“Silly Box”

A fun twist on the useless box concept!

History

- Based on the idea of a “useless” box in which a switch is turned ON triggering an electro-mechanical action that returns the switch to the OFF position.

- My “Silly Box" project is based on the Arduino useless box project found at:

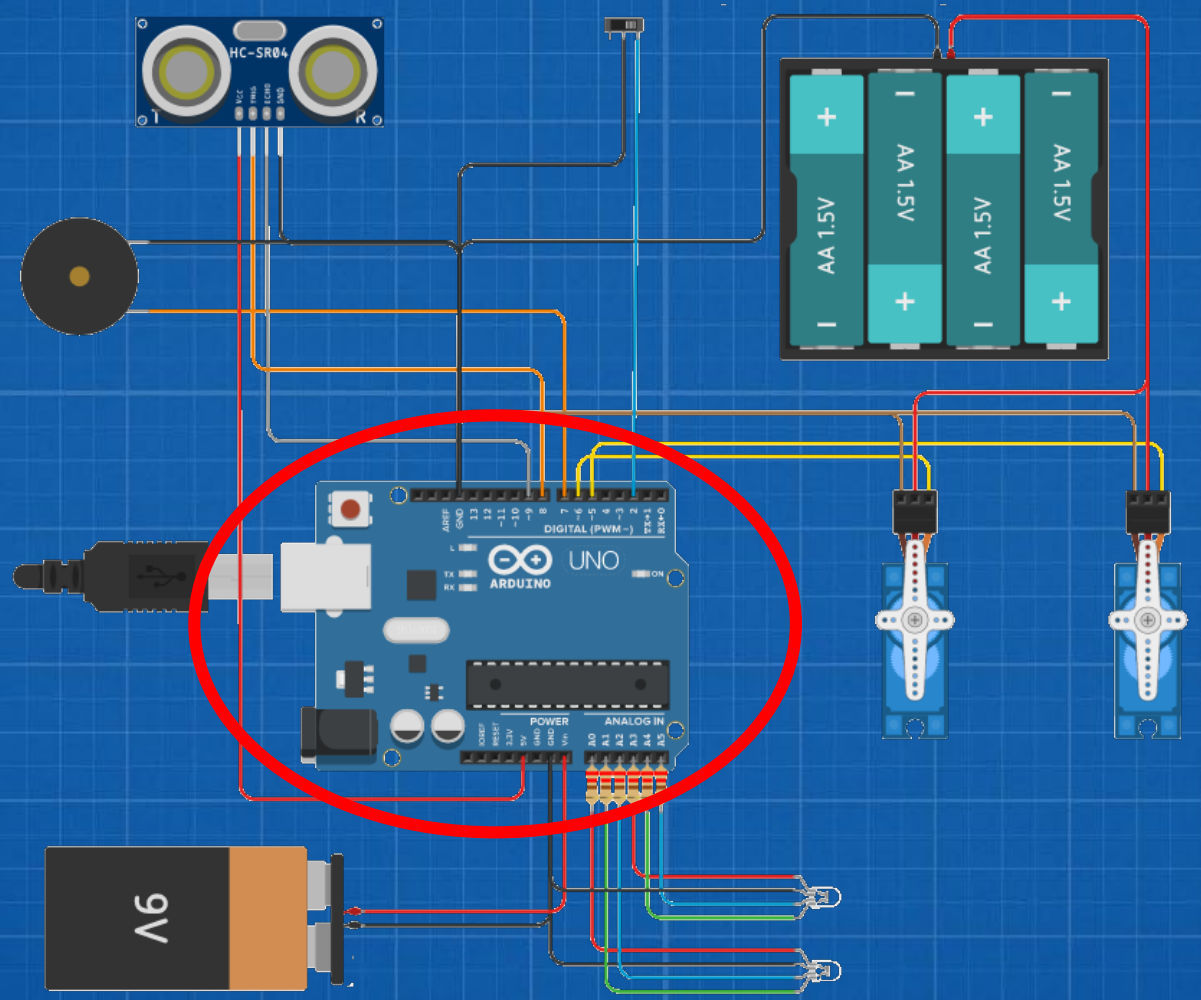
  https://create.arduino.cc/projecthub/viorelracoviteanu/useless-box-with-arduino-d67b47

  The difference is I added light, sound, and an ultrasonic sensor for proximity detection. I call this concept a “Silly Box”!

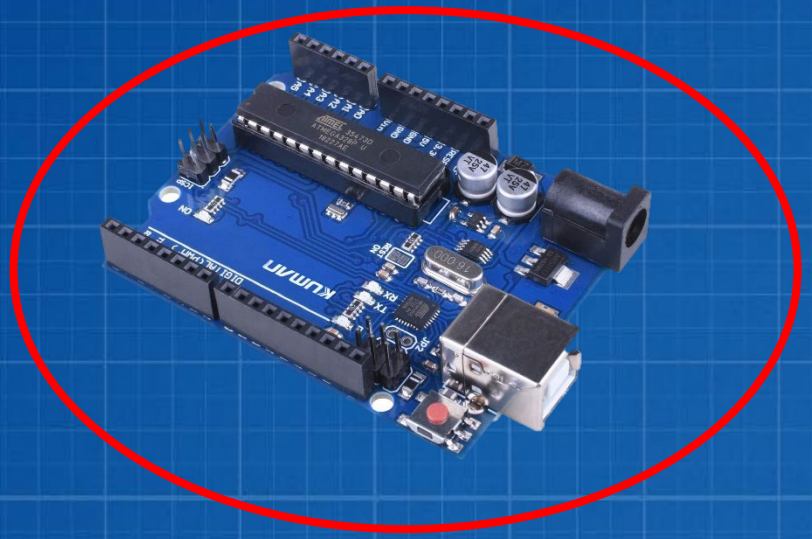
Concept of Operations

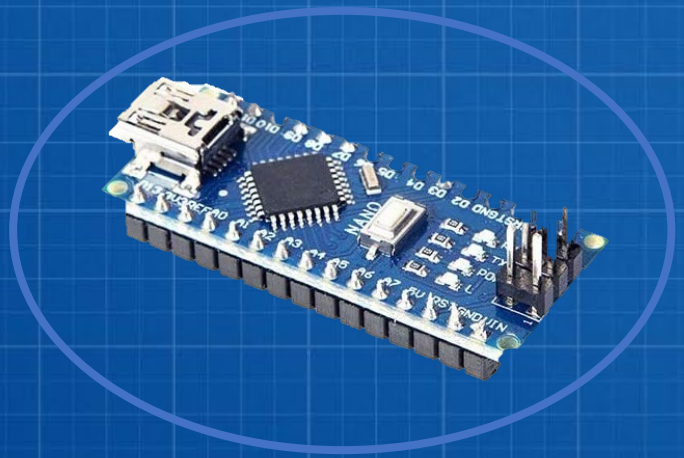
- The “silly box” adds interest to the useless box concept using the following methods:
  1. Randomly choosing sequences of motion, light, and sound in response to the switch being placed in the ON position.
  2. Randomly responding to attempted switch movement with sequences of motion, light, and sound.
- Movement is accomplished by servos commanded by PWM signals.
- Light is accomplished by one or more RGB LEDs with independently controlled red, green, and blue components.
- Sound is accomplished by outputting frequency signals to an inexpensive piezo speaker.
- Attempted switch movement is detected using an ultrasonic sensor.
- Custom Arduino C++ software monitors the front switch and the ultrasonic sensor and executes random movement, light, and sound sequences.
- All sequences are implemented in software tables in order to be easily modified and extended.

