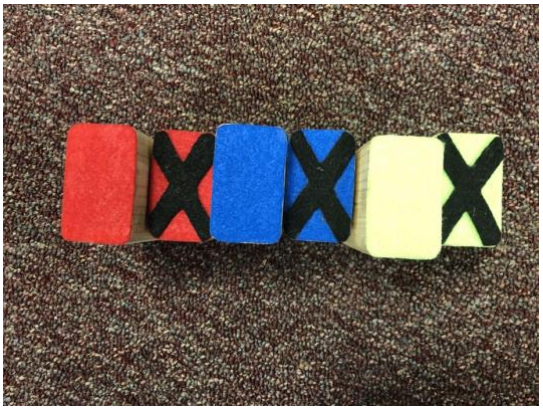
User Manual

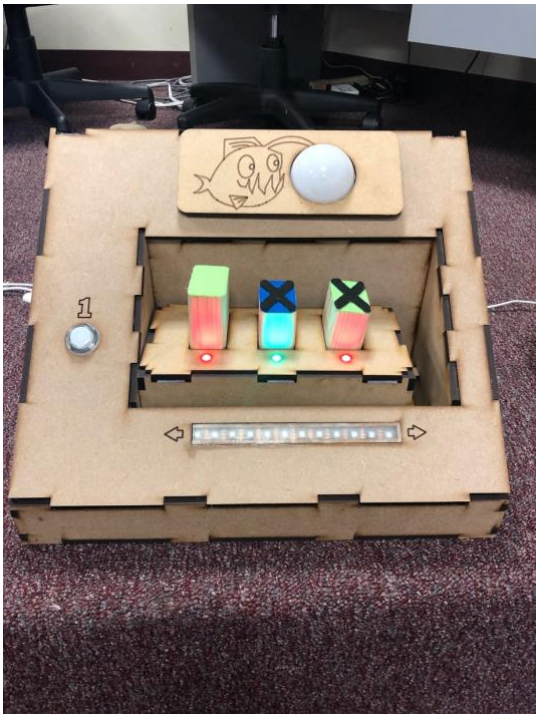
Overview

CRISPEE is a tangible toy created by Wellesley College's Human-Computer Interaction Lab in collaboration with Tufts University's DevTech Research Lab to teach children ages five through seven about the principles of bioengineering. CRISPEE has gone through several design iterations, and this guide focuses on the latest: Emu. In our introduction of bioengineering concepts to these young kids, CRISPEE was a tool used to solidify the idea of inhibitor and activator genes.

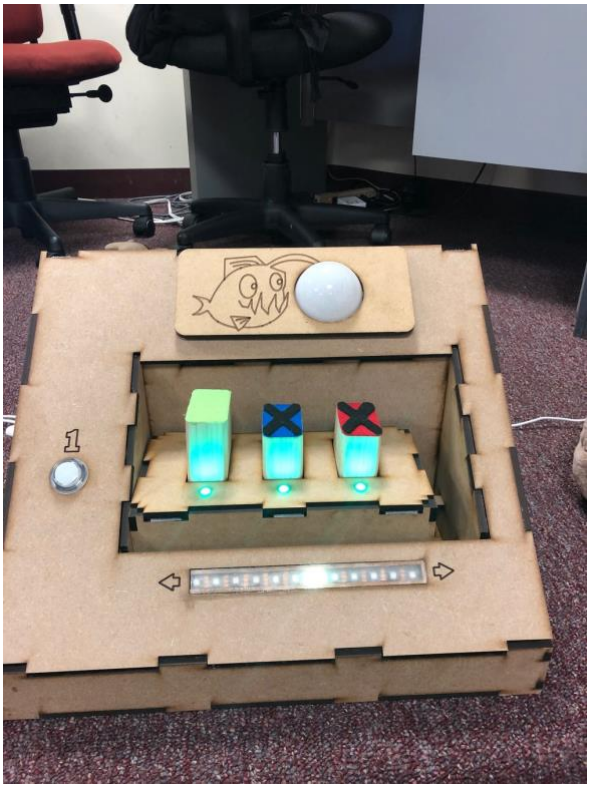
In this toy, six blocks are available to the kids to create their own color combinations. Two blocks are colored red, two are blue, and two are green. In each set of two, one block just has the color on the top and the other has a black 'X' over the color. The plain color block indicates that that block will express that color in the program, while the 'X' block indicates that the block will suppress that color.



There are multiple versions of CRISPEE available. Each version has a slightly different arrangement of buttons for the kids to interact with but accomplishes the same educational goal. The pictures included in this section are all of CRISPEE version 3, but the method of interaction is very similar across all of the versions. Kids form a combination of three of the six available blocks, place their combination in the mixing platform of CRISPEE, and press the button on the toy to see if their combination is a valid. If the lights under the blocks flash green the combination is valid, and if they flash red it is invalid. Invalid block combinations are combinations of either less than three blocks, or combinations that suppress and express the same color. For example, a combination containing the Green block and the GreenX block would be invalid and the lights under these two blocks would flash red.



When an invalid combination is entered, new combinations can be placed in the mixing platform and authenticated until one is deemed valid. Once this happens and all of the lights under the blocks are green, kids can slide the mixing platform back and forth.



Once the program has been “mixed” sufficiently, row of LEDs under the mixing blocks flashes bright green and the big colored light on the top of CRISPEE displays the result of the program.

Combinations Result Options

The output color from these combinations will be the same across all versions of CRISPEE.

Blocks Used	Output Color		Blocks Used	Output Color	
RedX, BlueX, GreenX	No color		RedX, BlueX, Green	Green	
Red, Blue, Green	White		Red, Blue, GreenX	Purple	

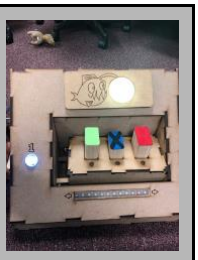
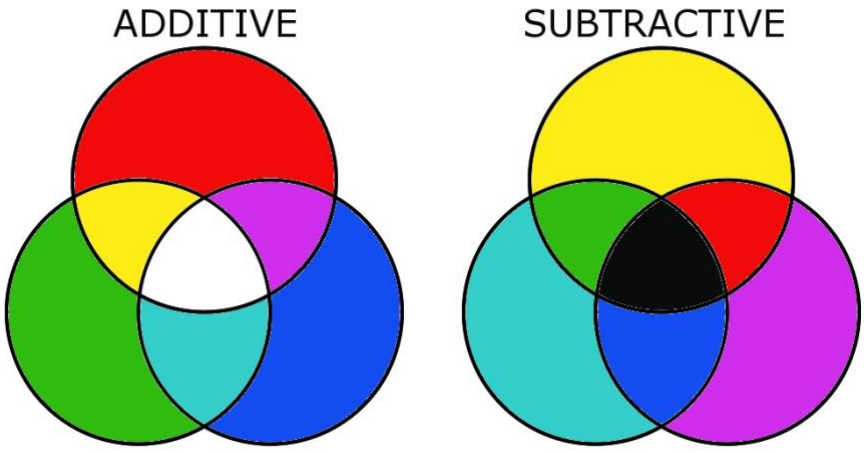
Red, BlueX, GreenX	Red		Red,BlueX, Green	Yellow	
RedX, Blue, GreenX	Blue		RedX, Blue, Green	Cyan	

Table 1. The above table shows the colors that will be expressed by different mixing block combinations. The colors expressed are the result of additive mixing. Additive mixing is how colors interact when lights of different wavelengths are "mixed". Subtractive mixing is how colors interact when different materials are mixed such as crayons or paints. Refer to the below graphic for more explanation of this.



(https://lucaskrech.com/blog/index.php/2010/01/22/color-theory-basics-additive-and-subtractive-color-mixing/)

Construction Guide

Materials List

Item	Instruction Section	Link or Specifics
Arcade Button	B	https://www.adafruit.com/product/471?gclid=EAIaIQobChMI39zNy57w3wIVycDICh1OKgPjEAQYASABEgIzrPD_BwE
Block LEDs	B	ttps://www.adafruit.com/product/1734
Arduino Nano	B	https://store.arduino.cc/usa/arduino-nano
Contact Adhesive	A, B, G	https://www.amazon.com/Amazing-GOOP-140211-Purpose-Adhesive/dp/B008AF1NHQ/ref=pd_lpo_vtph_60_tr_img_2?_encoding=UTF8&psc=1&refRID=J2310N6YHZCTZH5RHC06
Velcro	A, C, E, G	https://www.amazon.com/Strenco-Adhesive-Black-Sticky-Fastener/dp/B00FQ937NM
Wires	B, E	https://www.amazon.com/Electronix-Express-Hook-Wire-

		Solid/dp/B00B4ZRPEY/ref=sr_1_7?ie=UTF8&qid=1520019671&sr=8-7&keywords=hookup+wire
Conductive velcro	A, C, E	https://www.adafruit.com/product/1324
Conductive Thread	A, C, E	https://www.adafruit.com/product/641
Planks for the blocks	A	2” x 3” plank (higher quality lumber than MDF)
Resistors	B, C	https://www.amazon.com/30Value-600PCS-Ohm-1M-Resistor-Assortment/dp/B01N0RGA3O/ref=sr_1_5?s=electronics&ie=UTF8&qid=1519753474&sr=1-5&keywords=resistors • (1) 1.0 kΩ • (1) 2.2 kΩ • (1) 3.3 kΩ • (1) 4.7 kΩ • (3) 5.1 kΩ • (1) 6.8 kΩ • (1) 10 kΩ
Wire connector terminal block	B	• 1x8 block • 1x4 block
Felt	A	Different colors for blocks(red, blue, green, and black)
Ring connectors	B, D, E	Around 40 needed
Enclosure Wood	A, E, G	(2) 2’ x 4’ ¼” thick MDF, cut to size for laser cutter (1) 2’ x 2’ ½” thick MDF Extra for block ends
Ornament for large light	B	https://www.amazon.com/UNIQLED-Plastic-Fillable-Christmas-Ornament/dp/B01GFW8HPQ/ref=sr_1_3?ie=UTF8&qid=1519751904&sr=8-3&keywords=clear+christmas+ornaments+fillable+70mm
Wheels	E	4, 1 inch wheels
Mixing LED strip	B	https://www.adafruit.com/product/2842?length=1
NeoPixel Jewel	B	https://www.adafruit.com/product/2226

light		
Force Sensor	B	https://www.amazon.com/Bolsen-Tech-Pressure-Resistance-Resistor/dp/B07L6LVR7G/ref=sr_1_1_sspa?keywords=force+sensor&qid=1573841263&sr=8-1-spons&psc=1&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUExT1lFMkVIVEhTTjNKJmVuY3J5cHRlZElkPUEwMDM4MDgyMjRKM1lBWFZaMDVTMiZlbmNyeXB0ZWRBZElkPUEwOTc2MzkzM0VKMlU0M1ZSWTZEMSZ3aWRnZXROYW1lPXNwX2F0ZiZhY3Rpb249Y2xpY2tSZWRpcmVjdCZkb05vdExvZ0NsaWNrPXRydWU=
Solder	A, B	Generic tin lead solder for connecting metal components
Heat Shrink	B, C, D, E	(Want final diameter of .2 in, start with a diameter above .42 in)
Breadboard	B	https://www.amazon.com/MCIGICM-6PCS-tie-Points-Breadboard-Arduino/dp/B07PZXD69L/ref=sr_1_13?keywords=breadboard&qid=1573843405&s=industrial&sr=1-13 (only need one of this style)

