Circuit Playground Express Head-Tilt Ears

Created by Dave Astels

https://learn.adafruit.com/circuit-playground-express-head-tilt-ears

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Table of Contents

Overview 3

- Parts
- Supplies

Hardware 5

- Wiring

Construction 7

- Designing the ears
- Aside: Reinforced corner joints
- Connecting the servos
- Covering the mechanism
- Final assembly

Code 17

- First Some Theory
- The Code

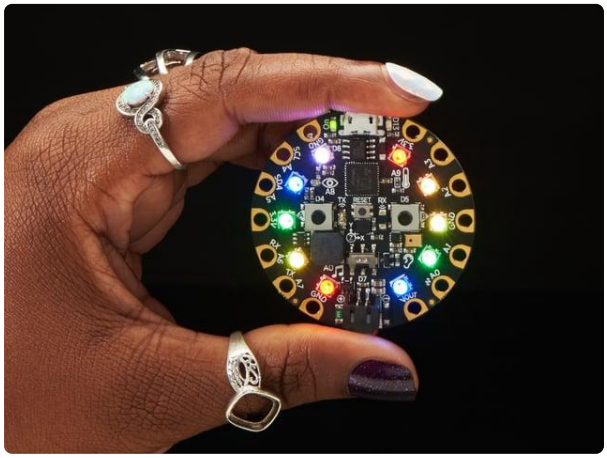
Overview

This project is a reuse of the project built in the Circuit Playground Express Perk-up Ears (https://adafru.it/Cr2) guide. It's a good example of how you can find new and interesting ways to reuse or extend an cool bit of hardware.

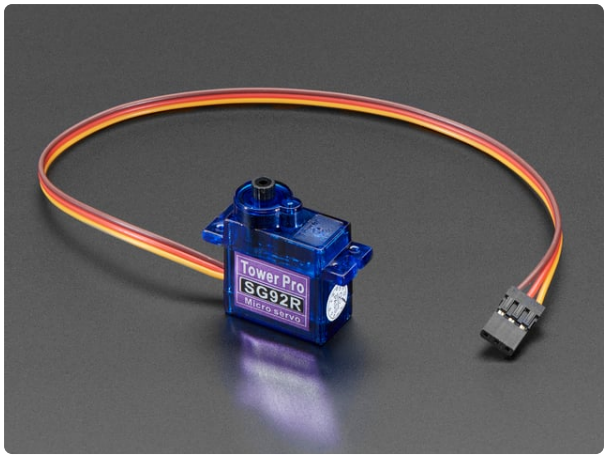
So if you built the perk-up ears headband from that guide, charge up the battery, and plug in the USB cable. Otherwise, work thought that guide (https://adafru.it/Cr2) to build the servo-ears headband.

Parts

This project uses a Circuit Playground Express, 2 servos, and a LiPo battery. Any size battery can be used, but the 1200 mAh model is a good balance between size and lifespan.



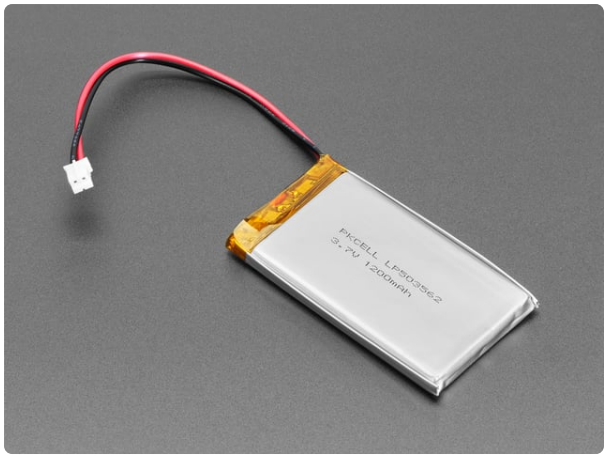
Circuit Playground Express
Circuit Playground Express is the next step towards a perfect introduction to electronics and programming. We've taken the original Circuit Playground Classic and...
https://www.adafruit.com/product/3333



Micro servo

Tiny little servo can rotate approximately 180 degrees (90 in each direction) and works just like the standard kinds you're used to but smaller. You can use any servo...

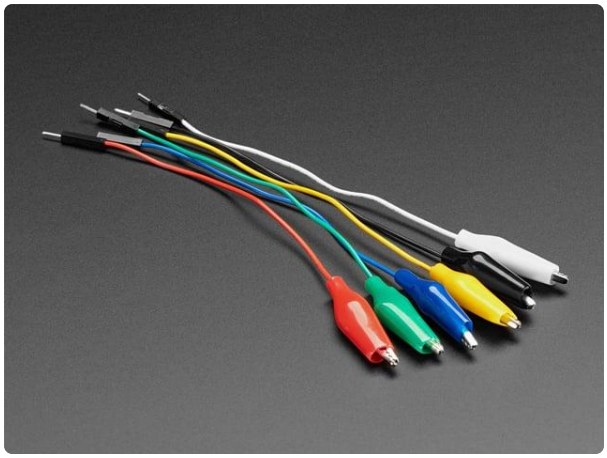
https://www.adafruit.com/product/169



Lithium Ion Polymer Battery - 3.7v 1200mAh

Lithium-ion polymer (also known as 'lipo' or 'lipoly') batteries are thin, light, and powerful. The output ranges from 4.2V when completely charged to 3.7V. This...

https://www.adafruit.com/product/258



Small Alligator Clip to Male Jumper Wire Bundle - 6 Pieces

When working with unusual non-header-friendly surfaces, these handy cables will be your best friends! No longer will you have long, cumbersome strands of alligator clips. These...