Components: Processor Board



Components: Processor Board



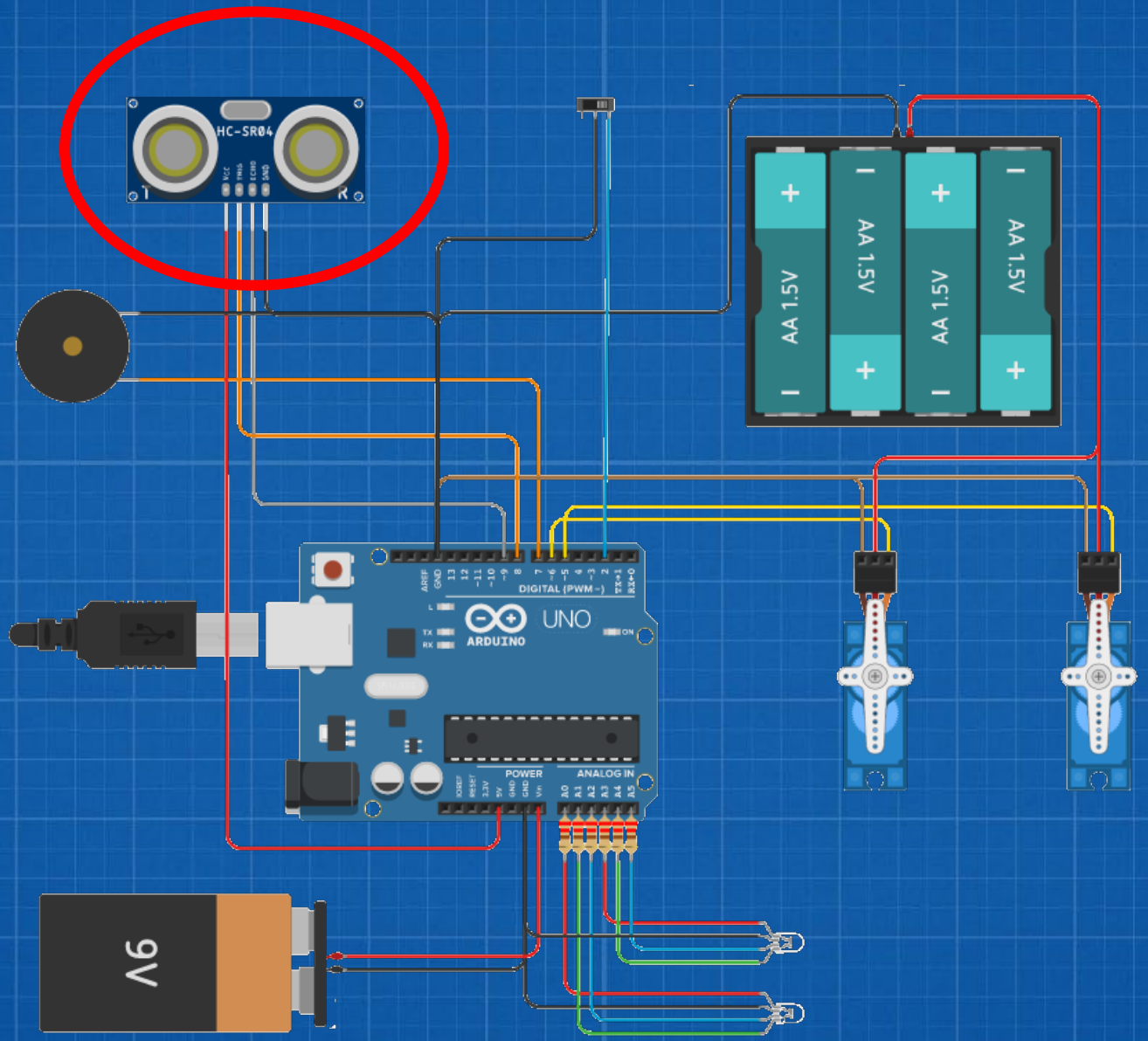


Arduino UNO or Nano

- *Processor:* ATmega328P
- *Operating Voltage:* 5VDC
- *Input Voltage:* 6-20VDC
- *Digital I/O Pins:* 14 (of which 6 provide PWM output)
- *Analog Input Pins:* 6 (can also be digital output)
- *Flash Memory:* 32 KB
- *RAM:* 2 KB
- *EEPROM:* 1 KB (not used in this application)
- *Clock Speed:* 16 MHz

- A clone of either device should work fine in this application
  - UNO clone: https://www.amazon.com/gp/product/B016D5KOOC
  - Nano Clone: https://www.amazon.com/gp/product/B07WK4VG58

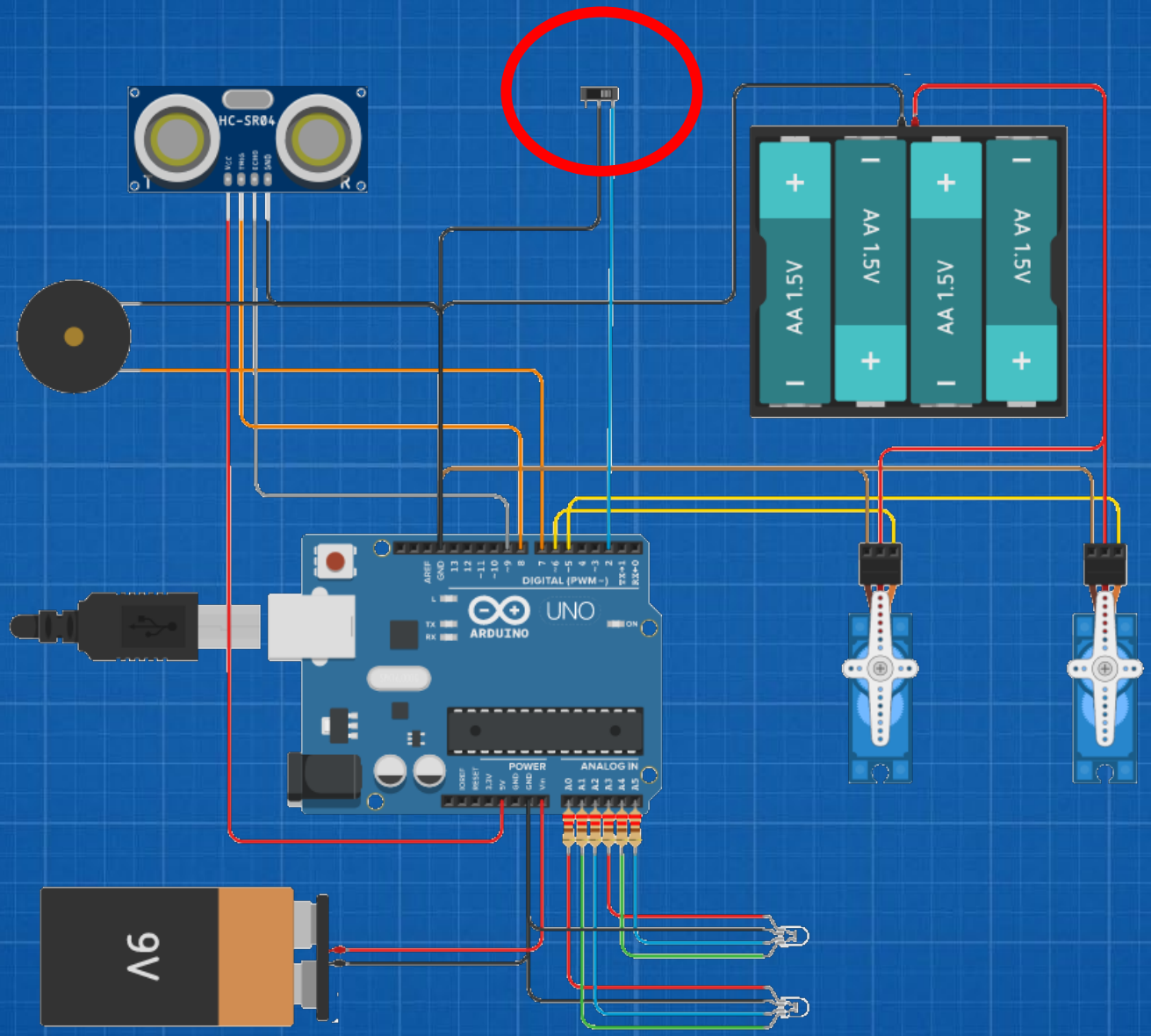
Components: Ultrasonic Sensor



Components: Ultrasonic Sensor

- **HC-SR04 Ultrasonic Sensor**
  - *Operating Voltage:* 5VDC
  - *Max Range:* 4m
  - *Min Range:* 2cm
  - *Ranging Accuracy:* 3mm
  - *Trigger Input Signal:* 10µS TTL pulse
  - *Echo Output Signal:* Pulse length is proportional to the time it took for the transmitted signal to be detected (e.g., round trip signal time)
  - https://www.amazon.com/HC-SR04-Ranging-Detector-Ultrasonic-Distance/dp/B01GNEHJNC

