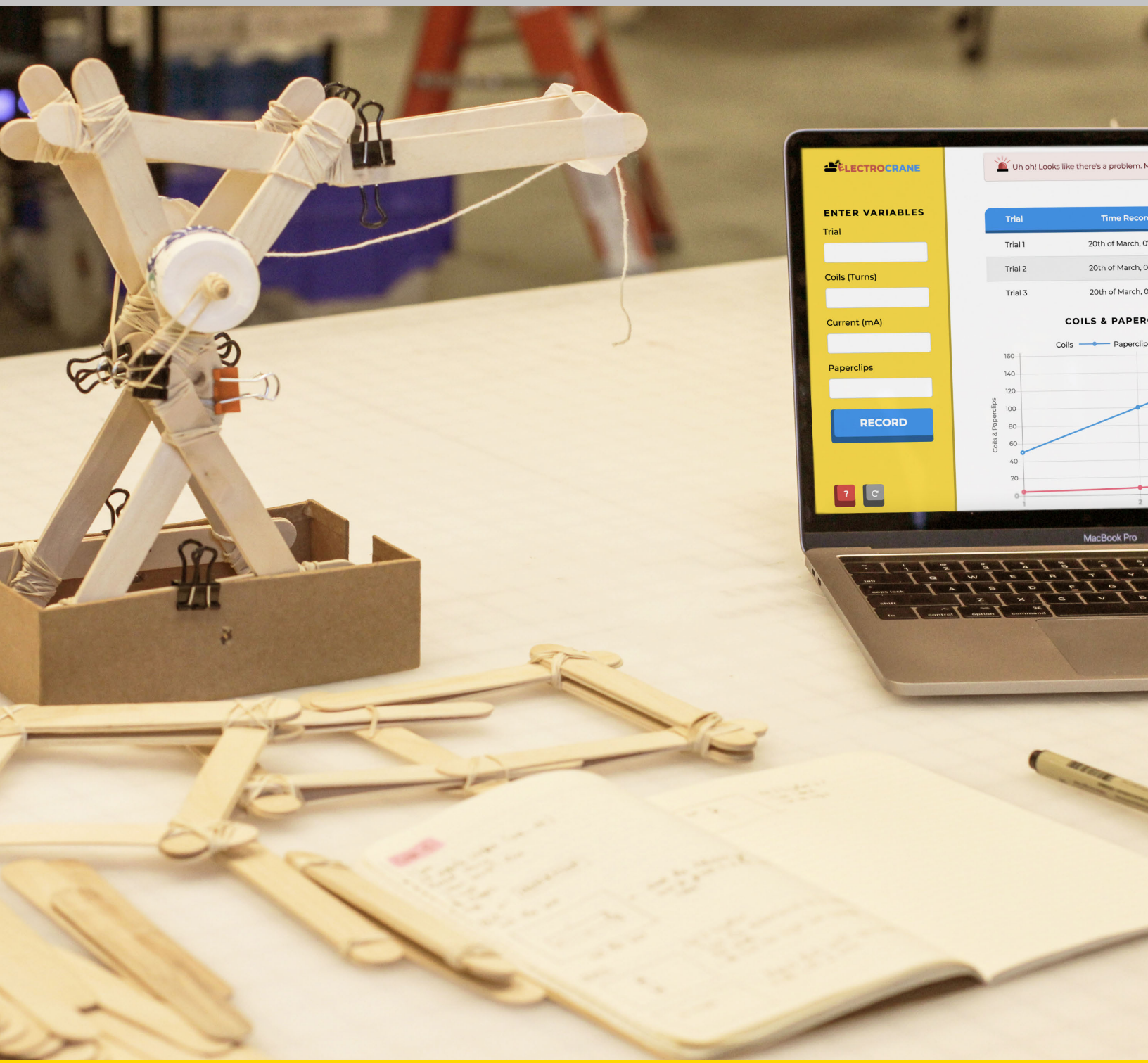

ElectroCrane Instructions

TeamBits

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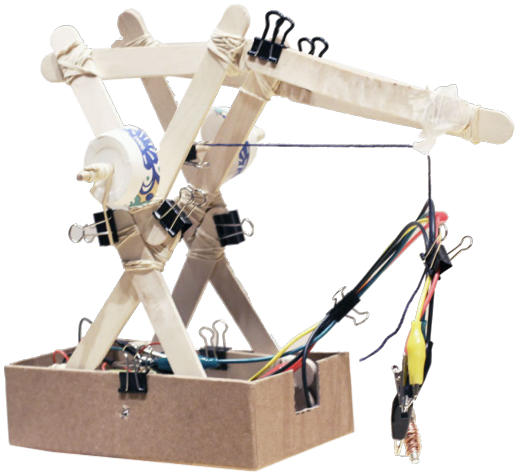
Activity Overview