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Plastic Pop Rivets for Cardboard Crafts (20-pack)

Enter the world of cardboard construction and build playful robot friends! Instead of slapping on tape or waiting for your hot glue to warm up, you can use these...

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Supplies

- Headband
- Construction paper
- Corrugated cardboard
- Hot glue and glue gun
- 2 rubber bands of an appropriate size
- Felt, faux fur, or fabric as desired to cover the ears
- Jumper wire with male pins if you want to solder to the CPX for a more robust connection
- flexible/stranded wire to use as an actuator
- 4 pieces of stiff wire (long male header pins work well) and wire to mechanically connect the servo

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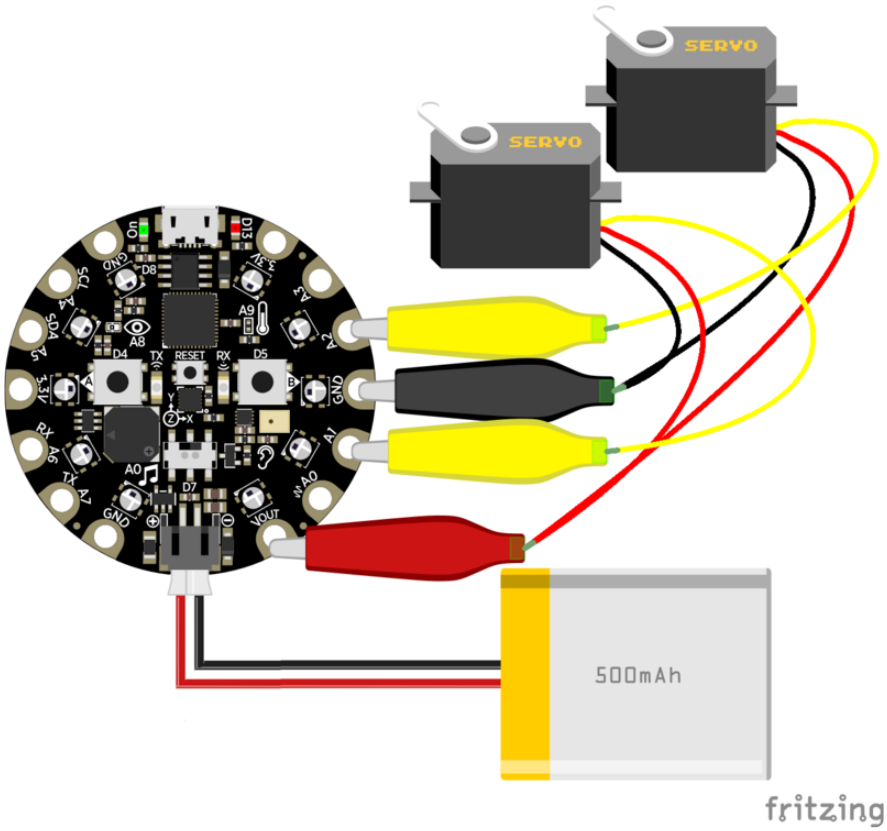
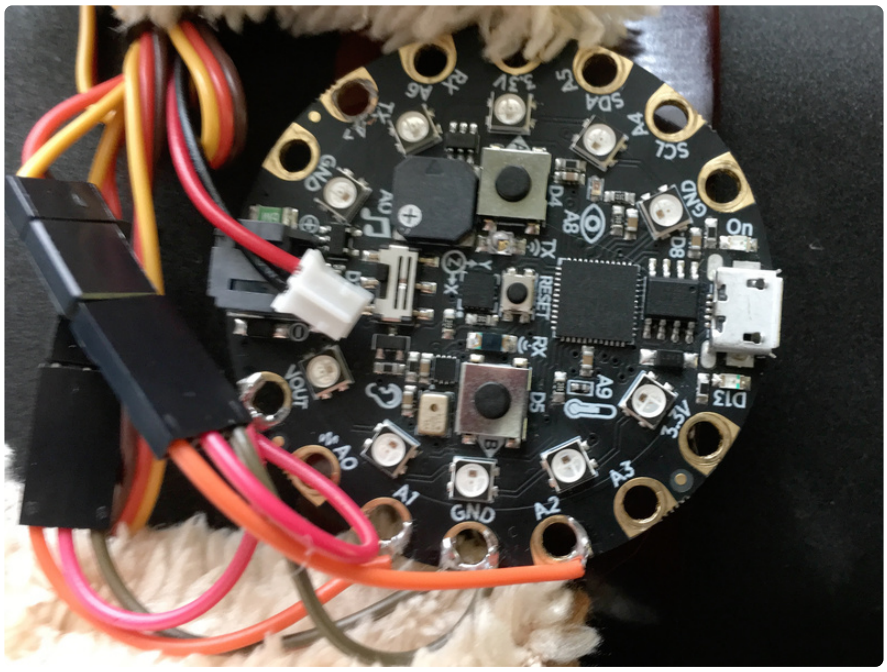
Hardware

Wiring

The diagram below shows alligator clip wires being used to connect the servos, and this is fine for prototyping. But if you want things to be more robust some solder is probably going to be involved. You can cut male jumpers just long enough to reach the required pads on the Circuit Playground Express, coming together at the servo plug and solder them in place. For something even more permanent, you can trim the servo cables and solder them directly onto the Circuit Playground Express.