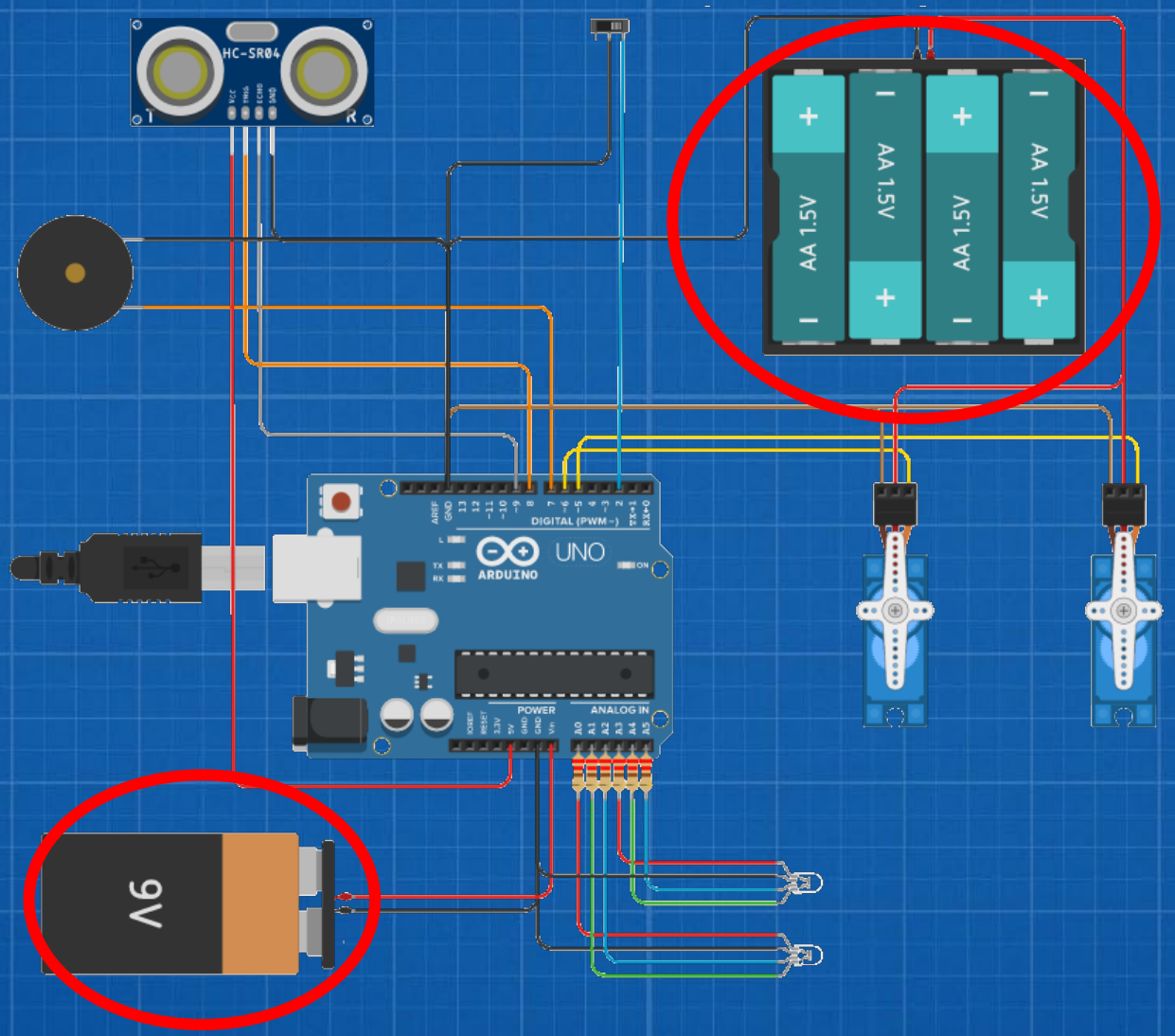
Components: Front Switch



Components: Front Switch

- **Front “useless switch”**
  - *SPST*
  - *Contact Rating:* 5A 125VAC
  - Overkill, but cheap
  - https://www.amazon.com/gp/product/B01GZS7FJO?th=1