Table 2. Material list for crispee V3

Table of Contents

Section A

Block Making Guide

- *This is a guide on creating the gene blocks for CRISPEE Emu. Roughly, making gene blocks involves the cutting and shaping of the wood and the sewing and gluing of the felt and conductive sewables. Refer to the sewing guide for an in-depth look at constructing the sewn circuits that complete the gene block and mixing platform. This section relates to all CRISPEE versions.*

Cutting the Blocks

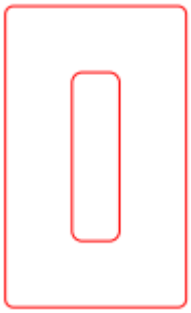
Blocks come in two sizes: 3 ½ inches tall and 2 ¾ inches tall. Both are about 2 ⅜ inches wide and 1 ⅜ inches thick. These measurements exclude the end cap, conductive sewables, and felt. To cut the blocks:

1. Measure out 3 x 3 ½ inch segments and 3 x 2 ¾ inch segments on a wooden beam, 2 ⅜ inches wide and 1 ⅜ inches thick, and of higher quality lumber than MDF.
2. Cut the beam completely through at each of these measurements, with any tool from a milling machine to a handsaw

Cutting and Gluing End Caps

We glue an end cap to the bottom of the block. The cap is ¼ inch thick MDF wood, laser cut to our specifications. We need this end cap to provide a space for the resistor to be, since the block wouldn't sit flatly in the mixing platform with the conductive Velcro circuit glued to the flat bottom.

The Illustrator file for the end cap looks like this:



To cut the end caps:

1. Ensure your through-cut lines are standardized
2. Export the Adobe Illustrator file to your home laser cut job management software
3. Ensure your laser engraver settings are standardized for a through-cut on MDF for the color and line weight you used in Illustrator
4. Lay a sheet of ¼ inch thick MDF in your laser engraver. We used a Trotec Laser Engraver.
5. Start the job and monitor the engraver

You'll want to keep the cutouts from the middle of the end caps, because these make great glue spreaders.

We use industrial glue for most major joints on CRISPEE Emu, and the attachment of end caps is no exception

To attach the end cap to the block:

1. Place a line of industrial glue around the hole in the middle of the end cap
2. Use the leftover wood from cutting out the end cap from the MDF to spread the glue evenly across the cap
3. Press the end cap onto the face of the block that will be the bottom. Make sure the cap is centered as much as possible. You'll know if you've added enough glue if it leaks out of the sides as you press the cap on. Scrape the excess glue away.
4. Let the block sit for several hours while the glue dries, checking that the cap is still centered

Sanding the Blocks

At this point, the end caps may be wider than the block itself and the block is rough around the edges.

We'll polish up the blocks by sanding them down. See this video for a demonstration on sanding. We use a belt sander, but the same result is achievable with some sand paper and some elbow grease.

To sand down the blocks on a belt sander:

1. Hold each longer face of the block against the sander, moving the block back and forth so that the motion is parallel to the longer sides of the block face. This will sand down the splintery parts of the block face and remove the excess width of the end cap
2. Lightly touch the sharp corners of the block to the sander to remove the worst of the angularity
3. Roll the block from one face to the next on each corner, to thoroughly round out the shape

Sewing the Block Side of the Circuit

CRISPEE Emu recognizes blocks because each resistor sewn into each block has a unique resistance. We have to build a circuit through the bottom of the gene blocks. To form a connection between the mixing platform and the gene blocks, we sew conductive Velcro to felt

on one side, sew a resistor to the other side of the felt, and connect these components with conductive thread sewn into the felt.
See the sewing guide for a step-by-step introduction to the creation of the circuits necessary to make blocks recognizable to CRISPEE Emu

Attaching the Circuit

After the conductive Velcro and resistor have been sewn and connected, they can be attached to the block(Section C)

1. Place the block so that the bare face is down, and the end cap is up
2. Dribble a thin line of industrial glue around the hole in the middle of the end cap
3. Use the leftover wood from cutting out the end cap to spread the glue evenly across the cap
4. Ensure that the resistor is centered over the hole in the end cap, and the conductive Velcro pieces are over each end of the end cap
5. Gently stretch the felt over the glue-covered end cap
6. Leave it to dry for several hours
7. Trim the felt down to the edges of the block using fabric scissors.

Indicating Activators and Inhibitors

Tall blocks are activators and short blocks are inhibitors. There is one activator and one inhibitor for each of the three colors: red, green, and blue. To make an activator:

1. Cut a 3 inch by 2 inch rectangle of felt of the desired color
2. Place the block end cap side down
3. Dribble industrial glue over the bare face of the block
4. Use the spare wood from cutting the end caps to spread the glue evenly over the block face
5. Center the section of felt over the glue-covered face of the block
6. Gently stretch the felt over the glue-covered face of the block
7. Leave the block standing for several hours so the glue can dry

8. Trim the felt down to the edges of the block

To make an inhibitor, follow the same steps as for an activator, but in addition:

1. Cut a 3 inch by 2 inch rectangle of black felt
2. Cut the felt rectangle so it makes a big X, with each stroke of the X about half an inch wide
3. Dribble industrial glue over the colored felt on the top face of the inhibitor block in an X shape, the strokes of the X going to opposite corners
4. Spread the industrial glue with the extra MDF from the end cap so it coats the whole area that the felt X will occupy
5. Center the X over the top face of the inhibitor block
6. Gently stretch the felt X over the industrial glue
7. Leave the inhibitor block to dry for several hours
8. Trim the felt X down to the edges of the inhibitor block

Section B

Electronic System Assembly Guide

- *CRISPEE's full electronic assembly is detailed here. It is assumed that you have already completed the steps in the Soldering Guide and have already completed the Base External Shell and the Internal Wall steps of the Wooden Shell Assembly Guide. This section relates only to CRISPEE 3 unless otherwise stated*

Arcade Button

To attach the button:

1. Sit the arcade button in the circular cutout on the left side of CRISPEE's face
2. Screw the black plastic nut onto the portion of the button sticking into CRISPEE's internal space

Lantern

*Lantern installation will be the same for all versions of

To create the light diffusion dome:

1. Paint the inside of an x inch wide acrylic dome with a moderate layer of white acrylic paint
2. Let the paint dry
3. Sand down the coat of paint so it's smooth and even

To attach the Neopixel Jewel that will light the faceplate lantern:

1. Thread the Jewel's leads through the hole at the top of CRISPEE's face
2. Spread industrial glue over the back of the Jewel
3. Press the Jewel down into CRISPEE's face so that the face plate will be centered over the platform opening (the Jewel will be sticking out of the hole in each face plate)
4. Dribble a thin line of glue over the base of the acrylic light diffusion dome
5. Press the dome down over the Jewel, ensuring the faceplate will still be centered over the platform opening

Connecting All the Pieces

After the systems have been assembled and each electronic piece is glued to its place on CRISPEE, it's just a matter of attaching the right lead or ring connector to the right pin or terminal block. To attach a ring connector to a terminal block:

1. Thread a screw through the ring connector
2. Bolt the screw into the terminal block

Lead and pin matchups are detailed below. If a lead is omitted in the chart, it remains disconnected, possibly covered with electrical tape for safety. If a lead connects to a terminal block, crimp a ring connector onto the lead to ensure a more secure connection. Refer to the Crimping Guide for instructions on crimping a ring connector onto these leads

Arcade Button Lead	Attach To
Button Data	Pin 5 on Arduino Uno
Button LED	Pin 4 on Arduino Uno
Button Ground	GND on 4-width terminal block
Button LED Ground	GND on 4-width terminal block

First 8mm Mixing Platform LED Lead	Attach To
Data in	Pin 10 on Arduino Uno
Data out	Data in lead of second mixing platform LED
+5V	+5V on 8-width terminal block

Ground	GND on 8-width terminal block

Second 8mm Mixing Platform LED Lead	Attach To
Data in	Data out lead of first mixing platform LED
Data out	Data in lead of third mixing platform LED
+5V	+5V on 8-width terminal block
Ground	GND on 8-width terminal block

Third 8mm Mixing Platform LED Lead	Attach To
Data in	Data out lead of second mixing platform LED
+5V	+5V on 8-width terminal block
Ground	GND on 8-width terminal block

Mixing Indicator LED Strip Lead	Attach To
Data in	Pin 7 on Arduino Uno
+5V	+5V on 4-width terminal block
Ground	GND on 4-width terminal block

Force Sensor Lead	Attach To
Data out	Pin A5 on Arduino Uno
Ground	GND on Arduino Uno

Lantern Jewel Lead	Attach To
Data in	Pin 11 on Arduino Uno
+5V	+5V on 4-width terminal block

Ground	GND on 4-width terminal block

Block Sensor 1 Lead	Attach To
+5V	+5V on terminal block
Data out	Split between ground and analog
Ground	5.1 kΩ resistor → GND on terminal block
Analog	Pin A0 on Arduino Uno