Wiring-wise the hardware for this guide is identical to the sound activated ears (https://adafru.it/Cr2). The only difference is that you need to orient the Circuit Playground Express correctly. Make sure it's lined up with the battery connector facing directly backward. This will align the X axis of the accelerometer with side-to-side head tilting.

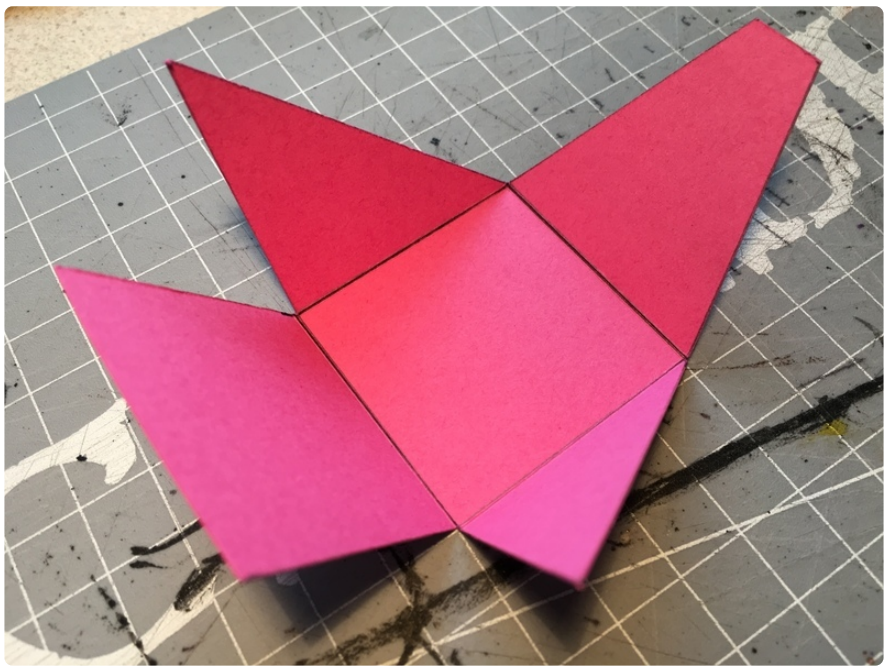


This might mean you have to adjust where the battery is attached to the headband, so that the cable reaches the battery connector with enough slack to connect and disconnect it as needed.

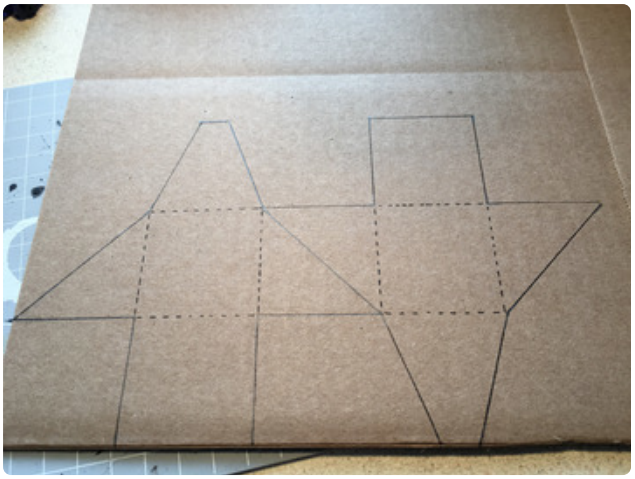
Construction

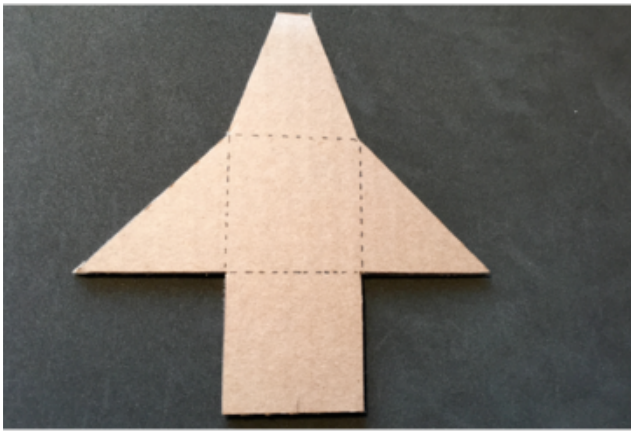
Designing the ears

The first step is to make some ears from cardboard. You can experiment with shapes using construction paper. It's thin enough to be easy to work with, and still stiff enough to keep it's shape when folded. Once you have a design you like, it can be a template for markign the design on the corrugated cardboard.