Components: Battery Holders



Components: Battery Holders

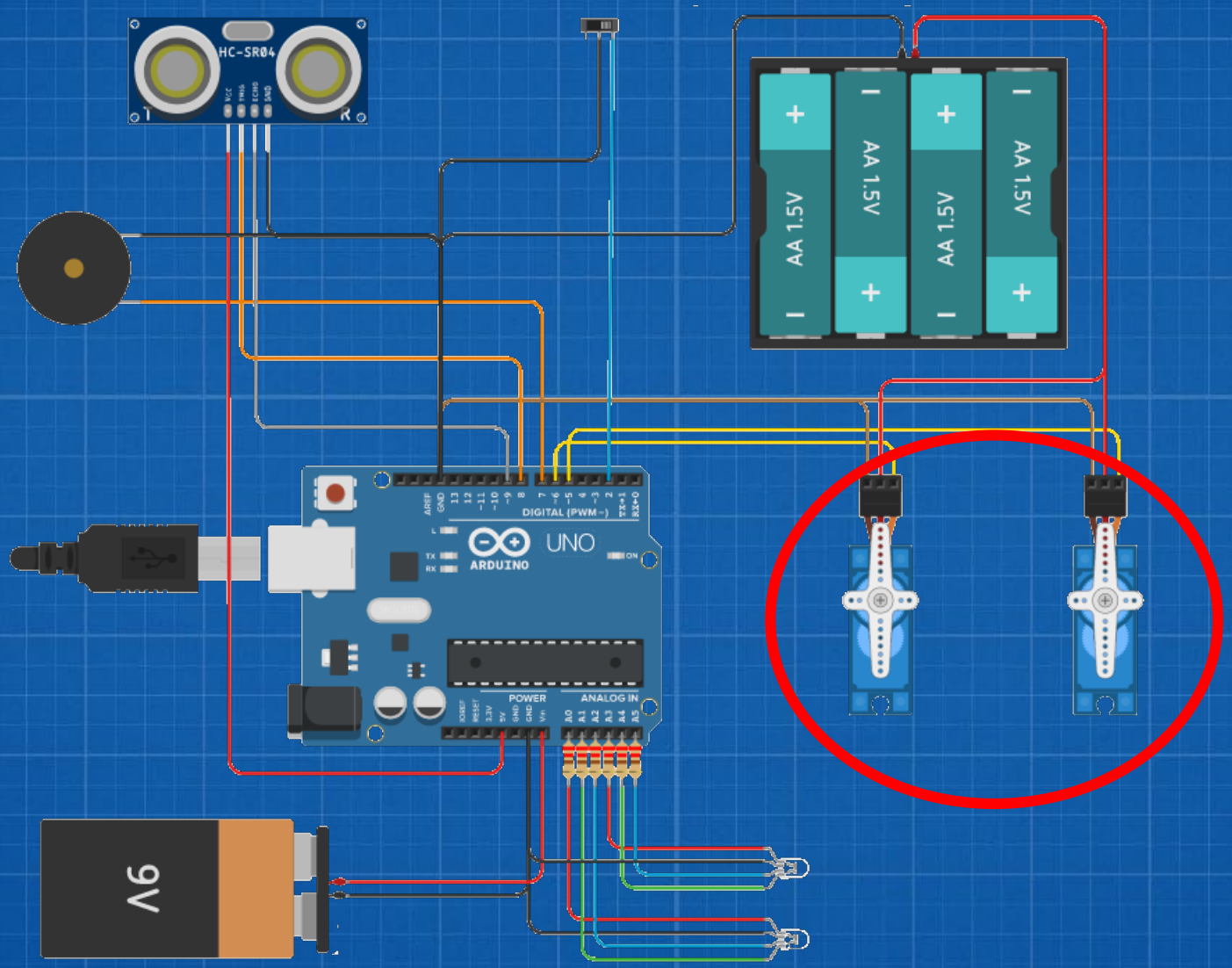
4xAA battery holder

https://www.amazon.com/gp/product/B07T7MTRZX

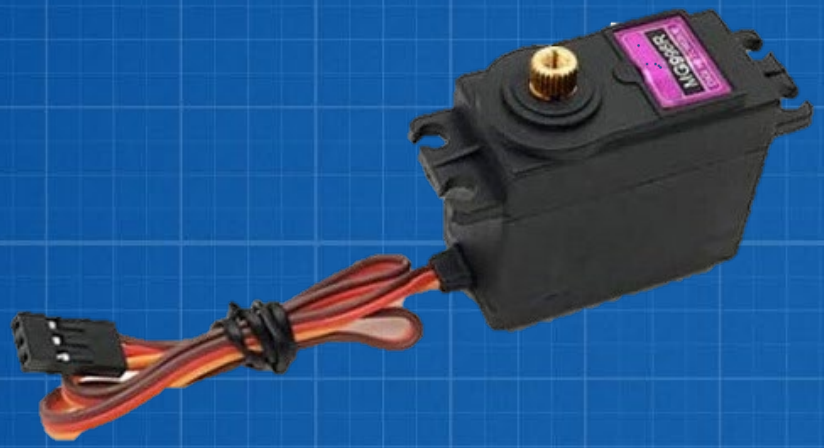
9V battery holder

https://www.amazon.com/gp/product/B0784FMY9J

Components: Servos

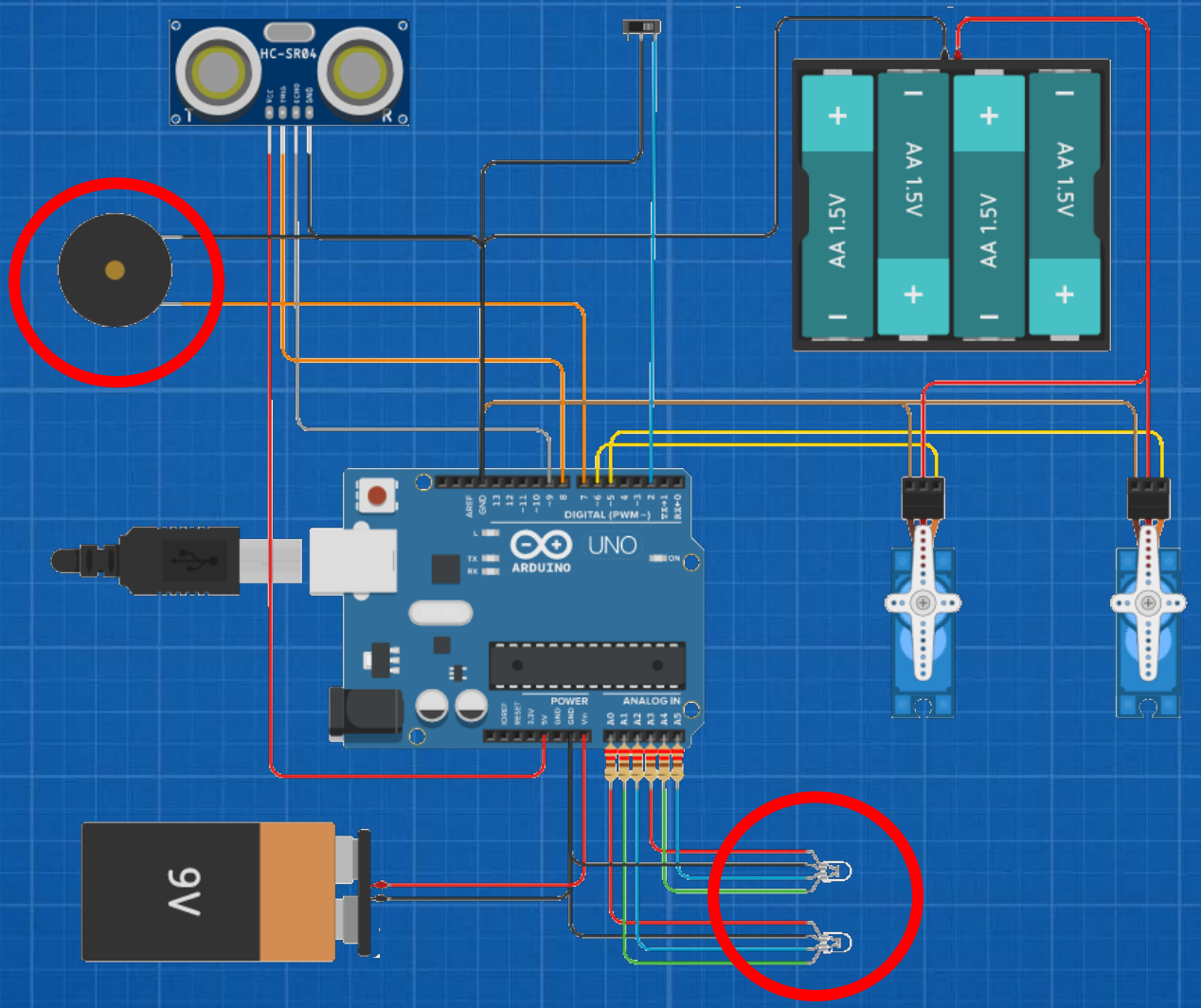


Components: Servos

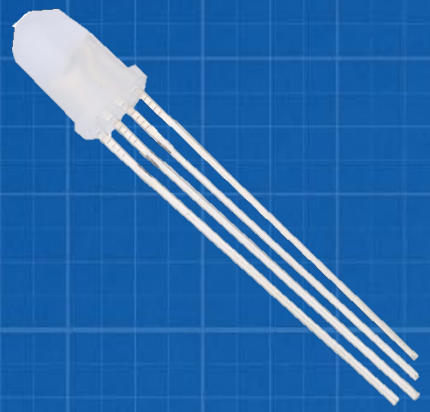


- **MG996R Servos**
  - *Operating voltage:* 4.8VDC to 7.2VDC
  - *Running Current:* 500 mA
  - *Stall Current:* 2.5 A (6V)
  - *Stall torque:* 11 kgf·cm (6V)
  - https://www.amazon.com/Treedix-MG996R-Servo-High-Torque-Helicopter/dp/B08743N181

Components: LEDs and Speaker



Components: LEDs and Speaker



RGB LED

https://www.amazon.com/gp/product/B077XGF3YR

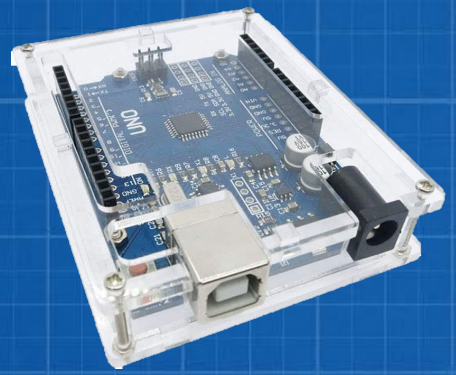
Piezo Speaker

https://www.amazon.com/gp/product/B00B0Q4KKO

Misc Components

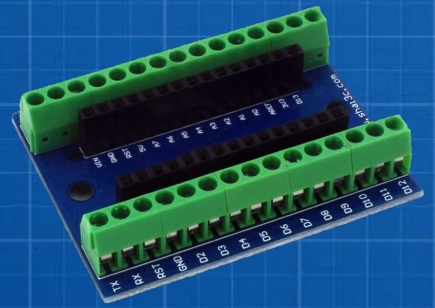
Back power switch SPST

https://www.amazon.com/gp/product/B08XBTJ8H6



Arduino UNO Case

https://www.amazon.com/gp/product/B07X5H4NGR



Arduino Nano Terminal Shield

https://www.amazon.com/gp/product/B07K8KM583

Materials/Equipment

- **Box**
  - Recommend size (L x W x H): 7"(175mm) x 5"(125mm) x 5"(125mm) at a minimum
  - I made my own but you can find craft boxes at Amazon or craft store. Just remove the latch(es) if any
- **22AWG wire**
  https://www.amazon.com/gp/product/B07GD2BWPY
- **If using an UNO these are handy for plugging directly into headers:**
  https://www.amazon.com/gp/product/B07GD2BWPY
- **Zip ties**
- **Heat shrink tubing of various sizes**
- **Standoffs for Nano terminal shield**
  https://www.amazon.com/gp/product/B00R4ZT1FY
- **1/4" plywood for servo arm and lid lift**
- **Soldering equipment**
- **“Cuddle Bracelet” from WalMart**

Adhesives

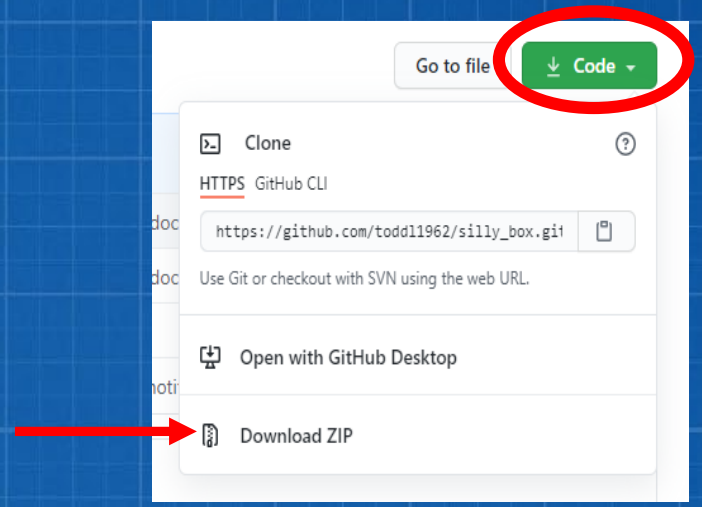
- Glue gun
- Liquid nails (or epoxy)
- Medium CA and accelerator
- Other adhesive of choice

Construction: Arduino Programming

- **Installing the Arduino IDE**
  - ✓ Navigate your browser to: https://www.arduino.cc/en/Guide/ArduinoUno
  - ✓ Follow the directions for using the Arduino Web IDE:
    https://create.arduino.cc/projecthub/Arduino_Genuino/getting-started-with-arduino-web-editor-on-various-platforms-4b3e4a
    or the Arduino Desktop IDE:
    https://www.arduino.cc/en/Guide/Windows
  - ✓ I recommend uploading the “Blink” example to verify that you can properly program and verify the board operation.
  - ✓ If you choose the Arduino Desktop IDE you will need to install the latest servo library using the IDE library manager. https://www.arduino.cc/en/Guide/Libraries

Construction: Arduino Programming

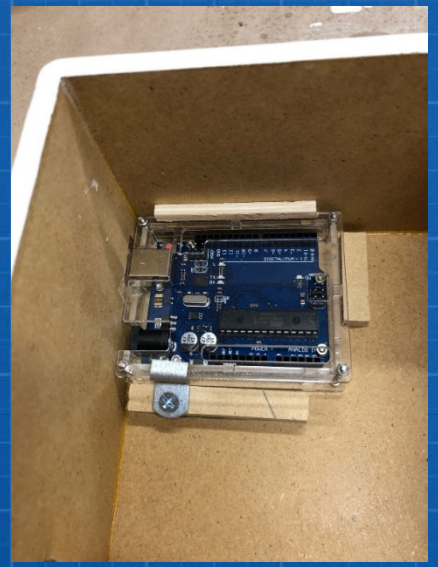
- **Downloading Silly Box Software from GitHub**
  - ✓ Navigate your browser to: https://github.com/toddl1962/silly_box
  - ✓ Click on the green box labeled “Code” and then click “Download ZIP.”
  - ✓ You will be presented with a “Save As” dialog with the “File name:” field set to ‘silly_box-main.zip’.
  - ✓ Save to your folder of choice.