ElectroCrane is an activity that teaches students about the relationship between electricity and magnetic field by having students build their own electromagnetic crane. Students will work in team of two and experiment how multiple variables affect the strength of an electromagnet. Students will log their experiment data and interpret graphs to reflect on the scientific concept via our companion website: www.electrocrane.fun/



- 3 - 5th, 8 - 10 years old
- Four to five 50-minute class periods
- Cost: $9 per student

Please note that lesson activities will require adult supervision.

Build and learn

Students will build a the crane using materials from daily life. They will learn about concepts of electricity and magnetic fields while developing crafting skills. They get more hands-on by creating their own electromagnet using nails and copper wire.

Practice electronics

Students learn essential prototying knowledge by building the circuit using the Arduino Uno, a potentiometer, and a hall effect sensor, which enable them to explore the relationship between electricity and magnetic field.

Interpret data

By connecting the circuit to a laptop, students see visualizations on www.electrocrane.fun from each trial to compare and contrast data. The mobile interface serves as immediate feedback for crane control while the website serves as a datalog to help students reflect on the scientific concepts.

NGSS standards

Performance Expectations

- 3-PS3-3. Ask questions to determine cause and effect relationship of electric or magnetic interations between two objects not in contact with each other.
- 3-PS2-4. Define a simple design problem that can be solved by applying scientific ideas about magnets.

21st century technical skills

- Electrical engineering
- Mechanical engineering

Lesson Plan

Teacher Preparation

Step 1: Review and complete this study guide before teaching. Modify the flow and process accordingly to make sure the lesson fits classroom's profile.

Step 2: Provide students with general knowledge about electricity, magnet, magnetic fields, and how electromagnet can be made before conducting classroom experiment.

Step 3: Print out instructions in advance before class. Prepare materials or pre-assemble the circuit if necessary.

Step 4: Test data visualizations on www.electrocrane.fun. Reach out to the ElectroCrane team for technical help if needed.

Suggested teaching timeline

Day 1: Familiarizing

Introduce lesson, form teams, clarify vocabulary, and go over scientific concdpts of electricty and magnet.

Day 2: Crafting

Assist students in building the crane and assembling the Arduino circuit.

Day 3: Experimenting

Instruct students to start experimenting and collecting data. Make sure students iterate along the process to improve crane performance.

Day 4: Reflecting

Help students interpret the data and visualization to draw conclusion and reflect on the experiment.

Advanced Level

If students learn and understand the relationship between electricity and magnetic fields quickly, they are encourged to further explore other variables that could affect the strength of an electromagnet beyond electric current. Electrocrane.fun allows sutdents to insert new variables into the experiment; they are able to log data and see visualizations of self-input variables.

Other variables to consider:

wire thickness | nail length | nail shape | wire material | wire material | nail material

Materials for the Crane

Component checklist

- [ ] 1 box
- [ ] 1 package of rubber bands
- [ ] 28 popsicle sticks
- [ ] 2 paper cups
- [ ] 1 string of thread
- [ ] 10 paper clippers
- [ ] tape

Tools

- [ ] 1 scissor
- [ ] 1 marker pen

Build the Crane

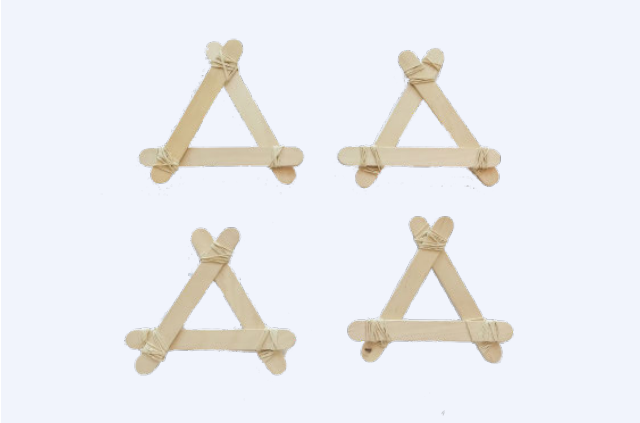
1 Hold 2 popsicle sticks together. Use a rubber band to wrap around both ends to make a stack.