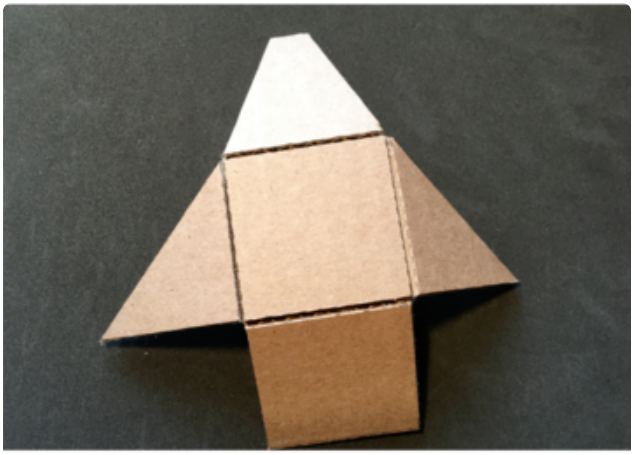


In this case the square edges are 4cm long. The tip of the ear is 1 cm (3/8") wide, with 1.5 cm (5/8") on either side..

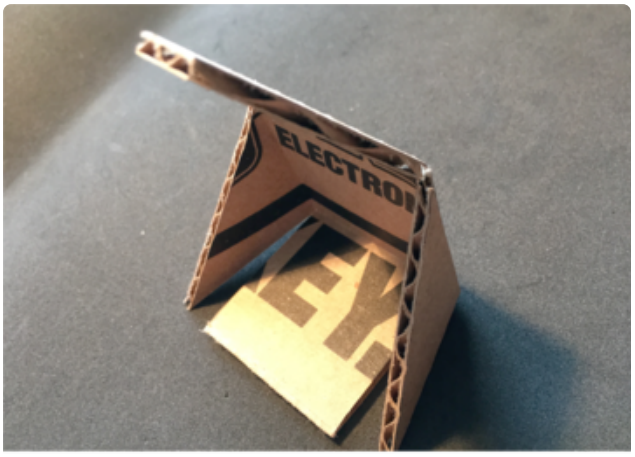




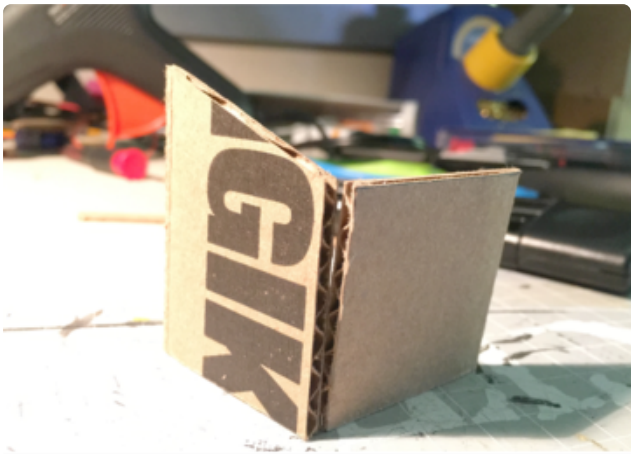
The construction paper prototype can be used as a template to mark out the design on cardboard. Mark them out with the corrugations running from the tip down the length of the piece with the two wings to the sides.



The dotted lines are cut part way though, leaving the bottom outside layer. These are the fold lines.

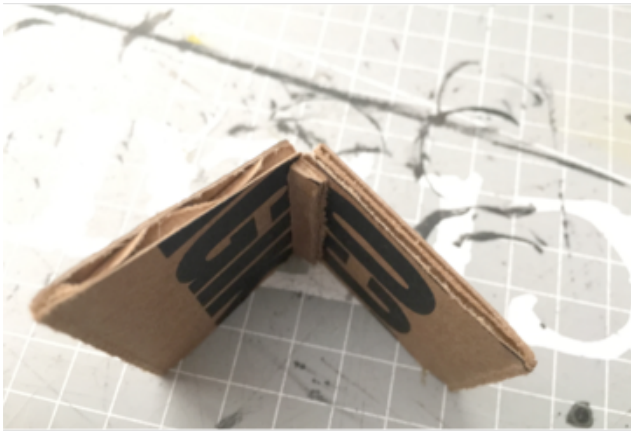


Aside: Reinforced corner joints

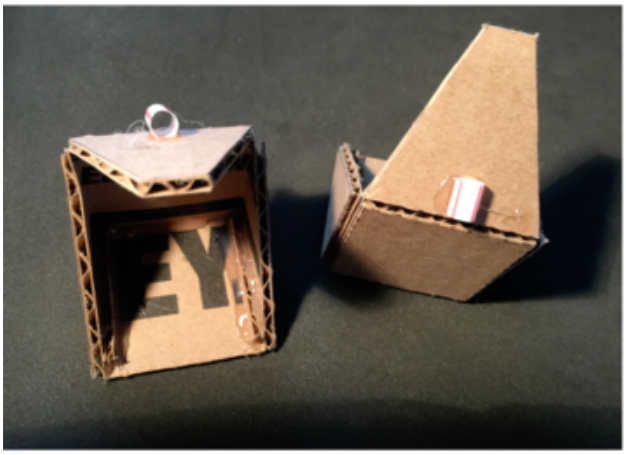


Folding the ear results in the bottom and sides meeting along the edges of the cuts. That means there's nothing to glue to. Although hotglue provides some structure itself, it's nice to have a bit more support for the joint. You can do this by cutting a matchstick shaped piece of cardboard to glue inside the corner. That lets each surface (the bottom and side in this case) be glued to this support.