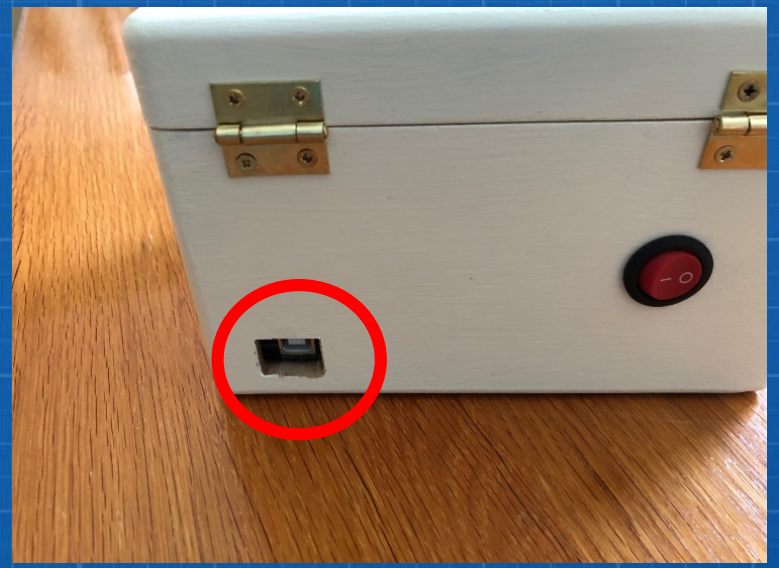


- **Uploading Silly Box Software to the UNO**
  - ✓ Extract the .zip file.
  - ✓ For the Arduino Desktop IDE navigate to the silly_box folder and double-click on the ‘silly_box.ino’ file.
  - ✓ For the Arduino Web IDE use the import function to bring in the sketch.
  - ✓ Build and upload the code like you did for the ‘Blink’ example.

Construction: Arduino Mounting

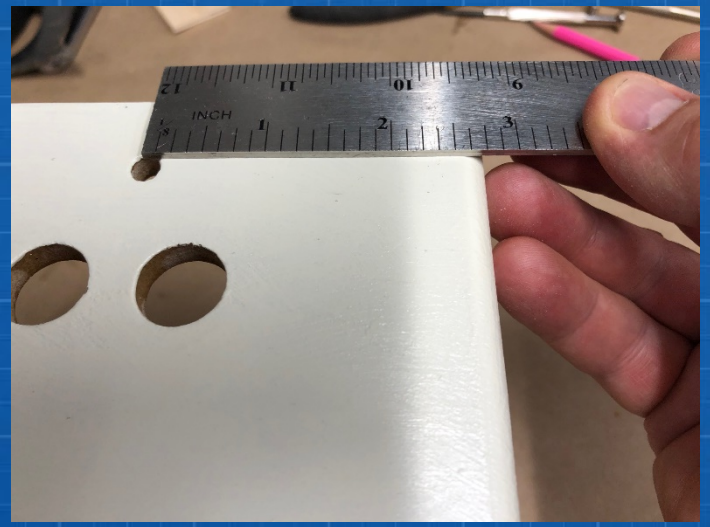
- ✓ I used an UNO case for protection.
- ✓ Scrap strips of wood were placed to “capture” the case.
- ✓ I fashioned a metal clip to secure the UNO and case.
- ✓ Alternatively, you can hot glue the case in although this will result in difficulty if the UNO needs to be removed.
- ✓ If you think you might want to reprogram the Arduino after construction you can create an access to the USB port on the back of the box as shown below.





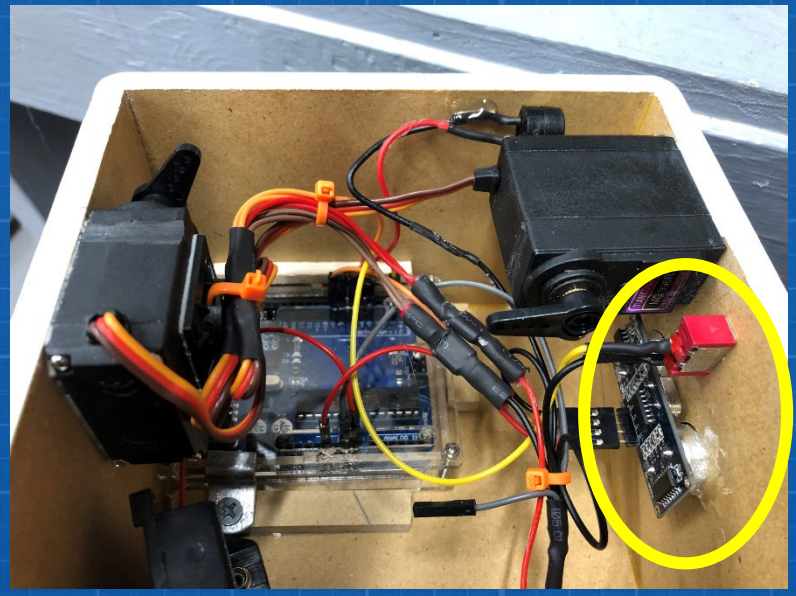
Construction: Front Switch Mounting

- ✓ About 2.75” from front right side and 0.75” from top edge. Your measurements don’t have to be exactly the same as long as the following criteria are met:
  1. The arm servo is mounted such that arm is aligned with switch
  2. There is enough room to the rear of the arm servo for the lid servo to operate without interference. This has more to do with the box size.



Construction: Sensor Mounting

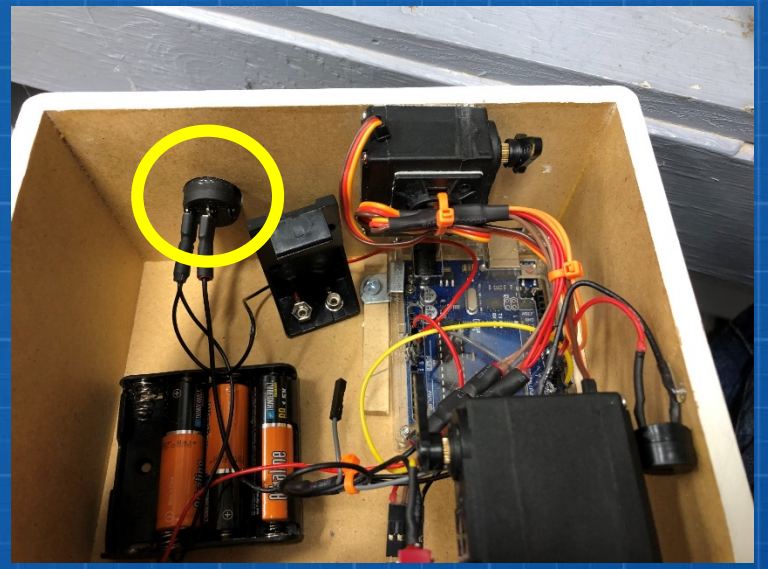
- ✓ Mount centered under the front switch and sufficiently below the front switch not to interfere with wiring the switch or the sensor. 1” is about right.
- ✓ I used hot glue to secure the sensor from the inside of the box.



Construction: Rear Power Switch Mounting

- ✓ If the power switch is loose in the hole then use hot glue from the inside of the box to secure it.
- ✓ If using an SPST switch then switch the COM (GND/-) leads from the batteries. If using DPST then switch individual battery positive (+) leads.

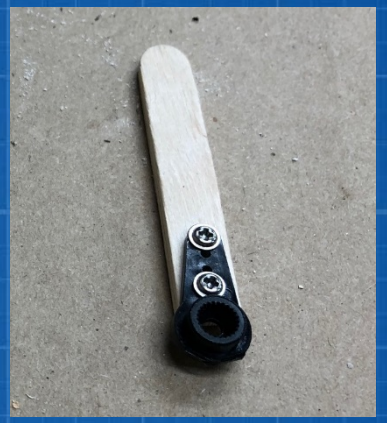
WARNING: Switching main power using COM is unconventional but since this is low power there is relatively little risk. DO NOT do this with high voltage DC or AC!!!



Construction: Lid Lever and Arm

- I used ¼” plywood for the arm and craft sticks for the lid lever
- I used the screws that would normally be used to mount the servos for attaching the lid lever and arm to the servo arms.

- **Lid Lever**
  - ✓ Glue 2 craft sticks together (I used medium CA with accelerator)
  - ✓ Cut the lever to 2 inches long
  - ✓ Use two screws to attach the lever to the servo arm. I drilled pilot holes for this.



- **Arm**
  - ✓ I used a band saw to cut out the arm. The diameter of the middle of the arm is the distance from the servo motor spindle to the middle of the switch lever. About 1.75”. I made the width of the arm about 0.75”.
  - ✓ Use two screws to attach the arm to the servo arm.