Block Sensor 2 Lead	Attach To
+5V	+5V on terminal block
Data out	Split between ground and analog
Ground	5.1 kΩ resistor → GND on terminal block
Analog	Pin A1 on Arduino Uno

Block Sensor 3 Lead	Attach To
+5V	+5V on terminal block
Data out	Split between ground and analog
Ground	5.1 kΩ resistor → GND on terminal block
Analog	Pin A2 on Arduino Uno

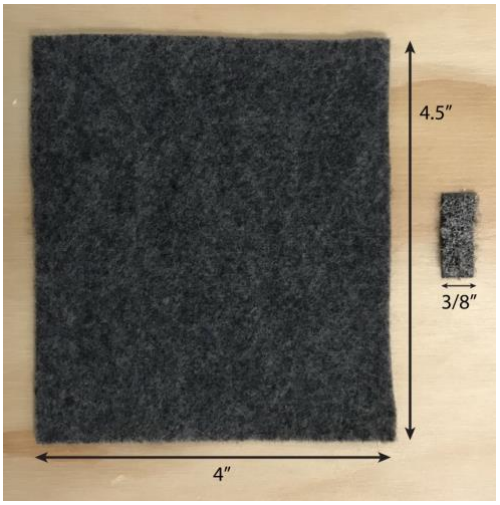
Section C

Sewing Guide

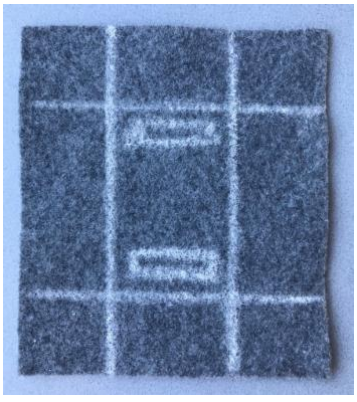
- *In this sewing guide, the process has been divided into two separate sections: first, sewing the block pads, and second, sewing the sensor pads. However, each of these sections have the same three parts: 1) cutting and marking, 2) sewing velcro, and 3) adding electronics. Therefore, it is possible to build both the block pads and the sensor pads at once, if you'd prefer to condense the steps. Parts 1 and 2 (cutting and sewing) are very similar for both pads. This section applies to all versions of CRISPEE.*

Block Pads, Part 1: Cut and Mark

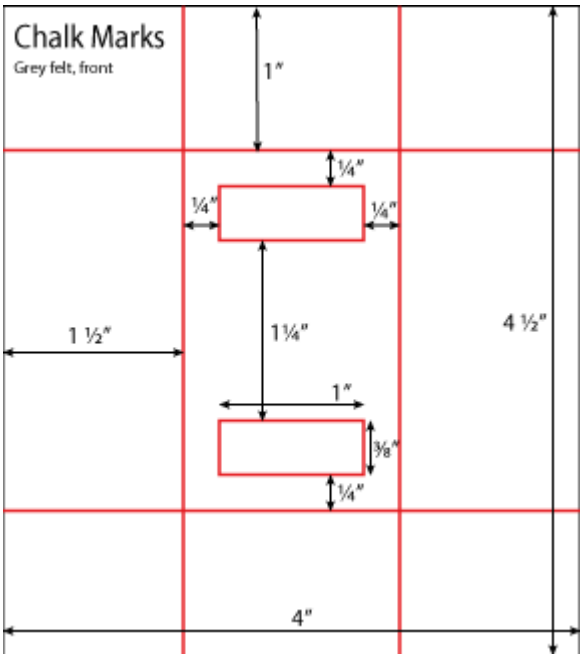
The felt will be cut much larger than necessary because it is essential that the felt is not too small. The overall size of the diagrams represents the whole felt pad, even though most of this is excess.



Cut a 9" x 12" sheet of grey felt into 6 rectangles (each 4" x 4.5")
Cut loop velcro (soft side) into ⅜" strips (12 total)

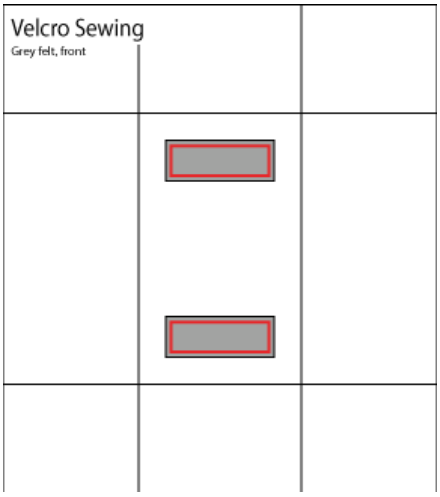


Based on the diagram below, use chalk to mark the edges of the final felt square and the edges of the velcro placement. These marks will only be made on the front side, leaving the back blank. Repeat with all 6 grey felt swatches.



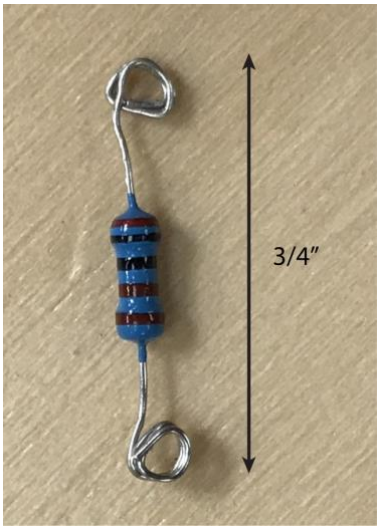
Block Pads, Part 2: Sew Velcro

Following the chalk markings that were made in the previous step, sew the loop velcro into the grey felt. Sew along all four edges of the velcro for a secure connection (see diagram below for stitch locations). This will be easiest and fastest with a sewing machine, yet hand sewing is also an option. Repeat with all six grey felt swatches.



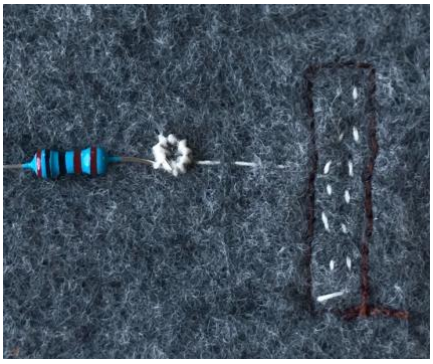
Block Pads, Part 3: Add electronics

In this step, the resistors need to be curled so that the wires form a secure loop on each end. This allows them to be sewn into the felt.



Using needle nose pliers, curl the ends of each resistor. The overall length doesn't need to be too precise; anywhere close to ¾" is fine. See the video below for an example of what this process will look like.

Next, sew the curled resistors to the back side of the block pads (the side without velcro). Unlike the velcro sewing, this must be done by hand.



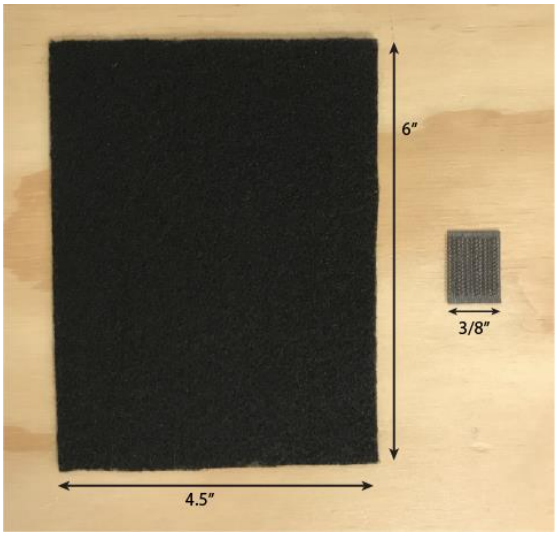
First, attach one end of the resistor to the felt by sewing multiple stitches around the resistor wire loop that was just created.

Next, once the resistor loop is securely in place, stitch up along the felt into the velcro. Sew back and forth along the velcro to ensure a secure connection.

Using the same process, sew the second end of the resistor to the other velcro patch.

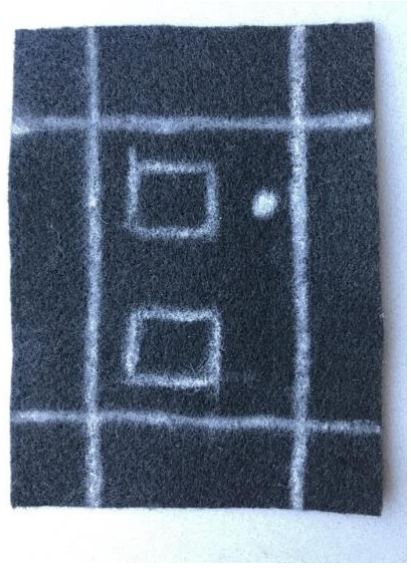
Repeat with the 5 other resistors.