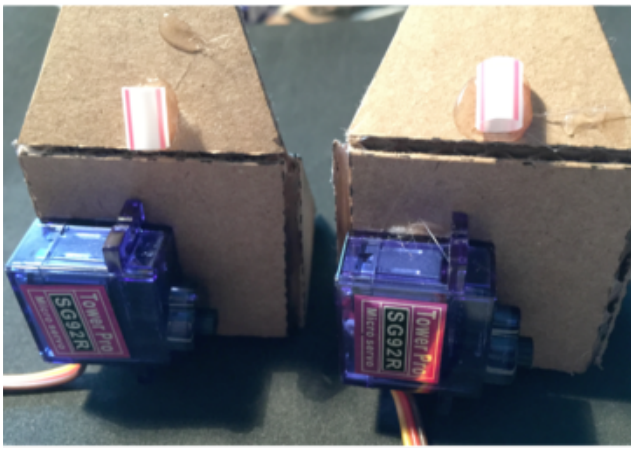
All three concave corners can benefit from a bead of hot glue to enhance the bond as well as provide additional structural support. Allow each bead to cool before adding the next or the heat may cause the entire joint to come apart.



The first step is to fold and glue the ears. You can use the method outlined above.

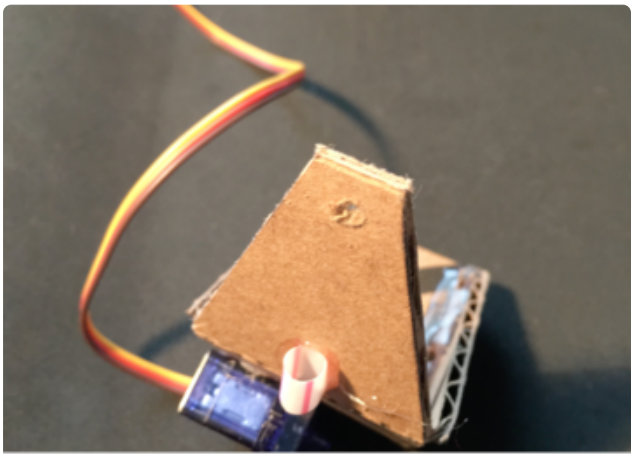


Glue a small piece of plastic straw to the middle of the base of the flap to be a guide for the actuating wire.

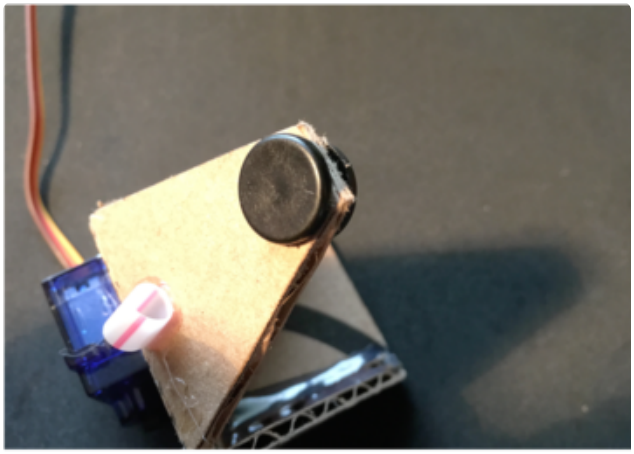


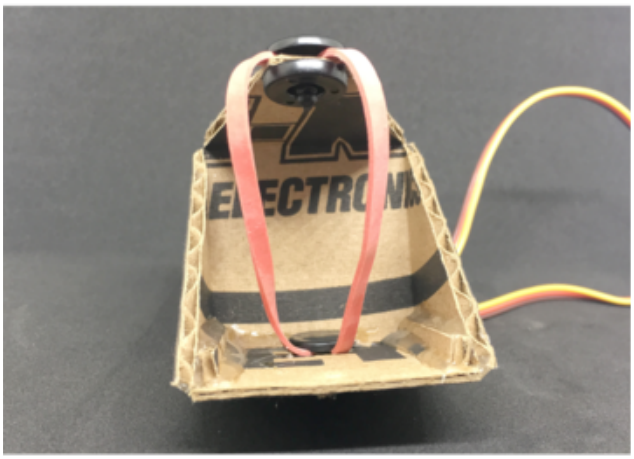
Next glue a servo to the back of each ear as shown: as far down and to the left as possible while still not protruding past the bottom or side of the ear. Consider peeling the foil label from the side of the servo being glued to the ear so that it won't later come off on its own.

Poke a small hole near the end of the flap and place a rivet in it. Put the plate on the rivet, but only to the first position. You'll tighten it later. Make a similar hole near the middle of the back of the base.