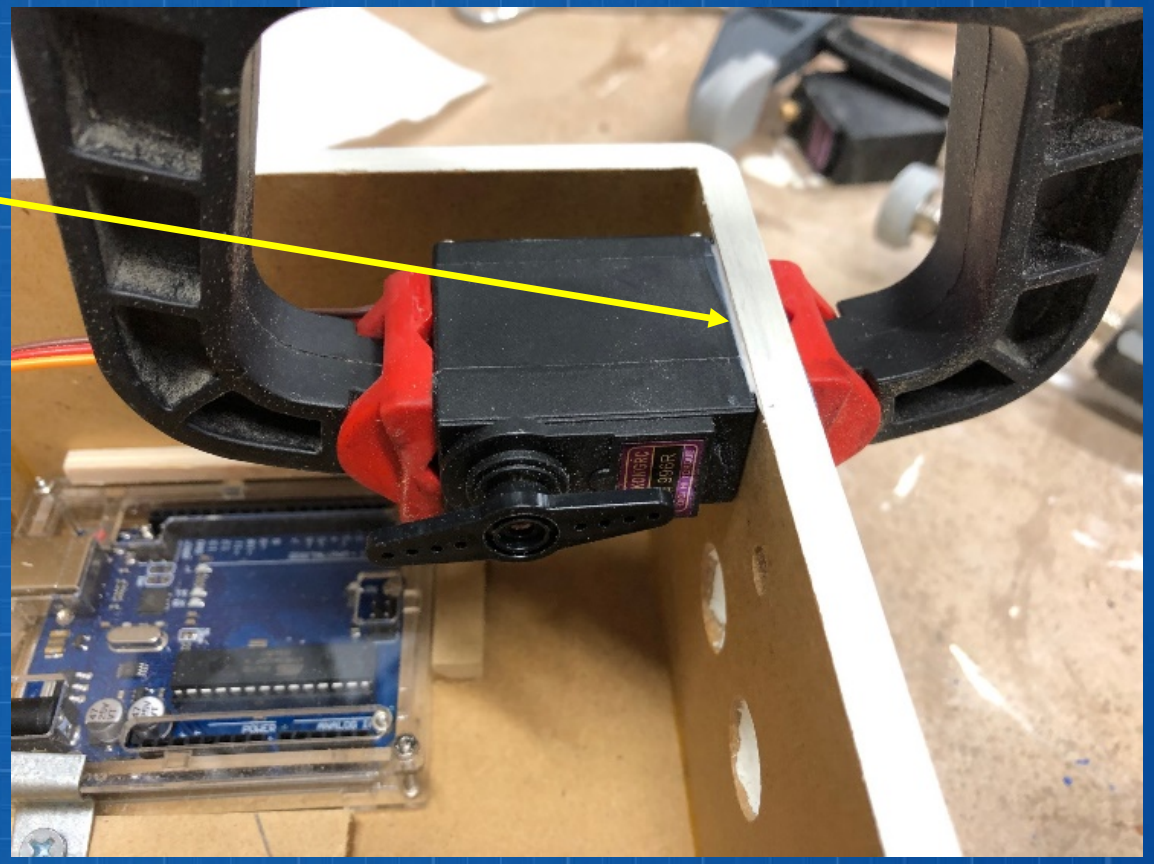
Construction: Servo Mounting

- ✓ Remove the mounting tabs from the servos. I used a band saw but a small handsaw or hacksaw would work.
- ✓ When installing the arm or lid lever servo horns you will have to press with quite a bit of force to get it fully seated.

- ✓ “Liquid Nails” or equivalent construction adhesive works very well for attaching the servos to the box.
- ✓ Lightly sand the surface to be glued.
- ✓ Make sure to clamp the servos securely while the adhesive dries.

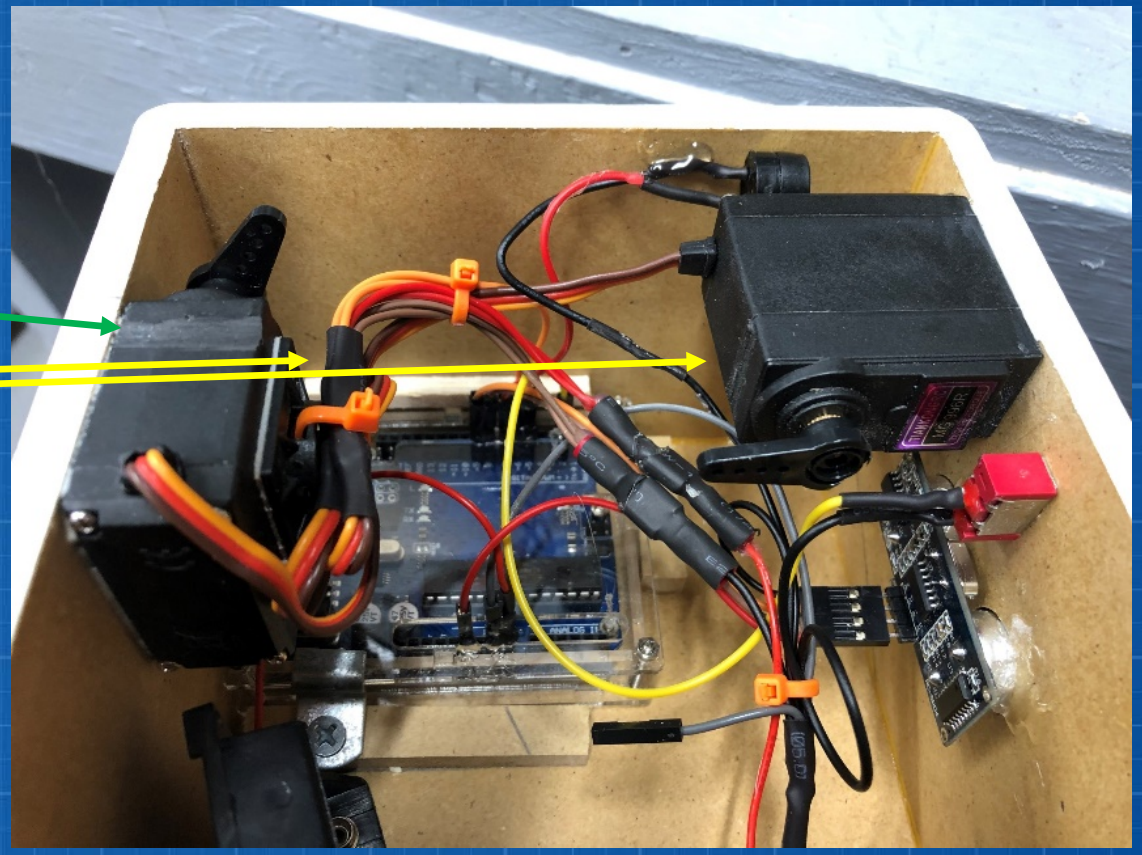
Construction: Arm Servo Mounting

- ✓ Note the orientation of the servo! The end face is glued to the box.
- ✓ Arm servo alignment:
  - ✓ If you have made the arm, attach it and ensure it aligns with the switch.
  - ✓ If you have not made the arm, attach a servo horn and the outside face of the servo horn should be 1/8” from the center of the front switch hole since the arm will be ¼” thick.



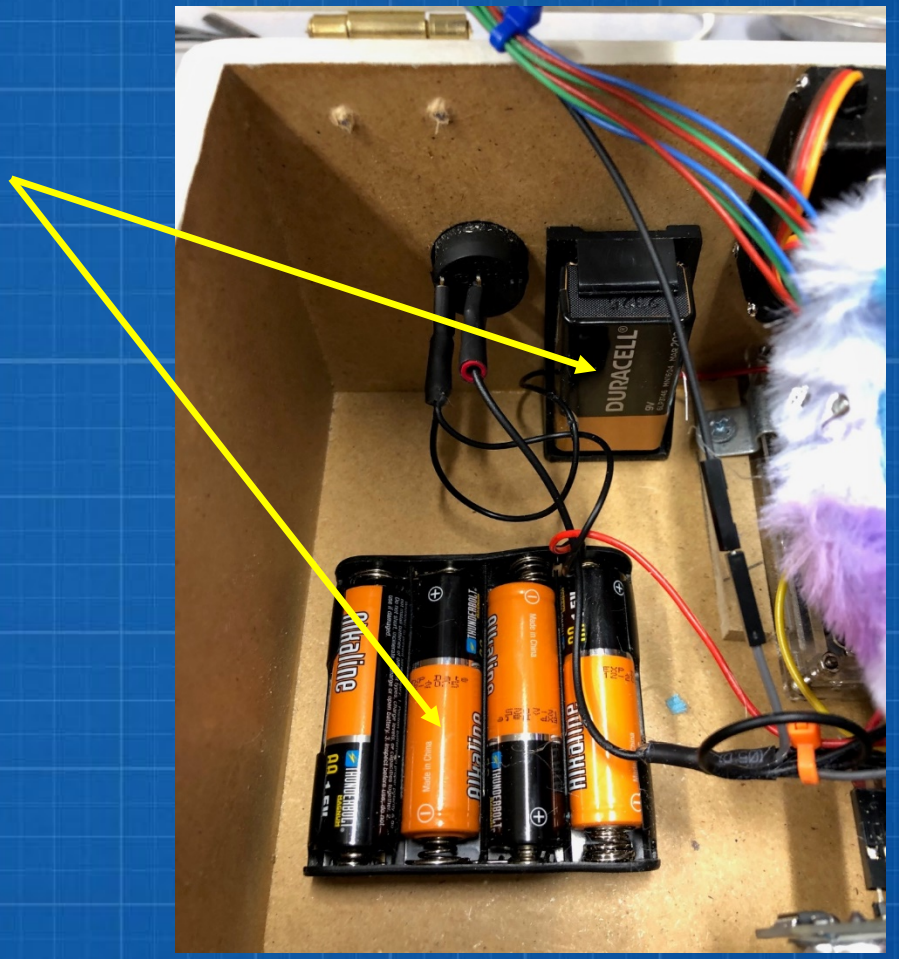
Construction: Lid Servo Mounting

- ✓ Note the orientation of the servo! The side face is glued with the servo spindle at the top and to the right side. The cable will exit the top in this orientation.
- ✓ There should sufficient clearance to accommodate a 2” long lid lever.