Sensor Pads, Part 1: Cut and Mark

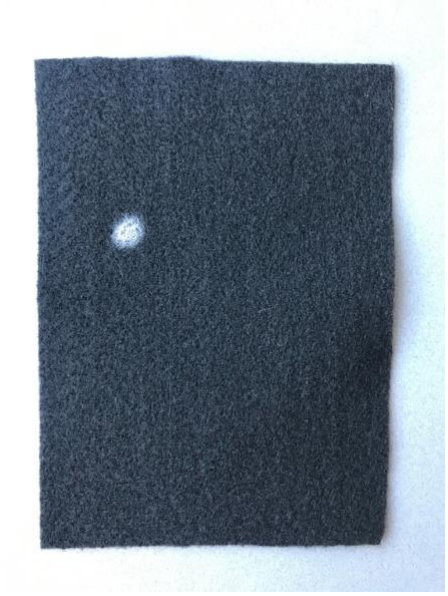


Cut 9” x 12” black felt into 4 rectangles (4.5” x 6”). Only 3 will be used, but this will produce an extra In case it is necessary
Cut hook velcro (rough side) into ¾” strips (6 total)

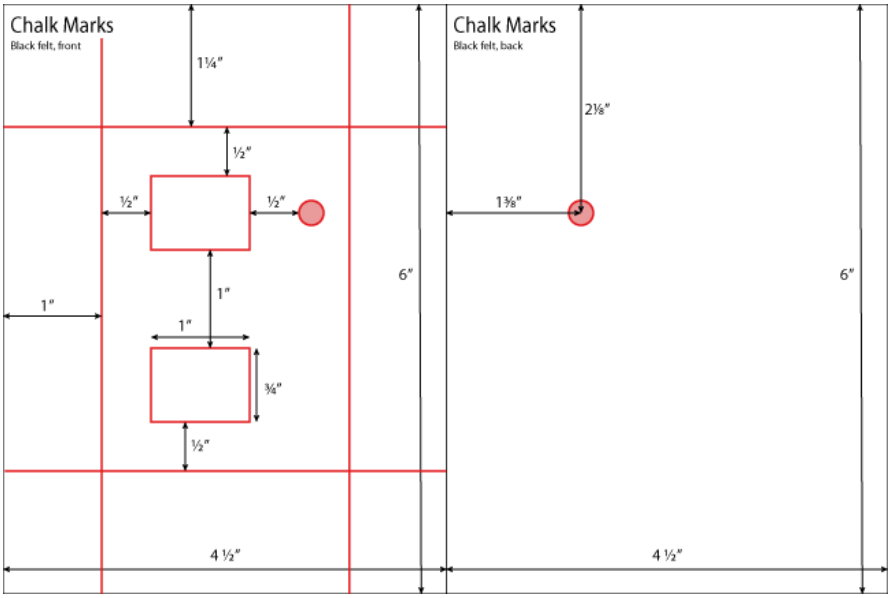
Front:



Back:

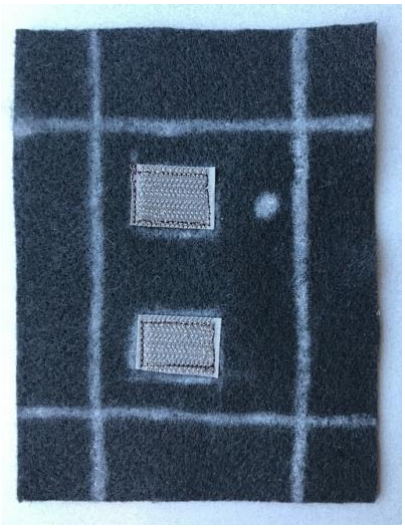


Based on the diagram below, use chalk to mark the edges of the final felt square and the edges of the velcro placement. Repeat twice more (you will have three total marked swatches).

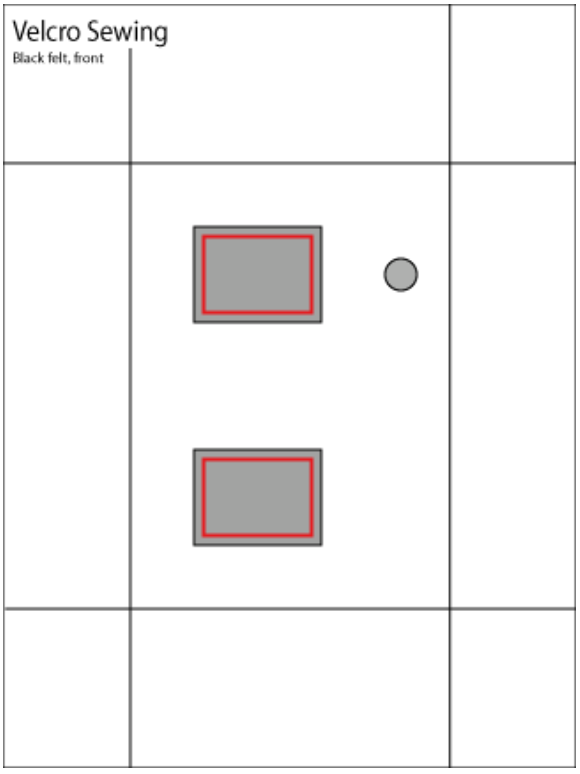


**The red dot should be marked in the same location, front and back*

Sensor Pads, Part 2: Sew Velcro



Following the chalk marks that were made in the previous step, sew the hook velcro into the black felt by sewing along all four edges of the velcro. See diagram below for a guideline of where to sew. Repeat with all three chalked swatches.



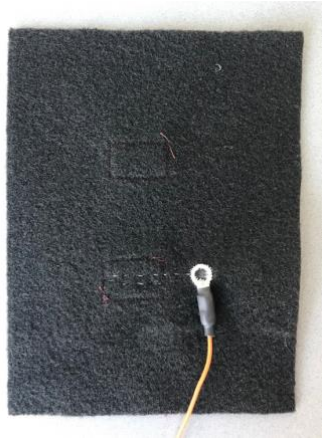
Sensor Pads, Part 3: Add electronics

In this step, you prepare the wiring that allows the velcro to act as a sensor and add it to the sensor felt pad.

1. Cut six 9” pieces of 26g silicone wire
    a. Three black or grey
    b. Three colored (make each of these different colors for easy distinction later on)
2. Strip approximately ½” of each end
3. Crimp the stripped end of the wire into the ring terminal (see Crimping Guide for assistance)
4. Cut a piece of heat shrink that will cover the plastic of the terminal ring (approx. ¾” to 1”). To heat shrink the tube, position the heat shrink so that it is entirely covering the poastic of the terminal ring, then apply heat from a heat gun evenly until it has sealed to the shape of the ring terminal and the wire.

Repeat with all wires until all six are crimped and heat-shrinked.

The wire is now ready to be sewn into the felt pad. First, take a colored wire and use conductive thread to secure the ring to the felt by sewing in a star shape around the entire ring. Next, wrap the conductive thread several times around the terminal ring (without sewing through felt) to secure the connection.



Once the terminal ring has a secure connection to the conductive thread, sew the thread across the felt to the velcro pad. Sew all the way across the velcro to secure the connection.

Sew the next terminal ring (using a gray/black wire) to the second velcro patch facing in the same direction.

Repeat with the next three felt pads so that each pad has one colored wire and one grey/black wire attached.

Section D

Crimping Guide

- *This is a guide to crimping connectors onto leads for different electronics. This applies to all versions of CRISPEE.*

Ring Connectors

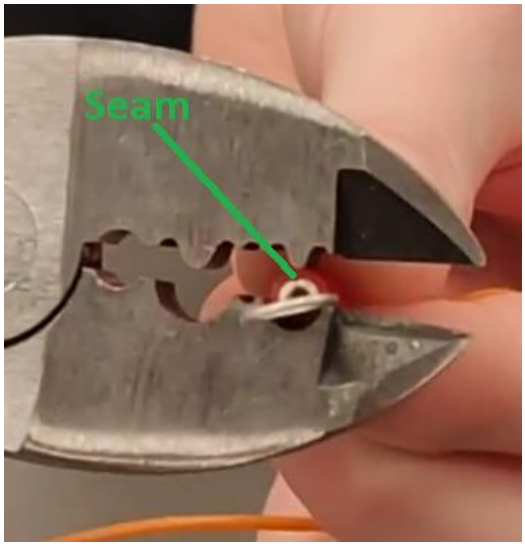
We can maintain more secure electrical connections by using ring connectors on a terminal block or to create the block sensors. We use these ring connectors by crimping wire leads into them. To attach ring connectors:

1. Strip a long section of the wire lead
2. Twist the filaments of the lead so they are all solidly together
3. Sit the ring connector in the crimper so that the smaller upper section of the plastic piece sits in a part of the crimper that is very close to its size, and so that the top part of the crimper will come down slightly to one side of the seam in the metal connector

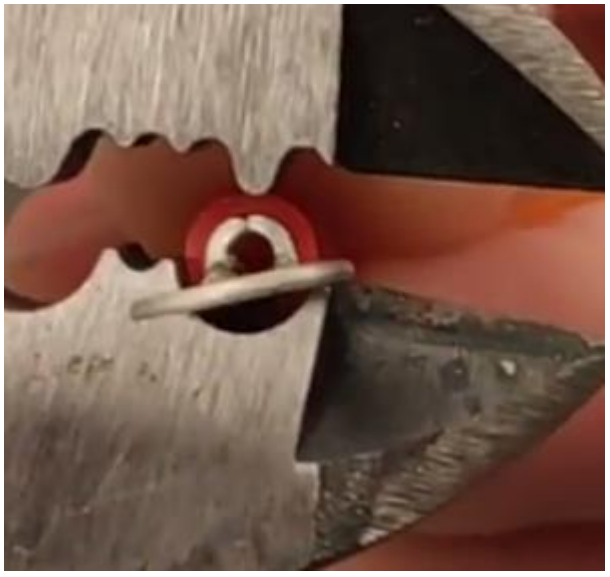
a. 

   i. The section indicated is the specified smaller section of the plastic cover on the connector

b. 