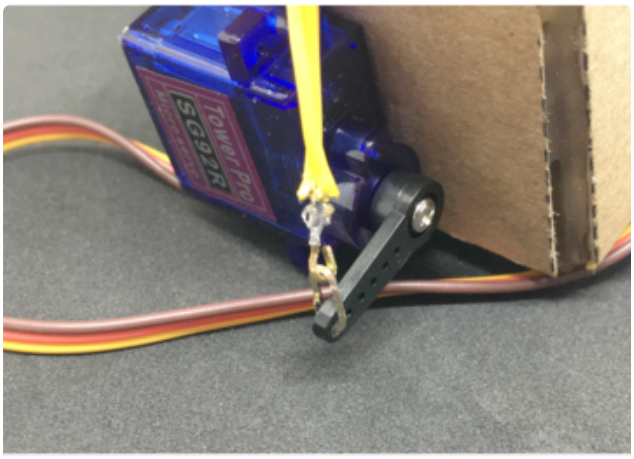


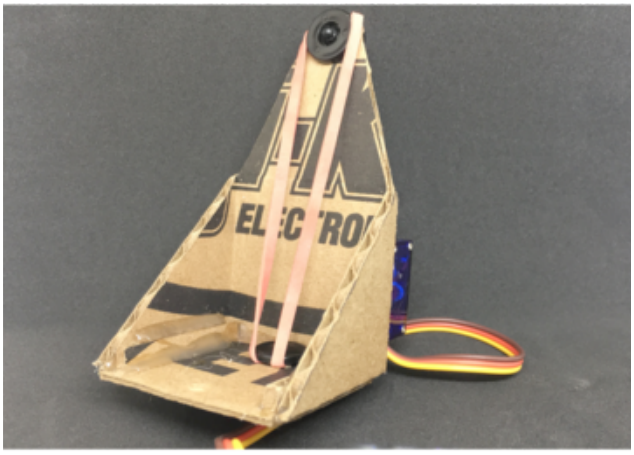
Place a rubber band around the flap rivet as shown. Use a rubber band that is taunt when the flap is extended and has enough strength to pull the flap back when it is released. Poke the other end of the rubber band through the hole in the base so that 2 mm (1/8") sticks through, then push the rivet through it from the top. Place the plate on the rivet and push it on to the second notch.

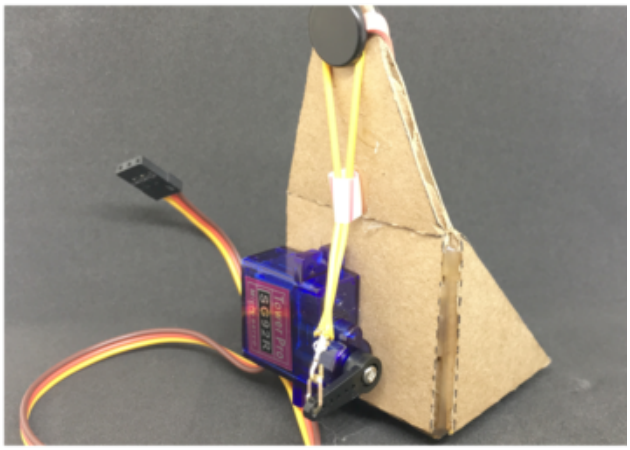




Connecting the servos





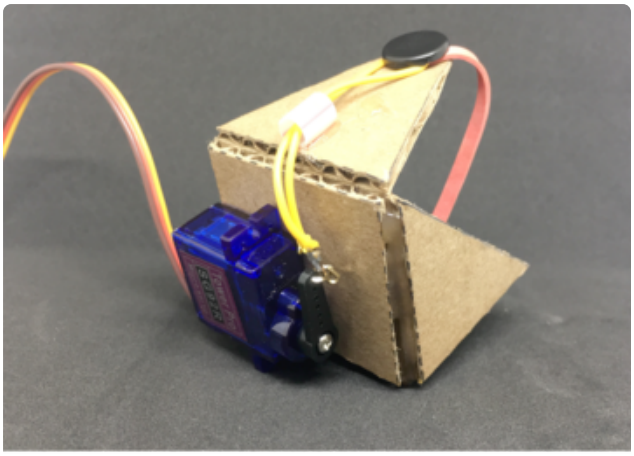


Connect the servos to a board and set them to 0 degrees. Put a "half" horn (see the photos to the left) onto the shaft so that it faces up.

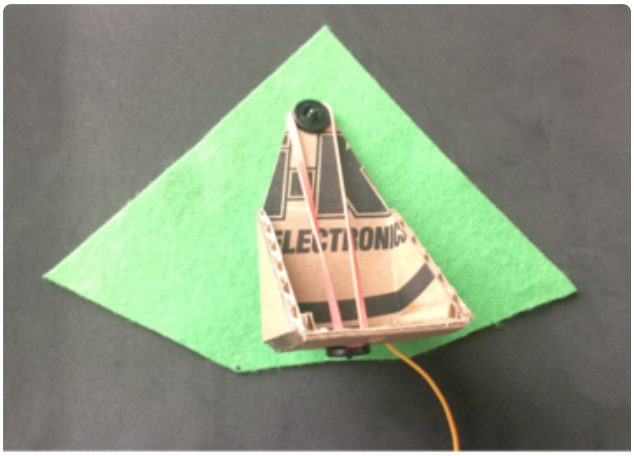
Next you need to link the horn to the ear flap. You can use a short piece of wire looped around the rivet at the end of the flap and through the straw guide. The ends can be soldered to a small hook made from a pin from a male header strip bent around the tip of needle-nosed pliers.

To connect the hook to the servo horn, make a loop from another, longer header pin and place it through the outermost hole in the horn. Squeeze the loop closed. Hook the hook on the wire through the loop on the horn and squeeze it closed. That will keep it from slipping out when the servo horn point up (and allowing the connecting wire to go slack).