2 You should have something like this.

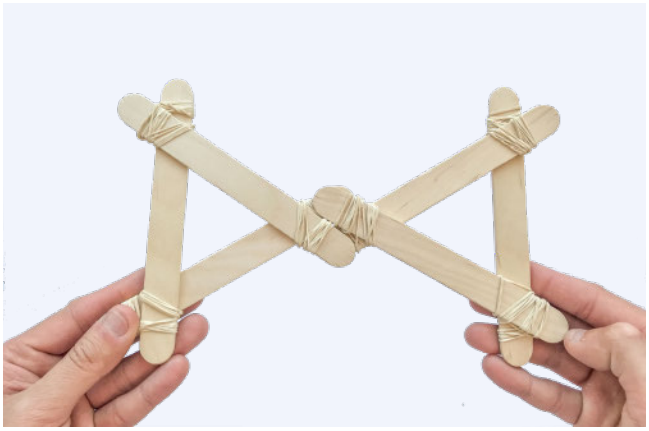
3 Repeat step 1 & 2 to make 12 stacks in total.

4 Use another rubber band to tight both ends of the stacks together.

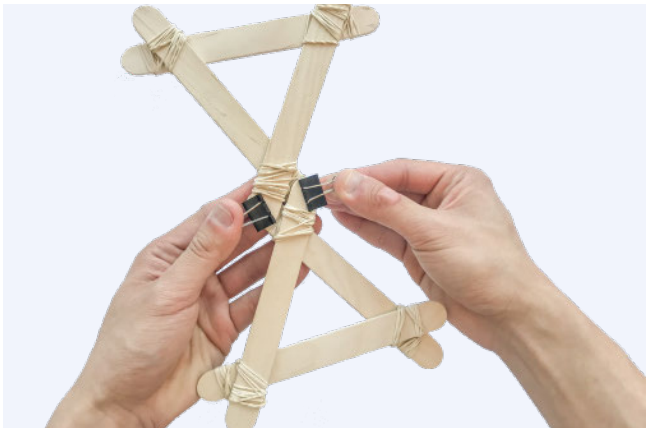
5 Use another stack, repeat step 4 for until you get a triangle like this.



6 Repeat step 4 & 5 to create 4 triangles.



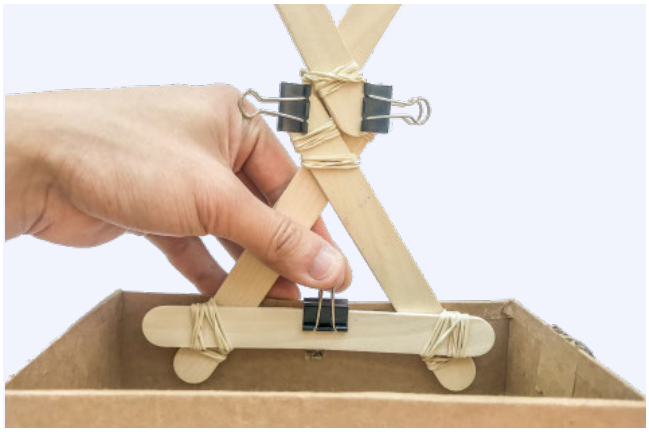
7 Place 2 triangles together, make sure the ends intersect with each other.



8 Use 2 clips to fix these 2 triangles.

9 Repeat step 7 - 8 to make 2 connected structures in total.

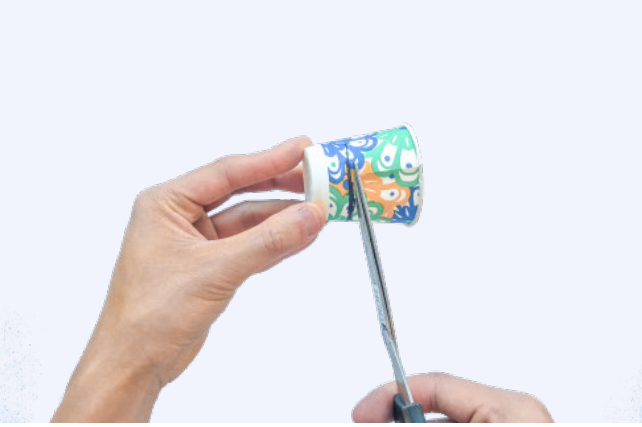
10 Find a box with a proper size.