Construction: Battery Holders

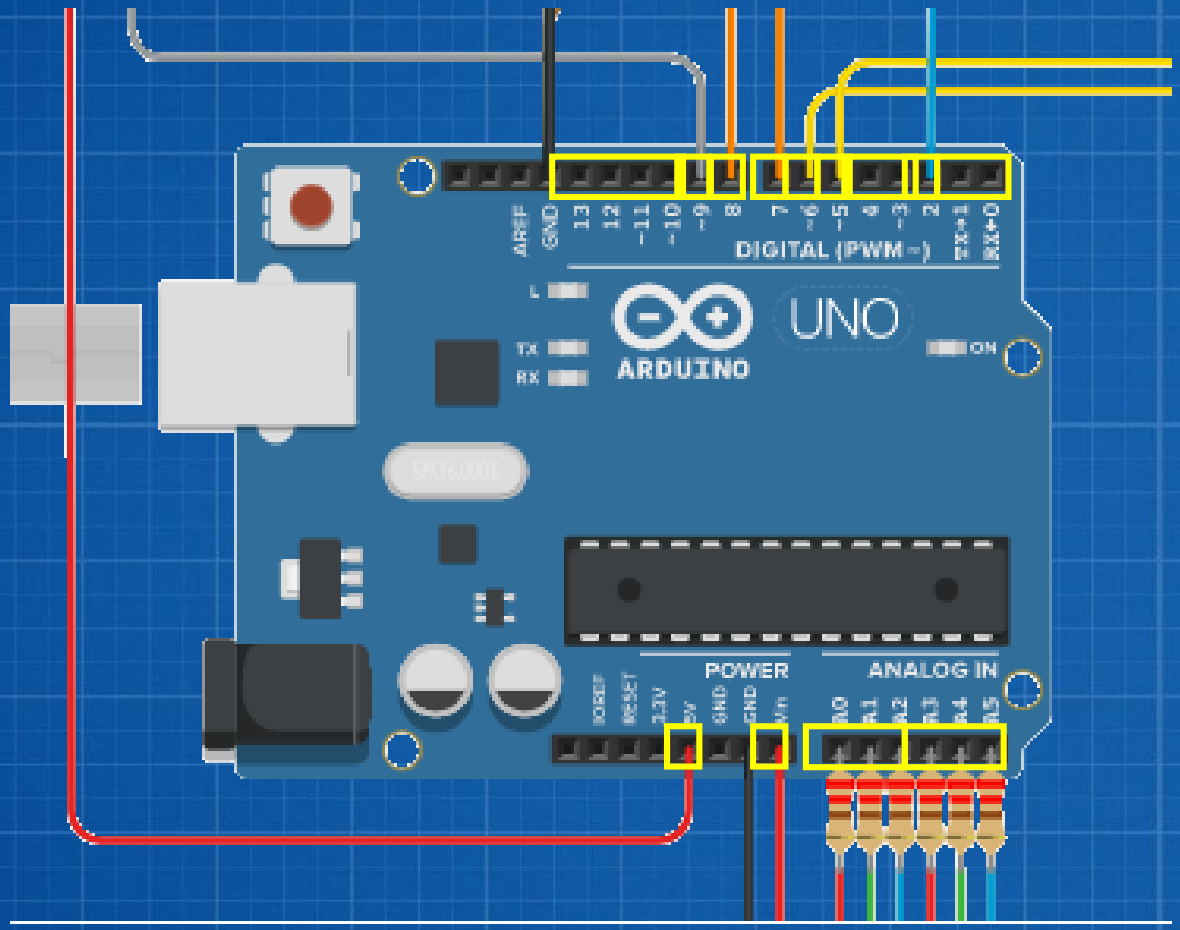
- ✓ I mounted the battery holders using hot glue to the inside of the box.
- ✓ This configuration worked well for me. Your box size might influence the placement of the holders.



Construction: Wiring

- Wiring is straightforward with respect to the connections.
- I did not specify wire lengths because you may find a better way to manage the wires.
- Wire management is important due to the moving parts. Wiring should not interfere with these movements.
- Wiring connections should be secure to avoid loose connections from shock.

Construction: Wiring



- *Pins 0, 1:* should not be used
- *Pin 2:* Front switch (On/Off)
- *Pins 3, 4:* not used
- *Pin 5:* Arm Servo (PWM)
- *Pin 6:* Lid Servo (PWM)
- *Pin 7:* Piezo speaker (frequency)
- *Pin 8:* Ultrasonic Trigger (10us pulse to trigger)
- *Pin 9:* Ultrasonic Echo (pulse width = round trip time)
- *Pins 10-13:* not used
- *A0, A1, A2:* RGB LED 1
- *A3, A4, A5:* RGB LED 2
- *Vin:* 9V from battery
- *5V:* Ultrasonic Sensor Power

Construction: Wiring

- **Common (Gnd) wiring**
  - ✓ I wired the common from both battery holders together and crimped onto a female spade connector that fits the rear power switch.
  - ✓ I created a common wiring harness with the following wires:
    1. Rear switch wire with female spade connector
    2. Servo common wire with female spade connector
    3. Front switch common wire soldered directly to front switch
    4. Ultrasonic common wire from the ultrasonic connector
    5. Piezo common wire soldered directly to Piezo gnd
    6. Arduino gnd wire with single male header pin
    7. LED common wire with single female header
  - ✓ I discovered when trying to manage the wires that wiring the harness with connectors for the rear switch, servos, and LEDs made it much easier to route the wiring and make adjustments before connecting those components.

Construction: Wiring

- **Positive wiring**
  - ✓ Install a female spade connector on the 4xAA holder positive lead. This will go to the servos.
  - ✓ Install a single male header pin on the 9V holder battery leader. This will go to the V_{in} on the Arduino.
- **Servo wiring**
  - ✓ I connected both positive leads to a male spade connector.
  - ✓ I connected both common (gnd) leads to a male spade connector.
  - ✓ Each signal lead should have a male header pin to connect to the Arduino.
- **Front switch wiring**
  - ✓ One terminal of the switch should be wired to the common wiring harness.
  - ✓ The other terminal should be wired with a male header pin to connect to the Arduino.

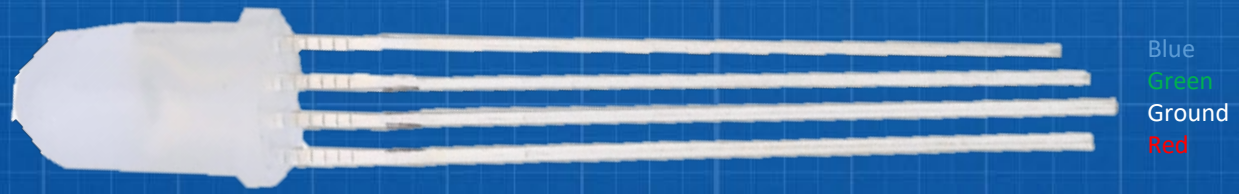
Construction: Wiring

- **Ultrasonic sensor wiring**
  - ✓ Most soldering can be avoided by using 3 male to female jumpers from the trig, echo, and V_{cc} pins to the Arduino.
  - ✓ I soldered a black jumper wire with a female header to the common harness.

- **Piezo Speaker**
  - ✓ Gnd terminal of the piezo should be wired to the common wiring harness.
  - ✓ The positive terminal should be wired with a male header pin to connect to the Arduino.

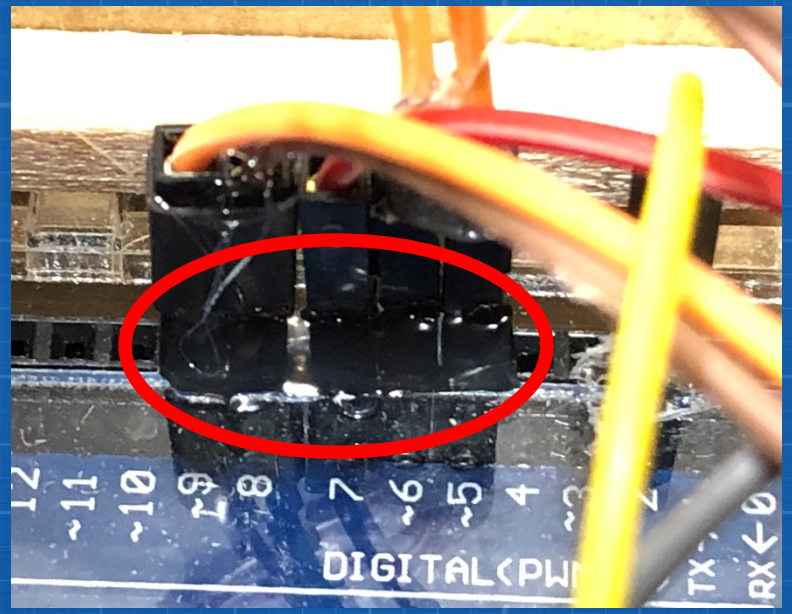
Construction: Wiring

- **LEDs**
  - ✓ I removed the eye buttons from the doll head, poked a hole from front to back for each eye. For each eye thread red, green, blue, and black wires through. These wires will eventually be terminated with RGB LEDs on one end and male header pins on the other.
  - ✓ Solder the resistors and wires sticking out of the front of the head to the red, green, and blue leads and the black wire to the ground. Don't forget to slip on the heat shrink tubing before soldering.
  - ✓ If you buy the LEDs that I did the wiring should match what I am showing here and you can use the resistors included in the package.
  - ✓ Now pull the wires from the back and use a small amount of hot glue to hold the LEDs in place for the eyes.
  - ✓ Solder the two black wires together to a male header pin.
  - ✓ Terminate the RGB wires at the back of the head with male header pins.