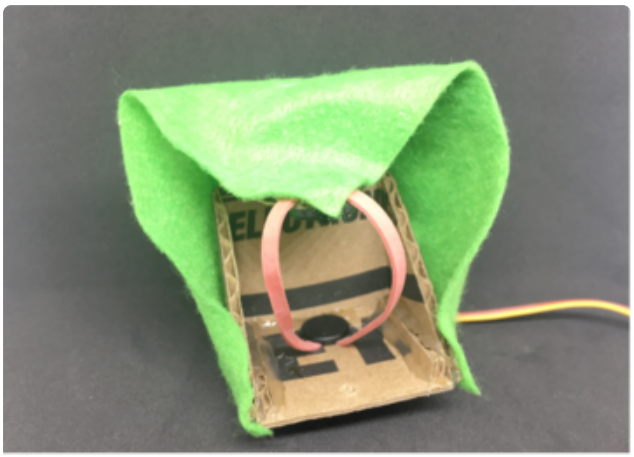
The goal is that when the servo is set to 90 degrees the flap is pulled vertical. When the servo goes back to zero degrees, the rubber band pulls the flap back down into the relaxed position.



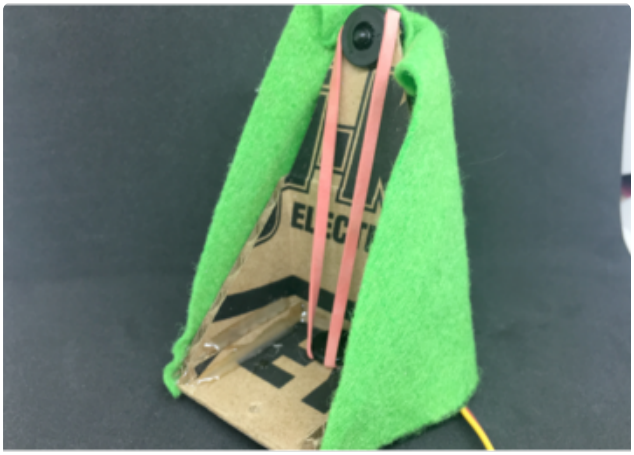
Covering the mechanism



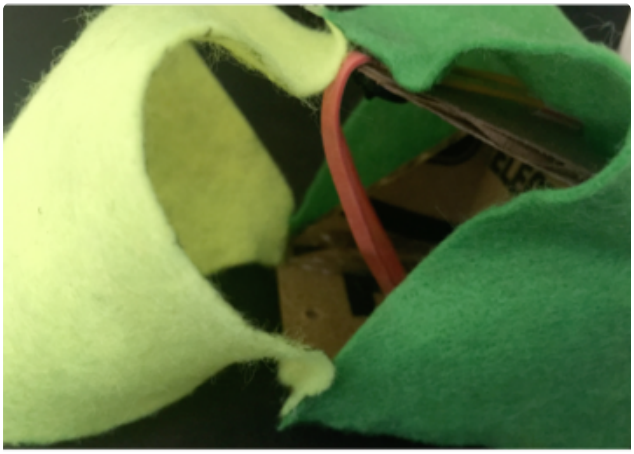
Now you have working ears. Let's make them look a bit better. You can use any sort of fabric to cover them, felt on the inside and fur on the back would be awesome, but here we just use some felt to keep it easy to see what's going on.

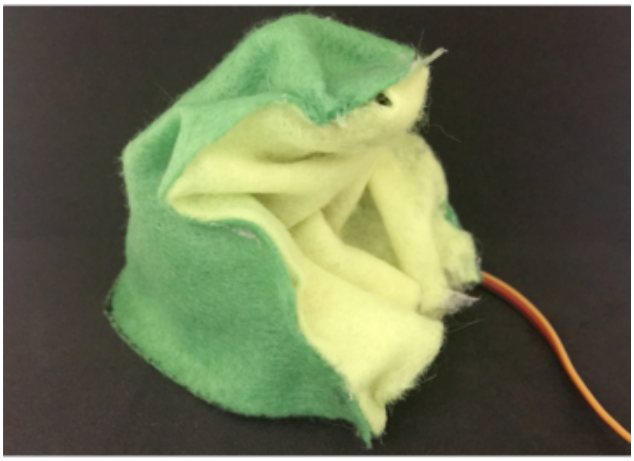


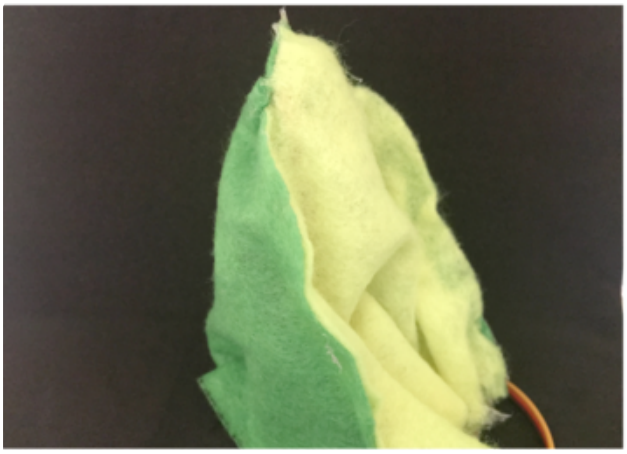
Start by cutting an outside piece for each ear. The exact shape isn't overly important; it has to be big enough to accommodate the servo and the motion of the flap, but not so big as to completely obscure the overall ear shape. Secure the corners as shown to the flap rivet, and the front corners of the base.



