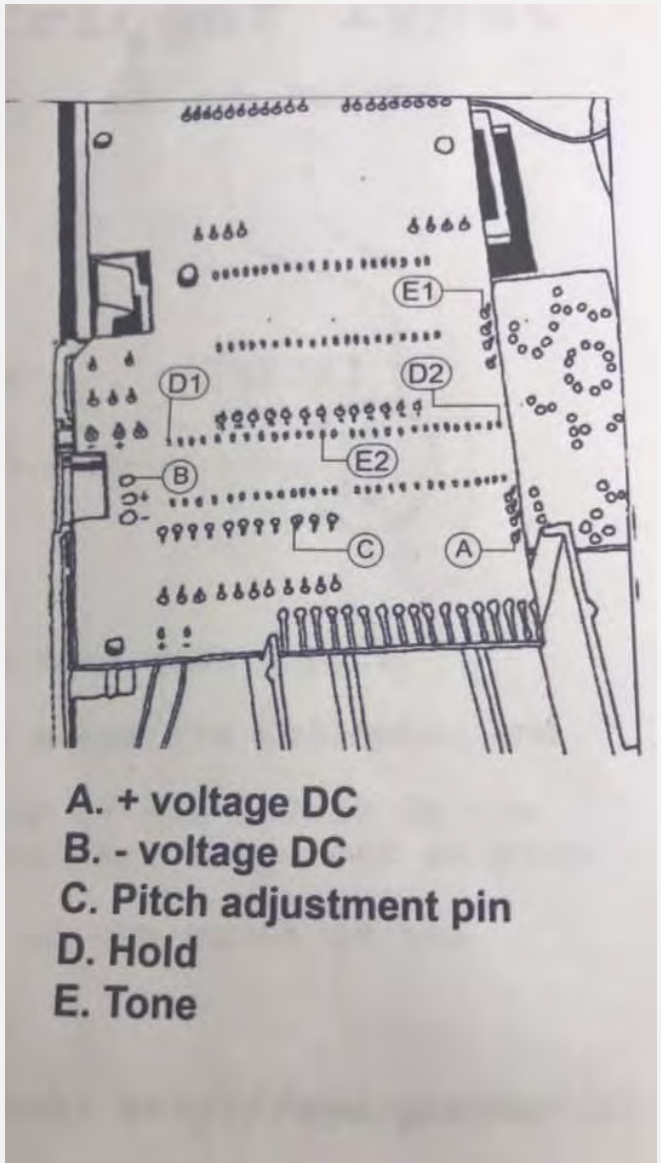


sample: bending the Speak&Spell

- bending guides –old links will need “waybackmachine”
  - http://samvssound.com/2016/06/29/speak-n-spell-part-1-set-first-glitch/
  - https://makezine.com/article/craft/music/how-to-speak-spell-bendin/
- getting started – tutorials/wiki
  - https://circuitbending.miraheze.org/wiki/Speak_%26_Spell
  - http://www.bentstruments.com/speak-spell.html
  - https://www.matrixsynth.com/2010/08/wwwpunksynthcom-circuit-bent-speak-and.html
  - https://toxicdwarf.wordpress.com/2011/02/11/circuit-bending-speak-and-spell/
- examples of bent toys
  - https://cdm.link/2017/03/circuit-bent-instruments-sounds-simply-gorgeous/
  - https://www.youtube.com/watch?v=iwBaU-nQ3l0
  - https://www.errorinstruments.com/a-54869669/new-synthe-noise-instruments-for-sale/circuit-bent-speak-and-math/#description
  - https://www.youtube.com/watch?v=VzycHDBfx3I
  - https://blog.adafruit.com/2020/07/14/sam-of-look-mum-no-computer-refurbs-his-speak-spell-breakout-1-2/

Speak & Spell diagrams





using Makerspace's *Pi-400* and *Pi-Zero W* kits

- Arrange a free appointment time to work with a kit (30min minimum)
- Have fun!
- Brainstorm by exploring Adafruit's hundreds of learning guides
  - *https://learn.adafruit.com/guides/beginner*
  - Adafruit Discord - *https://adafru.it/discord*
- Cruise all the projects featured by Raspberry Pi
  - *https://projects.raspberrypi.org/en*
- Join us again for *new* projects in our next, "Play with Raspberry Pi, Linux, and Python" and "Robots with Python" workshop

using Makerspace's *Electro* and *Robo* kits

- Arrange a free appointment time to work with a kit (30min minimum)
- Have fun!
- Brainstorm by exploring Adafruit's hundreds of learning guides
  - *https://learn.adafruit.com/guides/beginner*
  - Adafruit Discord - *https://adafru.it/discord*
  - *https://learn.adafruit.com/circuitpython-made-easy-on-circuit-playground-express/time-to-get-creative*
  - *https://learn.adafruit.com/welcome-to-circuitpython/what-is-circuitpython*
  - *https://learn.adafruit.com/adafruit-circuit-playground-express/overview*
  - *https://learn.adafruit.com/circuitpython-sound-box*
  - *https://learn.adafruit.com/circuitpython-fruitbox-sequencer-musically-delicious-step-pattern-generator*
  - *https://learn.adafruit.com/circuitpython-ble-crickit-rover*

moving forward

- The Staff and Student Assistants in the Makerspace are here to help!