11 Use another clip to fix the structure to one side of a box.

12 Repeat step 11 to fix 2 structures to both sides of the box.

13 Find two small paper cups and poke a hole in the bottom of each cup.



14 Cut the paper cup from the bottom.

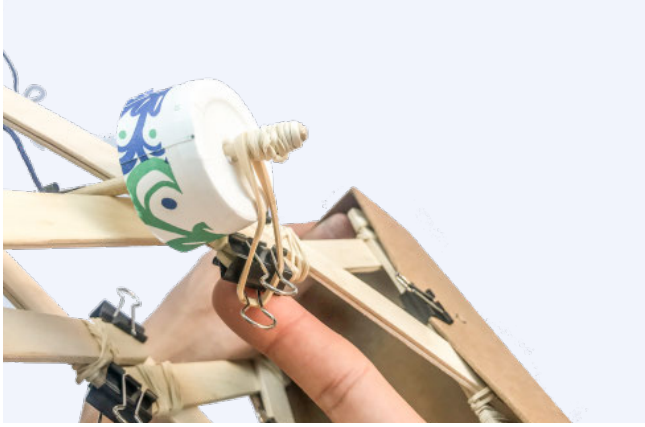
15 Repeat step13 - 14 to make 2 of them.

16 Prepare a stick that is longer than the box's width and use rubber bands to wrap one end.

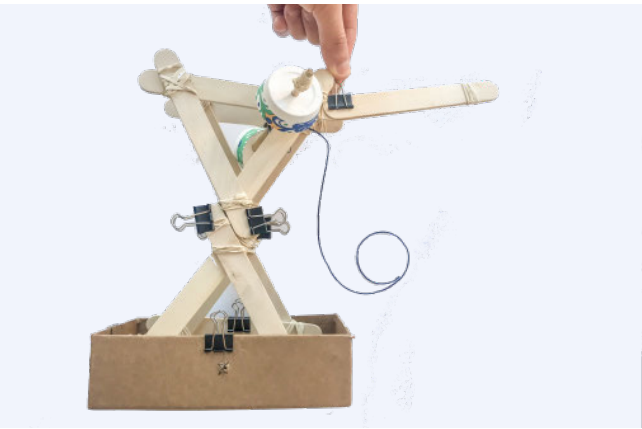
17 Let the stick go through the paper cup.

18 Place the stick with paper cup across through the upper triangles.

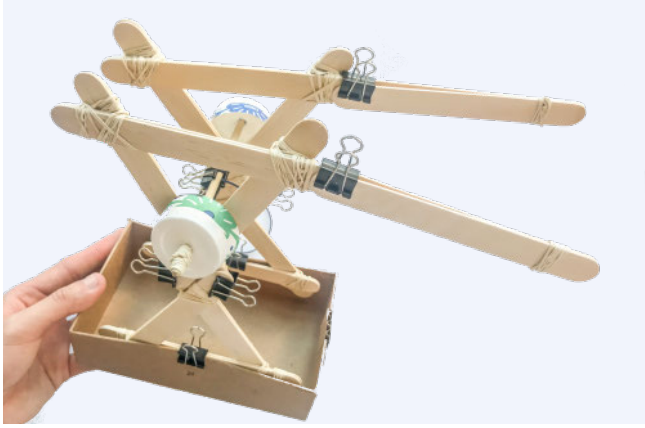
19 Repeat step 17 & 18 to make sure the both sides of the stick cannot go through the structures.