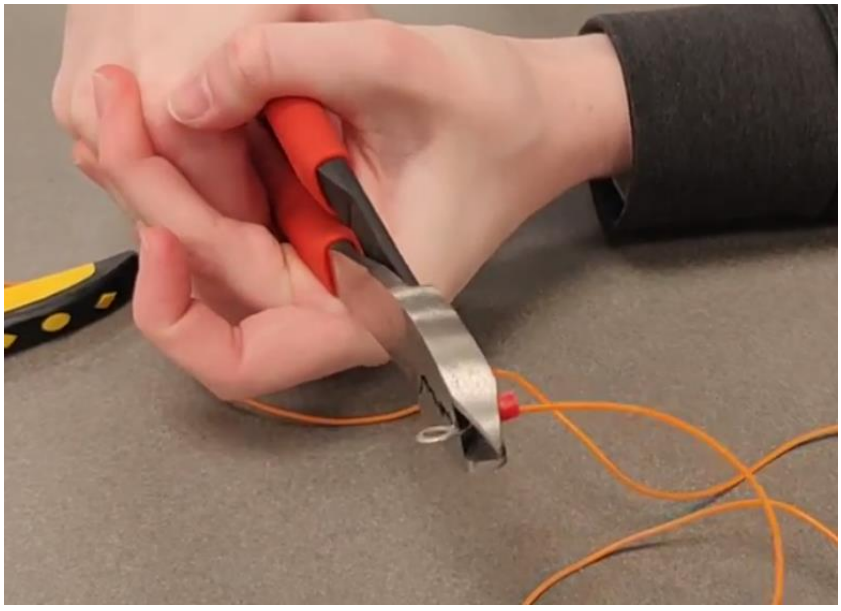
c. 

   i. Proper placement of the connector in the crimper for first compression

d. 

   i. Closeup of proper placement of the connector in the crimper for the first compression

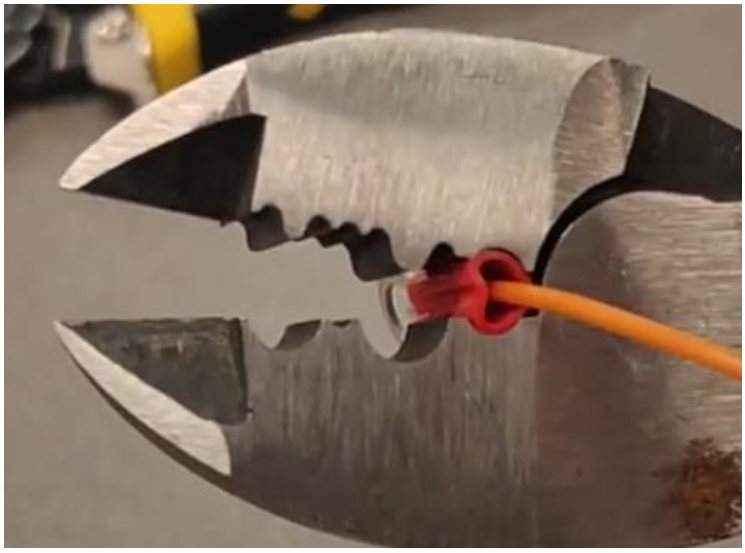
4. Feed the stripped portion of the lead into the metal connector on the inside of the crimper.
   a. Watch the lead as you're crimping, since it's easy for high gauge wire to slip out of connectors even when they've been crimped down. Make sure the crimper catches the lead solidly in the crimped connector
5. Press the crimper together. You'll have to press pretty hard

a. 

6. Release the crimper
7. Shift the connector so the top part of the crimper will come down on the other side of the seam in the metal connector
8. Press the crimper together again. This time, you won't need as much force
9. Tug gently on the lead and the connector, testing the connection

The following steps are optional. However, since heat shrinking the connector ensures a safe and solid electrical connection, it is strongly encouraged.

10. Place the larger part of the plastic part of the connector in a large part of the crimper
11. Gently compress the crimper, giving the large plastic section a sort of pleat
12. Place the larger plastic section into a smaller part of the crimper, with the pleat facing out of the side and away from the joint of the crimper

a. 

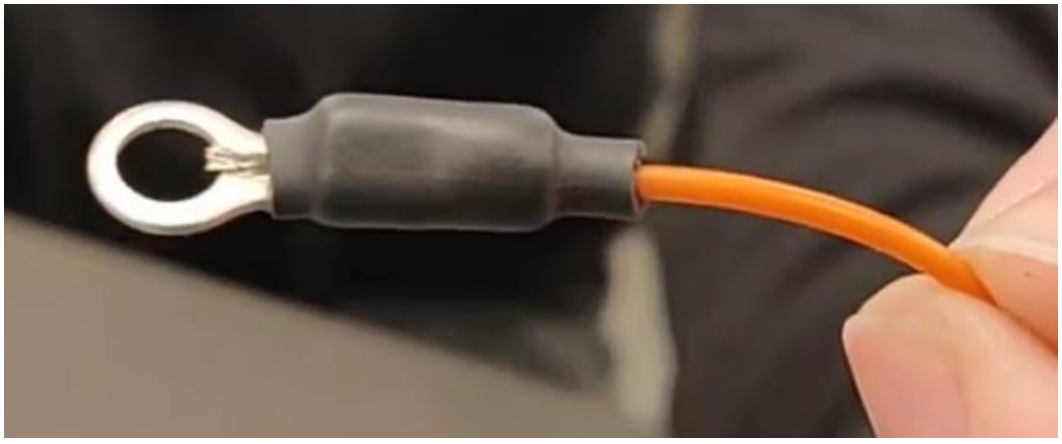
13. Compress the larger plastic section as small as possible

a. 

14. Cut a section of heat shrink to cover a small portion of the lead and the connector up to the ring
15. Slide the heat shrink over the connector, snugly up to the ring

a. 

16. Apply heat to the heat shrink until the connector is snugly covered

a. 

See this instructional video for a visual guide to crimping.

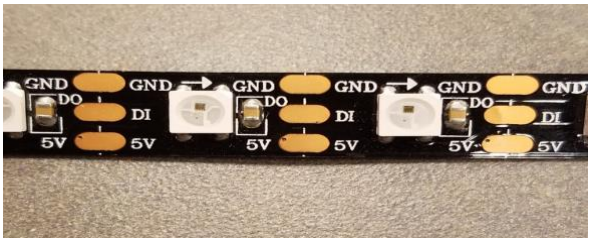
Section E

Soldering Guide

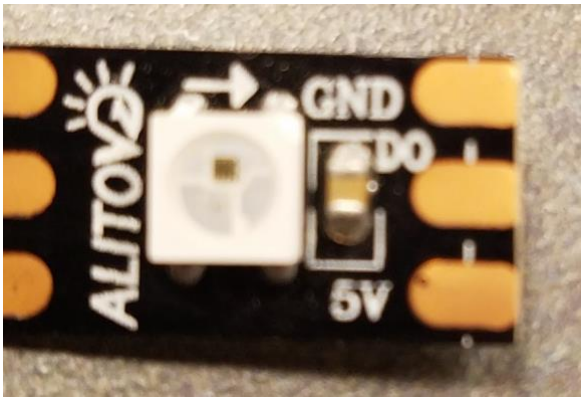
- *CRISPEE Emu's electronics require soldering in a few key places: the mixing indicator, the arcade button quick connects, the lantern, the mixing platform LEDs, and the force sensor. This guide describes the pieces of these electronics that require soldering and other special connections. The method of soldering pertains to all versions of CRISPEE, but the pictures included in this section are all of CRISPEE 3.*

Mixing Indicator

The LED strip on the front of CRISPEE 3, indicating the mixing motion, is a strip of RGBW Neopixel LEDs.



You can cut these strips of LEDs to whatever length you need. Be sure to cut down the center of the column of copper strips, so that one half comes away with GND, DO, and 5V labels, and the other half comes away with GND, DI, and 5V labels



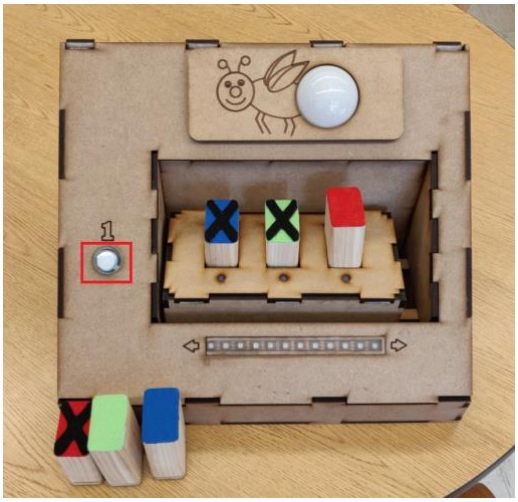
We do not want to solder to the DO side of the strip, because we have no need to daisy chain Neopixels across CRISPEE. Only solder leads to the side of the car with 5V, DI, and GND labels. The DI lead should be plugged into a digital data pin.

To solder leads to these LED strips:

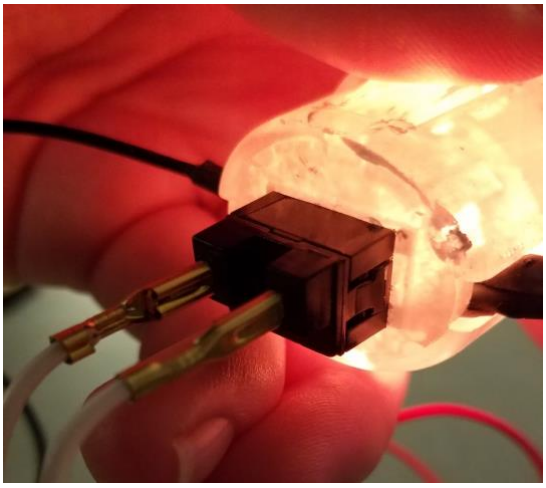
1. Strip a very small section of a high gauge wire
2. Apply a very small amount of tin to an in[dividual copper contact on the strip
3. Apply a very small amount of tin to the exposed end of the wire lead
4. Hold the wire to the copper contact and apply heat to the tin on the wire and the contact so it melts together
5. Ensure a solid connection, adding tin as needed
6. Repeat for all three contacts, ensuring clean separation of contacts, leads, and solder
7. Add heat shrink to excess exposed wire on the leads

Modifying quick connect leads

Block checking is initiated with the press of a slightly modified 30 mm translucent clear Adafruit arcade button



The Adafruit arcade button comes with quick connect leads. These slide onto the pins of the button mechanism and have snaps on the other ends for wires



We do want to use the button pin snaps, but we do not want to use the wire snaps. We cut the snaps off and strip the wires. One of the wires goes directly into a digital data pin. You may wish to solder a neater connector or wire onto the end of the data lead than to jam the stripped wire, with its many filaments and possibilities for shorting, into the pin. To do this, you would

1. Strip the end of the neater wire
2. Wrap the data lead and the neater wire together by crossing them at the halfway points of the stripped sections and twisting the sections together
3. Hold tin on top of the knot of wires
4. Apply heat to the bottom of the knot
5. Ensure a solid connection between the data lead and the neater connector
6. Cover the soldered knot with heat shrink
7. Apply heat to the heat shrink until there is a snug covering over the soldered connection

The button also needs to be connected to ground. We don't have enough +5V and ground pins on the Arduino for everything in CRISPEE that needs electricity, so we connect power leads to a terminal block