Cut a similar piece for the inside of the ear. It only has to allow for the flap movement. Tack the corners to the same points as the outside fabric, only on the inside of the ear. Then apply glue along the inside edges of the outside piece, and secure the edges of the inside piece. The final two photos show the result.







Final assembly

All that's left is to mount the two ears, the Circuit Playground Express, and the battery to a headband. Hot glue works well with the ears, while double sided tape will work for the board and battery.

Code

We'll be using CircuitPython for this project. Are you new to using CircuitPython? No worries, there is a full getting started guide here (https://adafru.it/cpy-welcome).

Adafruit suggests using the Mu editor to edit your code and have an interactive REPL in CircuitPython. You can learn about Mu and its installation in this tutorial (https://adafru.it/ANO).

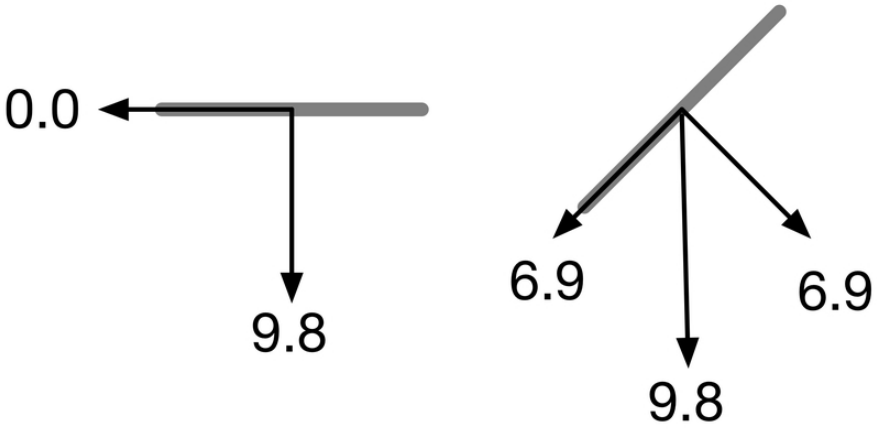
First Some Theory

The way we can tell when the acceleometer (i.e. the Circuit Playground Express) is tilted with respect to an axis (X in our case) is to track the value for that axis.

Gravity at the Earth's surface is nominally about 9.8 m/s^2. So when the Circuit Playground Express is level, the value of Z will be ~9.8 and X will be 0. This is show in the lefthand half of the figure below.

When the Circuit Playground express is tilted 45 degrees, the force toward the center of the earth will still be 9.8, but it will be divided now between the X and Z axis, as show to the right below they will each be ~6.9 (9.8 * sin(45)). Tilt it the other way and X will have a negative value.

By monitoring the value of X we can therefore tell how far along that axis the Circuit Playground Express is tilted.



The Code

While the hardware for this project is the same, the code is completely different and much simpler than the sound activated ears.

After setting up the interfaces to the accelerometer and servos, the loop continually monitors the X component of the accelerometer data (ignoring Y and Z). 1 G is ~9.8 m/s^2 so a comparison value of 5.0 m/s^2 is reasonable. That's a bit less than a 45 degree tilt, as shown above.

One thing to notice is that while X of over 5.0 (or below -5.0) will cause the top ear to perk up, it doesn't go back down until the absolute value of X is below 4.0. The range between 4.0 and 5.0 has no effect on the ear. This is generally called hysteresis and is used here to avoid jitter. If the ear went up when X was over 5.0 and down when it

was below, it would jitter when the head tilt put X close to 5.0 since you can't hold your head that still, so X would be going back and forth over 5.0. This behavior is typically undesirable, hence the use of hysteresis. The ears go down well below the point at which they go up. The result is nice clean movement.

```
# SPDX-FileCopyrightText: 2018 Dave Astels for Adafruit Industries
#
# SPDX-License-Identifier: MIT

"""
Circuit Playground Express head-tilt activated ears.

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"""

import time
import busio
import board
import adafruit_lis3dh
import pwmio
from adafruit_motor import servo


# Setup accelerometer
i2c = busio.I2C(board.ACCELEROMETER_SCL, board.ACCELEROMETER_SDA)
sensor = adafruit_lis3dh.LIS3DH_I2C(i2c, address=0x19)

# Setup servos
left_pwm = pwmio.PWMOut(board.A1, frequency=50)
right_pwm = pwmio.PWMOut(board.A2, frequency=50)

left_ear = servo.Servo(left_pwm)
right_ear = servo.Servo(right_pwm)

#initialize things
left_ear.angle = 0
right_ear.angle = 0

while True:
    x, _, _ = sensor.acceleration
    if x < -5.0:
        left_ear.angle = 90
    elif x > 5.0:
        right_ear.angle = 90
    elif abs(x) < 4.0:
        left_ear.angle = 0
        right_ear.angle = 0
    time.sleep(0.1)
```