20 Use rubber bands to tie the stick to the clip on both sides.

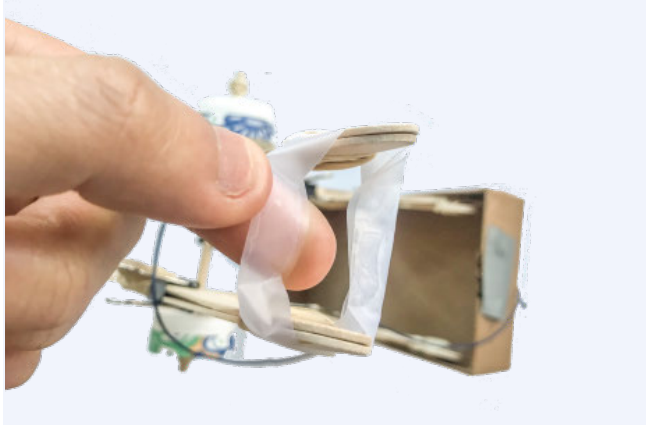


21 Use clip to connect another wrapped popsicle sticks to the upper triangle.

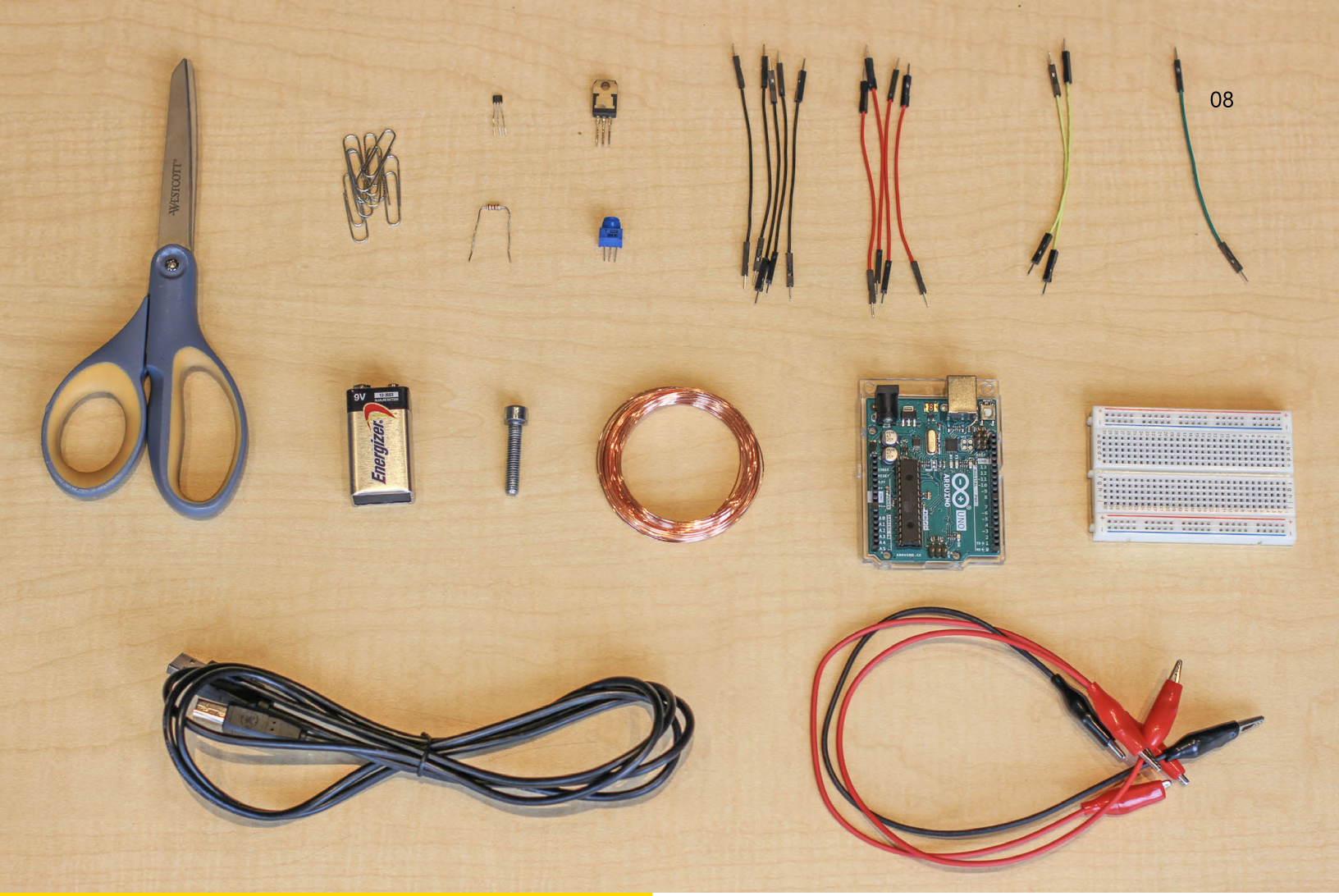


22 Repeat step 21 to fix two arms for the crane.

23 Fix one end of the string to the stick. Tie a knot and make sure it is not moving.



24 Wrap the tape at the end and fold it to create a pass between two arms.



Build the Circuit