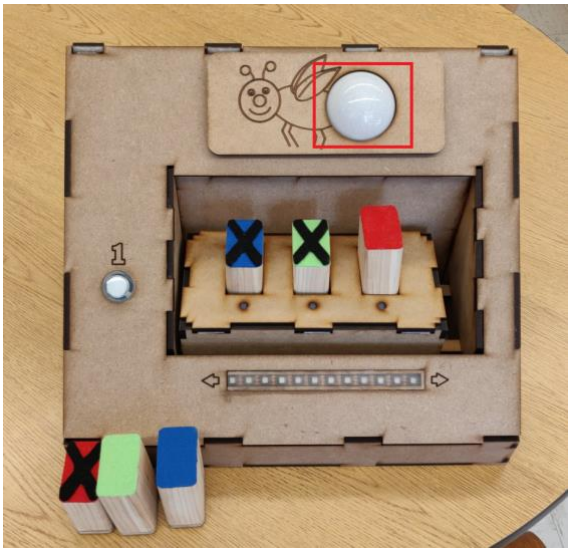
To connect the ground lead of the button to a power block:

1. Cut off the wire snap
2. Strip a small section of the wire

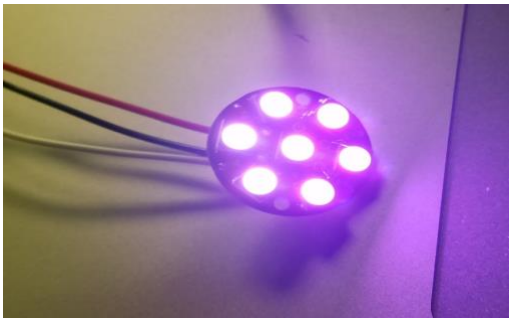
3. Crimp a ring connector onto the stripped section
    a. See the Crimping Guide for thorough instructions on attaching the ring connector
4. Thread a screw through the ring connector
5. Bolt the screw into the terminal block

If you use the LED that comes in the arcade button, you need leads to +5V and to a digital data pin. Modifying the leads to +5V and LED data follows similar rules to the ground and button data leads, respectively.

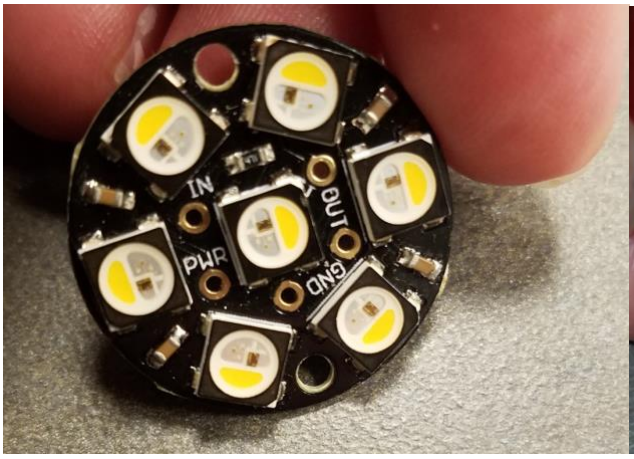
Soldering to Neopixel ring and individuals

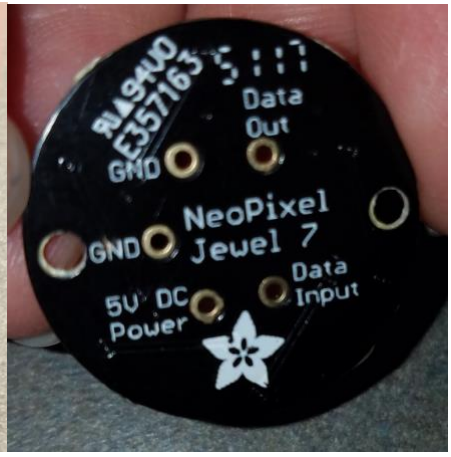


The lantern is a ring of 7 RGBW Neopixel LEDs inside of a plastic hemisphere coated with white acrylic paint on the inside to diffuse the light, since the Neopixels are very bright. This 7 LED ring is called a Jewel.



All Neopixel LED products follow the four pin schematic of +5V, ground, data in, and data out, with data out only being necessary for daisy chaining. Neopixel rings have the contacts for these various inputs in the middle of the boards. You can choose to thread wire through the contacts, or just solder on top of the front or back



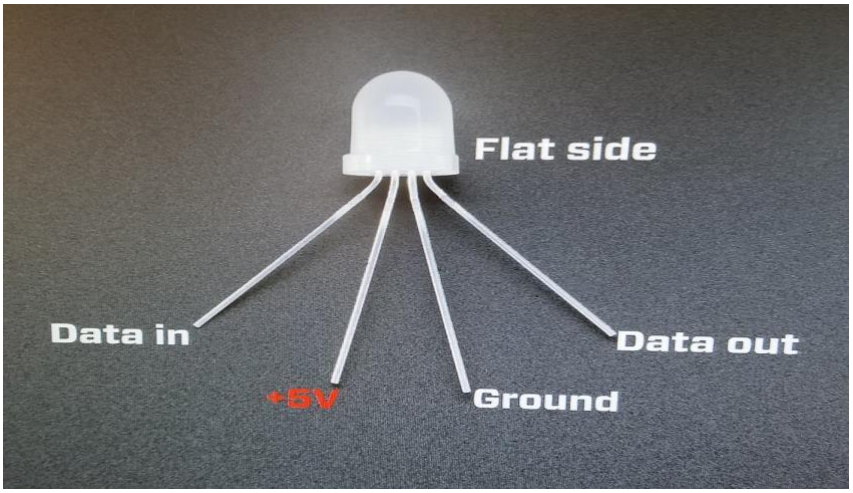


To attach leads to the back contacts of the Jewel:

1. Apply a small amount of tin to the Jewel input contact on the back. Don't hold the iron on the Jewel too long, or you'll damage the board.
2. Apply a small amount of tin to the stripped section on the wire
3. Hold the wire to the Jewel contact
4. Apply heat to the tin on the contact and the wire so they melt together
5. Ensure a solid connection is achieved between the lead and the input contact
6. Repeat for the ground, +5V, and data in contacts
7. Cover the connection with electrical tape if you wish, but this is unnecessary, as there is much lower risk for shorting, and there is a small amount of electricity flowing into the Jewel

The mixing platform LEDs are individual 8mm Neopixels. These are daisy chained, so the first two Neopixels connect their data out pin to the next Neopixel's data in pin.

You can identify the pins using the following diagram when you identify the flat side of the LED:



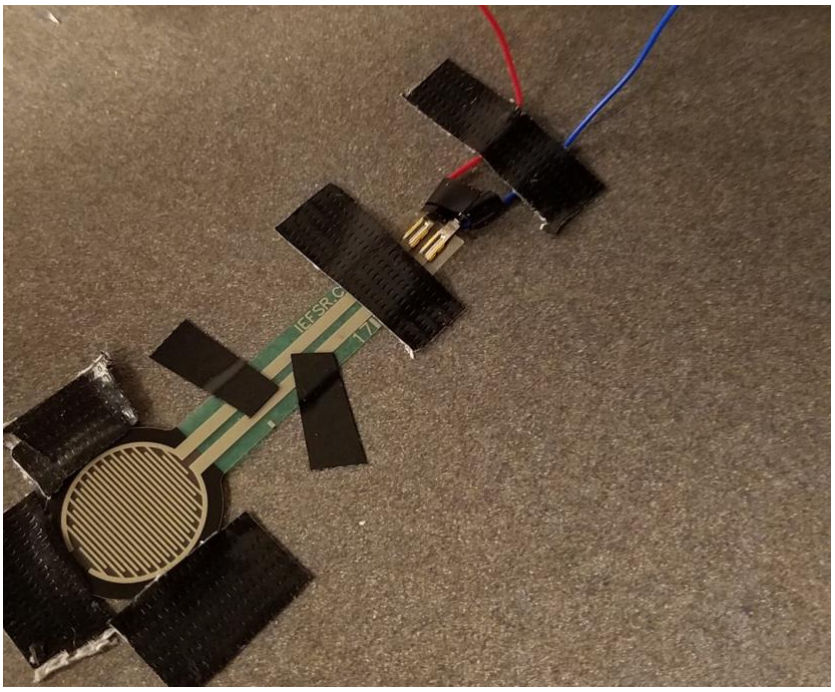
You can connect the leads of the individual Neopixels through the following steps:

1. Strip two ends of a short wire
2. Identify the data out pin of an individual Neopixel. This will be the first Neopixel in the daisy chain
3. Wrap one end of the stripped wire around the data out lead

4. Hold tin on the top of the data out wire wrap, and apply heat to the bottom of the wire wrap until the data out lead and the wire are solidly connected
5. Thread heat shrink up onto the data out lead as far as possible, ensuring the heat shrink covers all exposed portions of the wire and lead
6. Thread more heat shrink onto the wire, enough to cover another connection
7. Wrap the other end of the wire around the data in lead of the second Neopixel. This will be the second Neopixel in the daisy chain
8. Hold tin on the top of the data-in wire wrap, and apply heat to the bottom of the wire wrap until the data-in lead and the wire are solidly connected
9. Heat the heat shrink until both connections are covered snugly and completely

Soldering to force sensor

The mixing process is tracked by compressions of a force sensor, similar to this one:



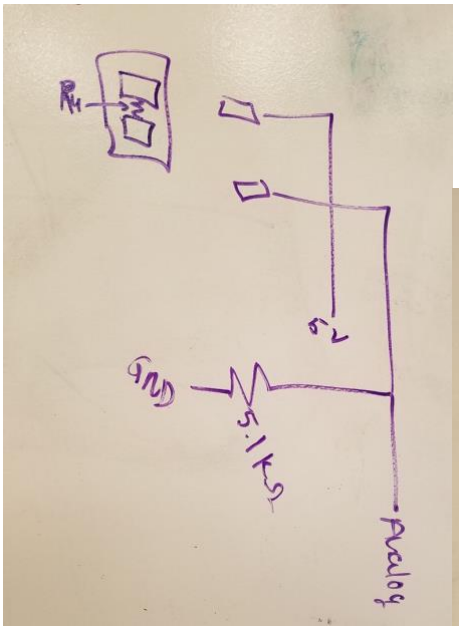
By a one inch wheel on the bottom of the mixing platform