Construction: Wiring

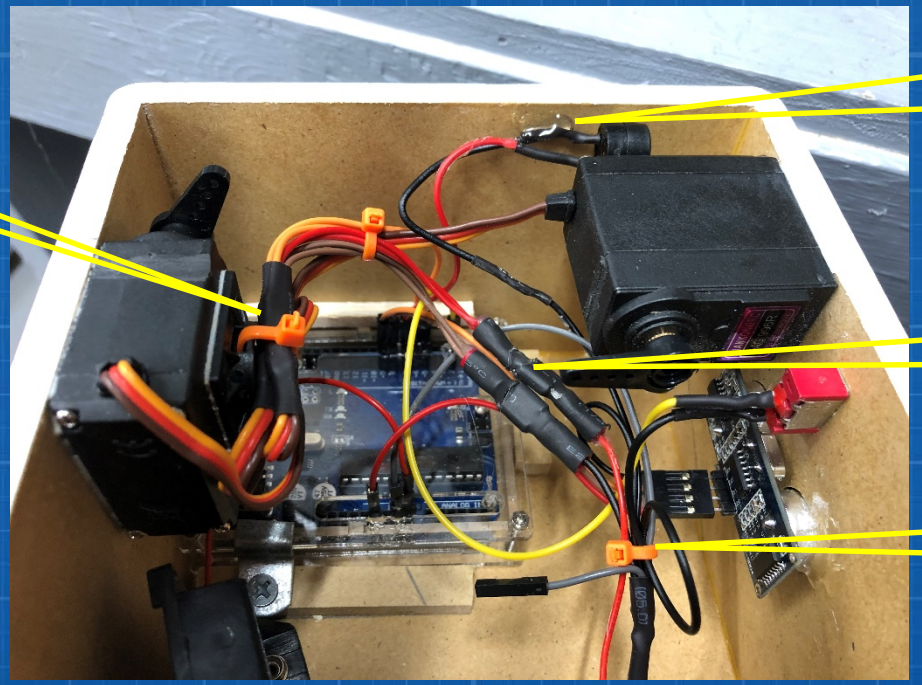
- **Secure Wire Connections to Arduino**
  - ✓ I used hot glue between the Arduino case and the header pin plugs.



Construction: Wiring

- **Wire Management**
  - ✓ I hot glued the piezo speaker to not interfere.
  - ✓ I used zip ties and hot glue to manage the wires.
  - ❖ LEDs connections to the Arduino are not shown.
  - ❖ Lid lever and switch arm are not shown.

Pull servo wires back to prevent interference with movement



Piezo speaker mounted out of the way

Servo power spade connectors

Common harness and positive leads

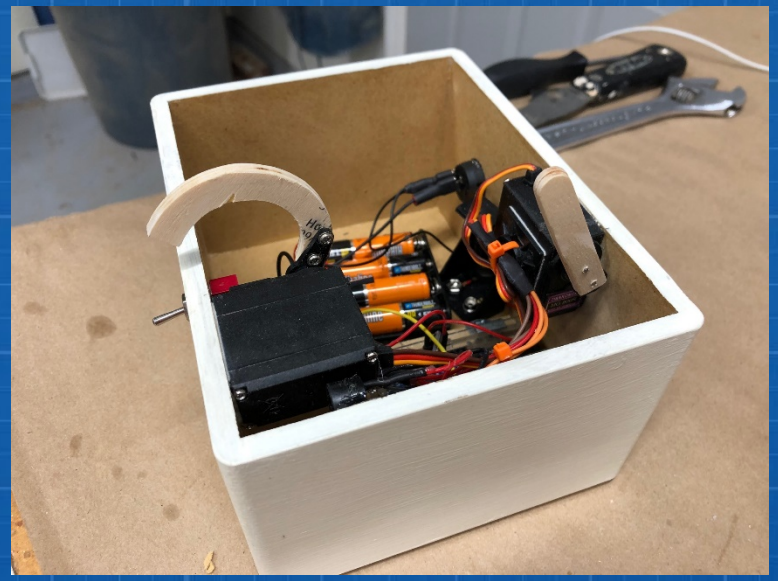
Construction: Doll

- I used a “Cuddle Bracelet” from WalMart. This is the Unicorn version and I like it because it has plastic eyes that can be pulled off and replaced with LEDs.

- ✓ Remove the head leaving excess material at the bottom.
- ✓ Fold over the excess material at the bottom of the head and hot glue to close up the hole.
- ✓ Remove the material from the wristband and save it to cover the arm on the arm servo.
- ✓ Refer to the LED slide in the wiring section to install the LEDs in the doll.

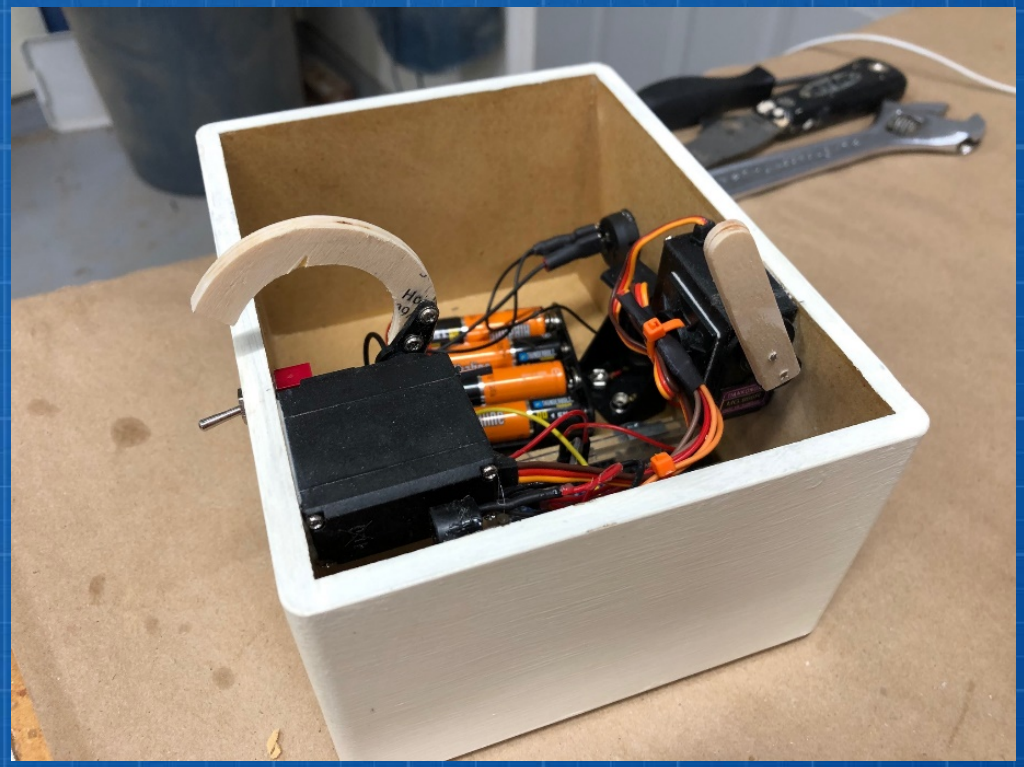
Construction: Installing Lid Lever and Arm

- ✓ Place the Arduino in test mode
  1. Jumper pin 11 to ground
  2. Power the box up
  3. Both servos should move to their fully extended position (e.g., lid is open and arm is fully depressing switch)
- ✓ Using the Doll head to judge what “fully open” is place the lid lever on the servo motor spindle so it holds the lid open. Also make sure the arm clears the lid.



Construction: Installing Lid Lever and Arm

- ✓ Place the arm on the arm servo motor spindle so it fully depresses the switch.
- ✓ Remove the pin 11 jumper and cycle the power on the box.
- ✓ Test the box by turning the switch on and ensuring the lid opens and the arm turns the switch off. Random sequences are chosen so some take longer than others.
- ✓ Make sure light and sound work.
- ✓ Make sure when you try to turn the front switch on the lid randomly opens and emits a sound and turn LEDs on. This may take a few tries since the software only randomly executes a sequence when your hand is detected.



Construction: Installing Doll and Arm Cover

- **Installing Doll**
  - ✓ Cut two slits on the top of the doll head and threaded a cable tie through.
  - ✓ Stick a cable tie mount on the left side of the lid and attach the doll using the cable tie.

- **Installing Arm Cover**
  - ✓ Cut the cloth off of the wristband and use it to cover the arm.
  - ✓ Cut off any excess material and hot glue the cloth on the spindle side of the arm.

YOU ARE DONE!!!