- There are O'Reilly video and text tutorials available to help learn the more advanced software (TinkerCAD, MakeCode, Python, etc.) through Library Databases:
  - *Search for "oreilly" @*
  - *http://texastech-ml.hosted.exlibrisgroup.com/V/?func=find-db-1*

- YouTube, Hackaday.com, Adafruit, hackster.io, many electronics forums, and most companies offer a wide variety of tutorial assistance

raspberry pi - inspiration

impact

- https://projects.raspberrypi.org/en
- https://raspberryshake.org/

Furby-eyes

- https://www.raspberrypi.com/news/these-furby-controlled-raspberry-pi-powered-eyes-follow-you/

podcast – Raspberry Pi + CircuitPython

- https://circuitpythonshow.com/episodes/6

Raspberry Pi vs. Arduino Uno

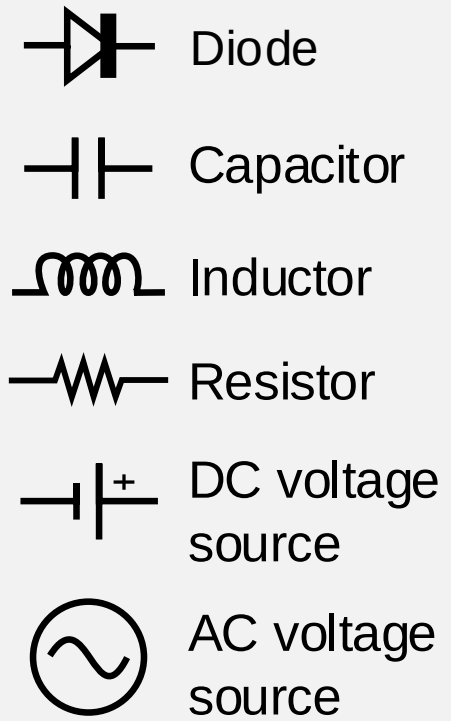
- https://www.arduino.cc/en/hardware
- https://makezine.com/article/technology/arduino/admittedly-simplistic-guide-raspberry-pi-vs-arduino/
- https://www.tomshardware.com/features/raspberry-pi-vs-arduino
- https://www.geeksforgeeks.org/difference-between-arduino-and-raspberry-pi/
- https://www.youtube.com/watch?v=p400etpplDg
- https://www.makerguides.com/arduino-vs-raspberry-pi-what-is-the-difference-between-arduino-and-raspberry-pi/

circuit-bending inspo

- My Little Hacker – Playlist of videos bending circuits and hacking toys
  - https://www.youtube.com/watch?v=890PQwlKc18&list=PLjF7R1fz_OOXgtmTKH-1Dinp_HjEHK14T
- Blog on retro-technology
  - https://blog.adafruit.com/tag/retrotech/page/2/
- Rise of the Maker Movement
  - https://www.youtube.com/watch?v=bkZw7QI0kCg&list=PLcajvRZA8E0-TmeMyRyafe1XVJVRje0RM&index=27
- CircuitBending
  - https://www.youtube.com/watch?v=FucKzUyeVag&list=PLcajvRZA8E0-0rQXj7nPbmfEpKVu7VvYs&index=61
- NFC Toys
  - https://www.youtube.com/watch?v=0xawSK2dKqk&list=PLcajvRZA8E0-TmeMyRyafe1XVJVRje0RM&index=96

right to repair

- expert panel
  - https://www.youtube.com/watch?v=NwTjZPvTtVs&list=PLcajvRZA8E0-TmeMyRyafe1XVJVRje0RM&index=37
- recent debate on Right to Repair
  - https://www.youtube.com/watch?v=N6cGP7x8ErE
- farmers and tractors
  - https://www.youtube.com/watch?v=EPYy_g8NzmI
- Open Source Farming
  - https://farmos.org/
- world of Bioprinting
  - https://www.youtube.com/watch?v=XgD04Bime7Q&list=PLcajvRZA8E09bgru8xIqs0rEjgH6YM27e&index=62



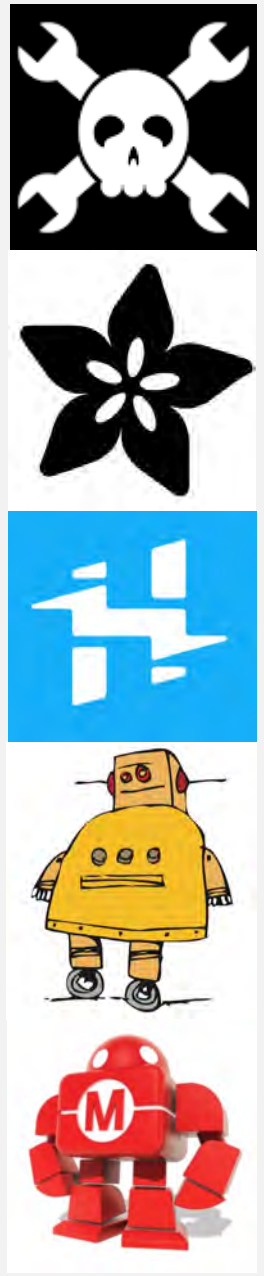
projects galore

project-sharing websites (some require membership)

- https://learn.adafruit.com/search?q=raspberry
- https://www.hackster.io/search?i=projects&q=raspberry
- https://www.instructables.com/search/?q=raspberry%20pi%20python&projects=all
- https://hackaday.io/search?term=ras+pi+python
- https://make.co/

Support/Forums/Discord

- Arduino
  - *https://discord.com/invite/j0JFwW7*
  - *https://support.arduino.cc/hc/en-us*
- Adafruit
  - *http://adafru.it/discord*



thank you!

please share your projects and progress!

"Play with Circuit-Bending" with Sean Scully
review this workshop here:
https://ttu.libwizard.com/f/workshop-eval-24-25_emerging_tech

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Workshops - https://guides.library.ttu.edu/make