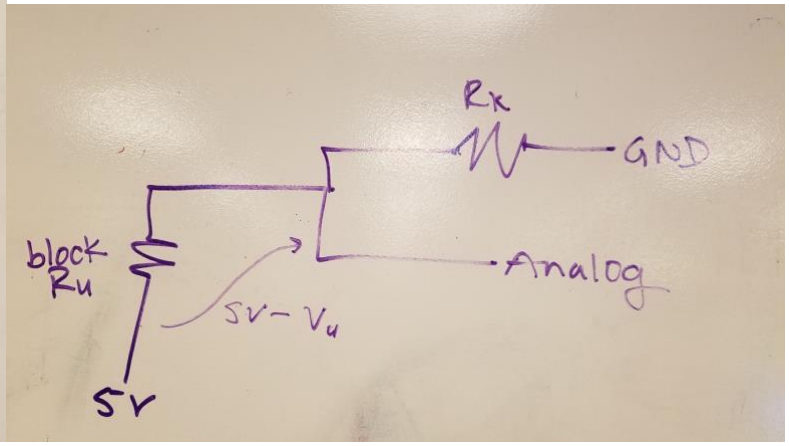
Connections are very shaky with the provided leads on the force sensor because they're only meant to be inserted into a breadboard. Calling them leads at all instead of contacts is a tenuous choice in itself. So, we give the force sensor longer leads:

1. Strip short sections of two long wires
2. Splay the filaments of the stripped wire
3. Place the lead of the force sensor in the splayed filaments of the wire
4. Twist the filaments around the force sensor lead
5. Hold tin on top of the wire knot and apply heat to the bottom of the knot until a substantial amount of tin has melted into the knot
6. Add tin to the knot as needed in order to solidify the connection. The lead for the force sensor is *very* short, so add more extra tin than you used for other wire knots
7. Repeat for the other force sensor lead
8. Choose heat shrink of a very high gauge, so it fits snugly over the connection of each lead
9. Push the heat shrink as far up the lead as possible, covering all of the connection
10. Apply heat to the shrink until it snugly protects the connection
11. Repeat for the other lead
12. Choose a lower gauge heat shrink that will fit over both connections
13. Slide this larger heat shrink over both connections and part of the lower portion of the force sensor
14. Apply heat until the larger shrink keeps both connections solidly together, and the only movement is from the wire leads
15. You'll have to tape or glue down the sensor so it stays in place in the mixing platform track

Creating Block Sensors

At this point you should have the platform sensor pads assembled as described in the Sewing Guide, with wires crimped into each of the ring connectors as described in the Crimping Guide. The sensors work by subtracting a known resistance value from a total resistance to calculate an unknown resistance value, the value added by the resistor in the block. The circuit setup is shown below:





To finish making one block sensor:

1. Designate one sensor pad wire as +5V and the other as data out
2. Strip the end of the data out lead that is not crimped into the ring connector
3. Separate the filaments of the stripped data out lead into two even groups and splay the filaments of each group, keeping them separate
4. Strip one end of two other silicone coated wires
5. Splay the filaments of the stripped parts of the two loose wires
6. Put the splayed filaments of a loose lead together with one group of splayed filaments on the data out lead and twist the filament groups together
7. Hold tin to the top of this wire knot and apply heat to the bottom of the wire knot until sufficient tin has melted into the knot to hold the connection
8. Repeat steps 6 and 7 for the other data out filament group and loose wire
9. Choose one of these new leads to be analog, and the other to be ground. Ground should be the shorter lead, if there is one
10. Strip a small portion of the analog lead, twist the filaments, and leave it alone
11. Strip a small portion of ground
12. Splay the filaments of ground
13. Insert one end of a 5.1 kΩ resistor into the splayed filaments of ground and twist the filaments around the resistor lead
14. Hold tin to the top of this wire knot and apply heat to the bottom of the wire knot until sufficient tin has melted into the knot to hold the connection
15. Strip a small portion of a new length of silicone wire and splay the filaments
16. Insert the other end of the 5.1 kΩ resistor into the splayed filaments of the new length of wire and twist the filaments around the resistor lead
17. Hold tin to the top of this wire knot and apply heat to the bottom of the wire knot until sufficient tin has melted into the knot to hold the connection
18. Cut a length of heat shrink long enough to cover the resistor and soldered wire knots inserted into the ground lead
19. Slide the heat shrink over the resistor and solderings
20. Apply heat from a heat gun or soldering iron to the heat shrink until the connection is snugly covered

Section F

Mixing Platform Building Guide

- *The color of the lantern light is dependent on the combinations of gene blocks set into the mixing platform, whose construction is detailed here. More detailed step by step guides are available for sewing the conductive velcro circuits, crimping the ring connectors, and soldering the mixing platform LEDs. This section pertains specifically to CRISPEE 3.*

Sewing Velcro

We use conductive Velcro to make an electrical connection between the gene blocks and the mixing platform. On the mixing platform, we sew conductive Velcro to one side of plain felt with conductive thread, and we sew a ring connector crimped to a silicone wire to the other side of the felt, also with conductive thread. Electricity flows up through one silicone lead, through the conductive thread to the conductive Velcro on the platform and then on the block, through the block's unique resistor, and back down through another set of conductive Velcro, thread, ring connector, and silicone lead.
See the sewing guide for a detailed description of the process of sewing the mixing platform side of this circuit

Crimping Rings to Silicone Wire

We used silicone wire for the leads coming out of the back of the mixing platform. Silicone coated wire is preferable because it is incredibly flexible and does not become brittle and break like PVC coated wire under the stress of the motion of the mixing platform. We want to use silicone coated wire on

- Block sensors
    - +5V
    - Data Out
    - Ground
    - Analog
- Mixing LEDs
    - +5V
    - Ground
    - Data In

To attach a silicone wire lead to an existing lead:

1. Strip small sections of each lead
2. Splay the filaments of each stripped wire
3. Put the splayed filaments together (or the splayed filaments and the lead, in the case of an LED lead)
4. Twist the filaments together
5. Touch soldering tin to the top of the wire knot and apply heat to the bottom of the knot
6. Cover the knot in heat shrink and apply heat until the connection is snugly covered

We use ring connectors to create the block sensors and to connect the block sensors and the mixing LEDs to the power block. This crimping process is described in detail in the Crimping Guide.

Laser Cutting the Wooden Sections

The vast majority of CRISPEE's wooden pieces are laser cut. We used a Trotec Laser Engraver and loaded Adobe Illustrator files into the engraver job manager. We printed CRISPEE's pieces on ¼ inch thick MDF. In the Illustrator files, we standardized through-cut lines to RGB (255, 0, 0) and 0.1 pt weight, and we standardized engraving lines (used only on the face plate and identifying marks) to RGB (255, 255, 255) and 0.1 pt weight. Through-cut lines required three passes and engraving lines required one pass by the laser.

Assembling the Box

All wooden pieces of CRISPEE Emu have interlocking pieces. The mixing platform has symmetrical interlocking pieces, meaning that you'll want to be careful not to glue the back long face on upside down even though it interlocks upside down. The oval cutout on the back long face should be closer to the bottom of the platform.

To assemble the box:

1. Dribble glue over the side interlocks of the short side pieces of the box

   a. The short side pieces have roughly this shape:
2. Press the interlocks of the long side pieces into the interlocks of the short side pieces
   a. The front and back pieces have roughly this shape, however the back has an oval cutout near the bottom

3. Dribble glue over all of the interlocks of the bottom face of the mixing platform
4. Press the whole unit of side faces into the interlocks of the bottom face
5. Let the unit dry for several hours, ensuring the interlocks are kept snugly together

The top of the box should not be glued down, to make maintenance easier. Instead:

1. Cut Velcro into ¼ inch wide strips
2. Cut a section of Velcro for each pair of interlocks. Interlocks vary in length, so be sure to measure each
3. Apply industrial glue to both sides of the Velcro unit
4. Place one glued side of the Velcro unit on the side face interlock

5. Rest the top face on top of the side face interlocks and the glued Velcro units
6. Leave the mixing platform to dry for several hours
7. The top face should easily rip off of the rest of the mixing platform

Adding Inserts

The blocks sit too low in the mixing platform after assembling the box. To solve this problem, we add inserts in the bottom of the mixing platform.

The long side face of the mixing platform with the oval cutout is the back of the platform. This is the place for the sensor and mixing LED leads to exit the platform and go to the Arduino or power block. The flat long side of the insert should be glued snugly against the front wall of the mixing platform, and the side with rectangular cutouts should face the back wall of the mixing platform

To add the inserts:

1. Spread industrial glue over the bottom of each of the inserts. You will know that it's the bottom because the cutouts of the insert will align with the non-cutout portions of the mixing platform top
2. Place an insert in the mixing platform box, with the flat side snugly against the front wall
3. Stack inserts as necessary
4. Leave the platform to dry for several hours

Gluing Wheels

The mixing platform is meant to be shaken back and forth. In the Emu model, the platform sits on 1 inch wheels

In previous models, the platform sat on modified drawer slides, but these were eliminated because they were relatively expensive, required inaccessible equipment to modify, and added a lot of height and weight to CRISPEE.

The wheels can be screwed into or glued onto the bottom of the mixing platform. We chose to glue the wheels. To attach the wheels:

1. Mark four rectangles on the bottom of the mixing platform for the wheel bases to be glued to. There should be two sets of wheels on either of the short ends of the bottom of the mixing platform, each x inches apart from each other, according to the spacing of the wheel tracks on the base of CRISPEE
2. Dribble industrial glue around the perimeter of each rectangle
3. Spread the glue evenly across the measured wheel base area
4. Center the wheelbase over the glued area

5. Press the wheelbase down into the glue
6. Repeat for all four wheels
7. Let the wheels dry to the mixing platform bottom for several hours

Gluing Sensors

Creation of the block sensors is detailed in the Sewing Guide
Once the block sensors have been assembled with conductive thread, ring connectors, conductive Velcro, and felt, the sensors must be attached to the mixing platform

1. Draw the block sensor leads out of the back of the mixing platform
2. Dribble industrial glue over the section of the top insert that corresponds to this sensor
3. Spread the glue evenly over the platform insert section
4. Center the sensor over glued section of the insert
5. Press the sensor down into the glue
6. Repeat for all three block sensors
7. Leave the platform to dry for several hours

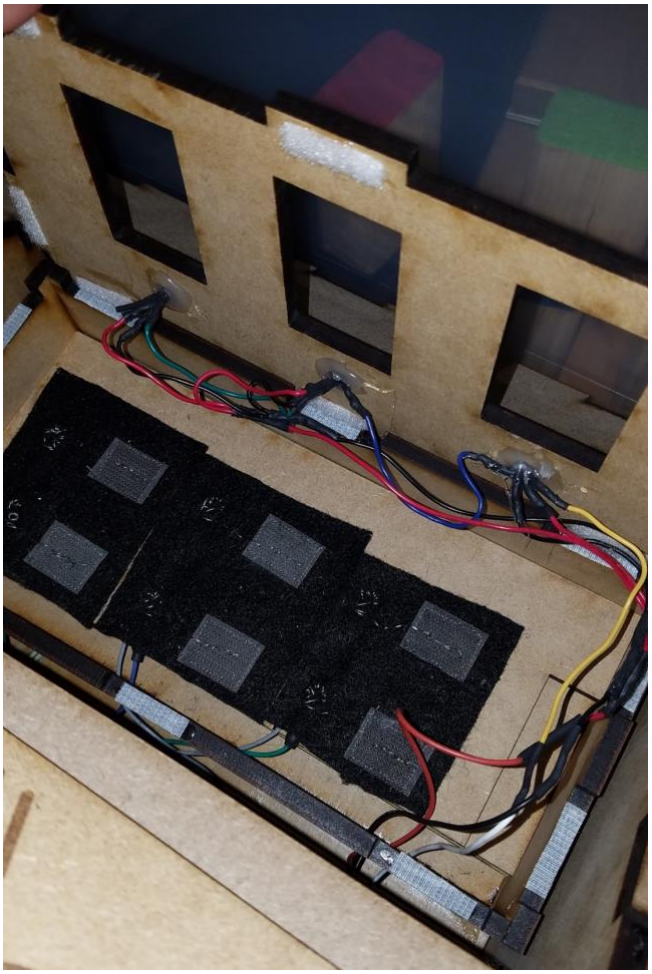
Gluing LEDs

Creation of the daisy chain of mixing platform LEDs is detailed in the Soldering Guide
There are three single 8mm through-hole Neopixels on the mixing platform. They should poke through the holes at the front of the top face.
To attach the LEDs:

1. Poke the Neopixel through the hole in the MDF so it just peeps out of the top
2. Apply liberal amounts of glue to the bottom of the LED
3. Make sure the LED stays put while the glue dries

Full Platform Electronic Assembly

Refer to the Electronic System Assembly Guide for full instructions on how to complete the setup of block sensors and mixing LEDs



Section G

Wooden Shell Assembly Guide

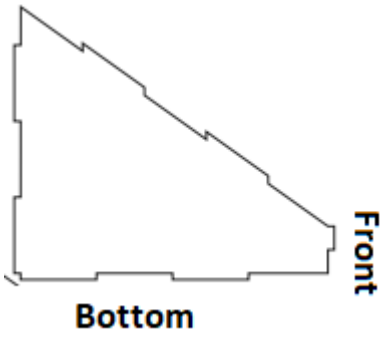
- *This guide details the assembly of the wooden body of CRISPEE, excluding the platform, which is detailed in the Platform Building Guide. This section applies to all versions of CRISPEE.*

Laser Cutting

The vast majority of CRISPEE's wooden pieces are laser cut. We used a Trotec Laser Engraver and loaded Adobe Illustrator files into the engraver job manager. We printed CRISPEE's pieces on ¼ inch thick MDF. In the Illustrator files, we standardized through-cut lines to RGB (255, 0, 0) and 0.1 pt weight, and we standardized engraving lines (used only on the face plate and identifying marks) to RGB (255, 255, 255) and 0.1 pt weight. Through-cut lines required three passes and engraving lines required one pass by the laser.

Base External Shell

1. Find the side of the external bottom that interlocks with the long rectangular front wall. This is the front of the CRISPEE, and the side of the external bottom that lies face down when the front wall is interlocked is the bottom face.
2. Apply industrial glue to the bottom interlocks of the front wall
3. Fit the bottom interlocks into the front interlocks of the external bottom
4. Apply industrial glue to the bottom and front interlocks of both side pieces

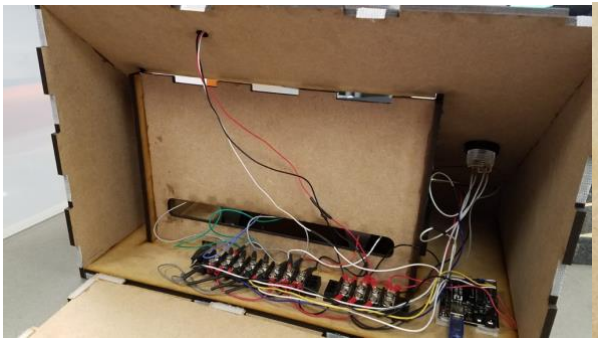


a.

5. Fit the interlocks of the side pieces into the interlocks of the external bottom
6. Prop the side and front walls so that they dry perpendicularly to the external bottom
7. Leave the assembly to dry for several hours

Internal Walls

1. Find the face of the internal bottom that allows the interlocks of all three internal walls to snap in. This is the top of the internal bottom. The side closest to the opening of the U shape of cutouts in the internal bottom is the front side
2. Spread liberal amounts of glue over the bottom of the internal bottom
3. Press the glued side of the internal bottom onto the top of the external bottom, ensuring that no part of the internal bottom overhangs the interlocks of the external bottom, and that the front side of the internal bottom aligns with the front side of the external bottom
4. Apply liberal amounts of glue to the side interlocks of the internal walls
5. Fit the internal walls together
6. Apply liberal amounts of glue to the cutouts of the internal bottom
7. Fit the unit of internal walls into the cutouts of the internal bottom
8. Leave the internal wall unit to dry for several hours, checking it periodically to ensure that the interlocks are still snugly together and straight



Closing off the External Shell

The face and back of the external shell should be left unattached until everything else has been assembled, glued, and wired. See the Sewing Guide, Electronic System Assembly Guide, Platform Building Guide, Soldering Guide, Block Making Guide, and Crimping Guide for detailed instructions. When that has been done:

1. Dribble glue over the top interlocks of the side and front external walls and the internal walls
2. Fit the external face over the interlocks of the front and side external walls and of the internal walls

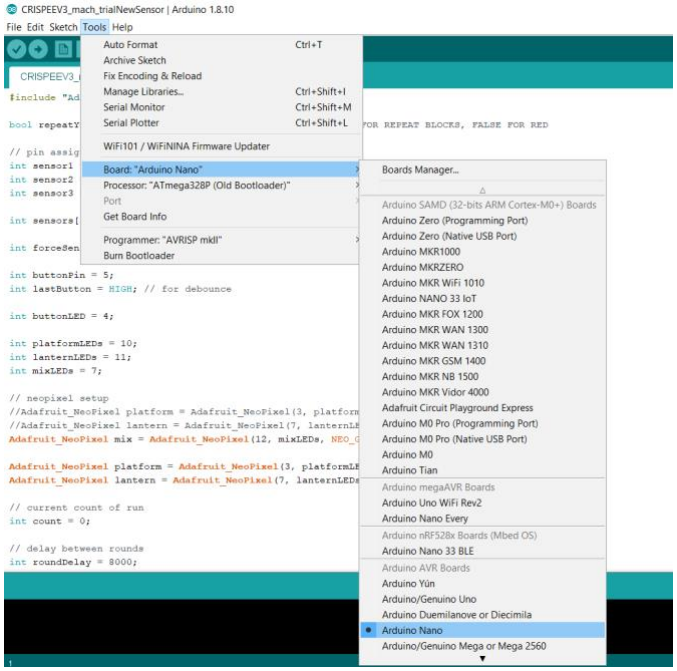
3. Leave the assembly to dry for several hours
4. Cut ¼ inch wide Velcro strips for all of the interlocking sections of the back panel
5. Apply industrial glue to each side of each Velcro unit
6. Place one Velcro unit onto each interlocking section of the back panel
7. Press the back panel into the interlocks of the back of the external face, sides, and bottom
8. Let the Velcro dry to the interlocks

Common Technical Issues and Fixes

Some common errors

Accidentally clearing the Arduino

- If the white reset button in the middle of the Arduino is held down for a few seconds, the code that is currently on the Arduino will be erased and CRISPEE will not function at all.
- To fix this issue simply re-upload the code onto the Arduino by opening the most recent code in Arduino IDE, making sure the board is properly configured (properly your port, board type and processor -- detailed below), and pressing the upload button
    - Port- Determine which COM the Arduino is plugged into by using your device manager(port section), then select that specific COM in the Tools dropdown menu
    - Board Type- For CRISPEE Emu an Arduino Nano was used. In order to connect to the board go to Tools, then select the tab called “Board” and click at the top on “Boards Manager…”. Once you are in the Boards Manager install “Arduino AVR Boards by Arduino” version 1.6.21. Having the correct version is very important in order to successfully connect your computer to the CRISPEE’s Arduino. Once you have downloaded the boards you need to select the “Arduino Nano” option under the “Arduino AVR Boards” section. For different Arduino models the same steps should be followed but with the appropriate board selected under “Arduino AVR Boards”.



    - Processor- To connect to the Arduino you also need to select the correct option under “Processor” (which is directly below “Board” in the Tools dropdown menu) “ATmega328P(Old Bootloader)”. This should apply to other Arduino board as well.

Accidental disconnected wires

- CRISPEE is exposed to wear and tear as children play with it. The wires attaching the LED’s in the mixing platform are easy to disconnect by accident if the lid of the mixing platform is pulled off too quickly.
- If the CRISPEE is not functioning and loose wires are seen, refer to Section E (or other specific sections depending on where the wire is found) to reconnect the wire