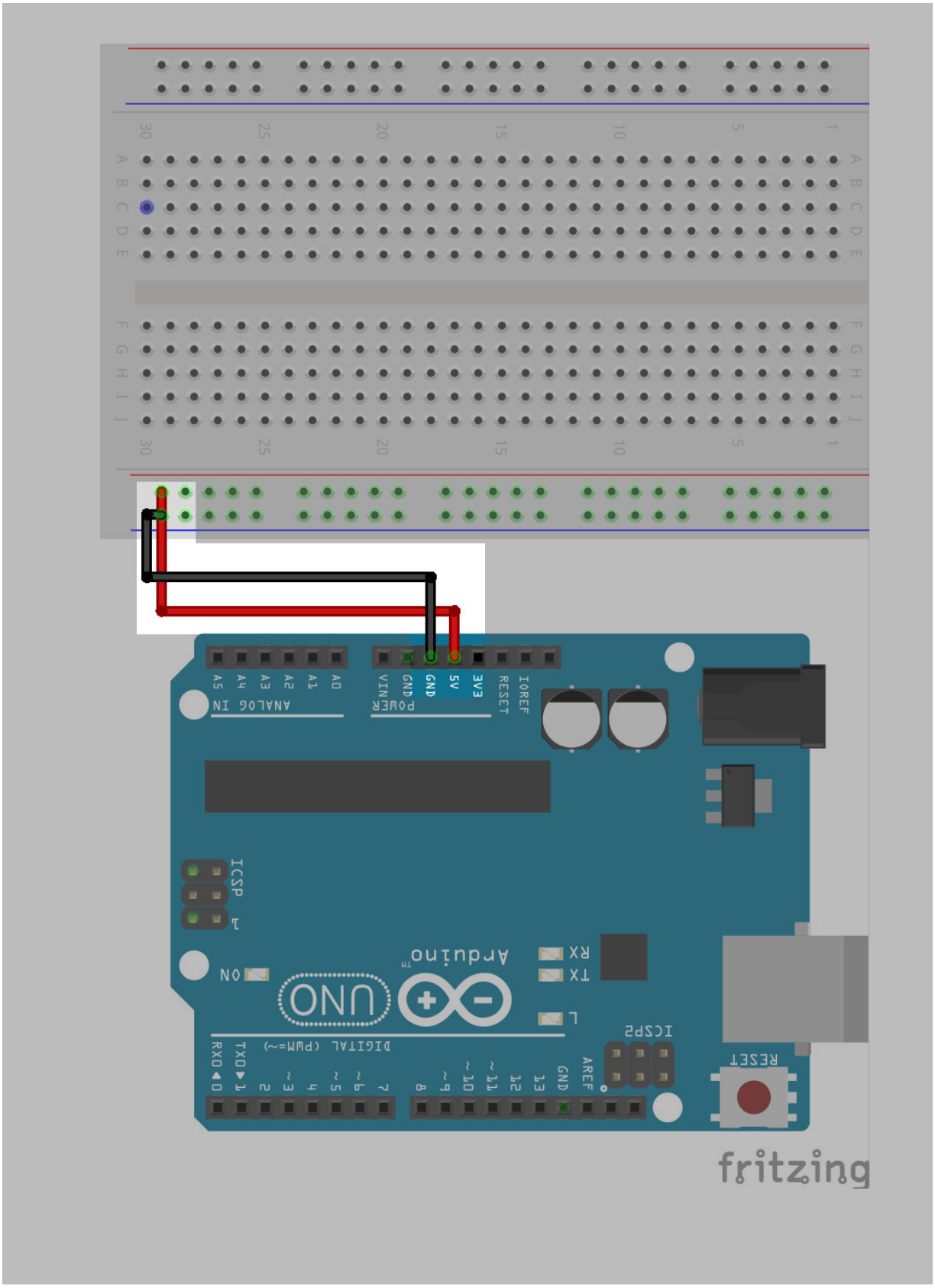
Component checklist

- [ ] 1 microcontroller (Arduino UNO)
- [ ] 1 breadboard
- [ ] 1 copper wire (0.11mm, 38 AWG)
- [ ] 1 iron nail
- [ ] 2 green jump wires
- [ ] 3 yellow jump wires
- [ ] 4 red jump wires
- [ ] 4 black jump wire
- [ ] 1 potentiometer
- [ ] 1 220 kΩ resistor
- [ ] 1 linear hall effect sensor
- [ ] 1 green alligator clip
- [ ] 2 black alligator clips
- [ ] 1 red alligator clip
- [ ] 1 yellow alligator clip

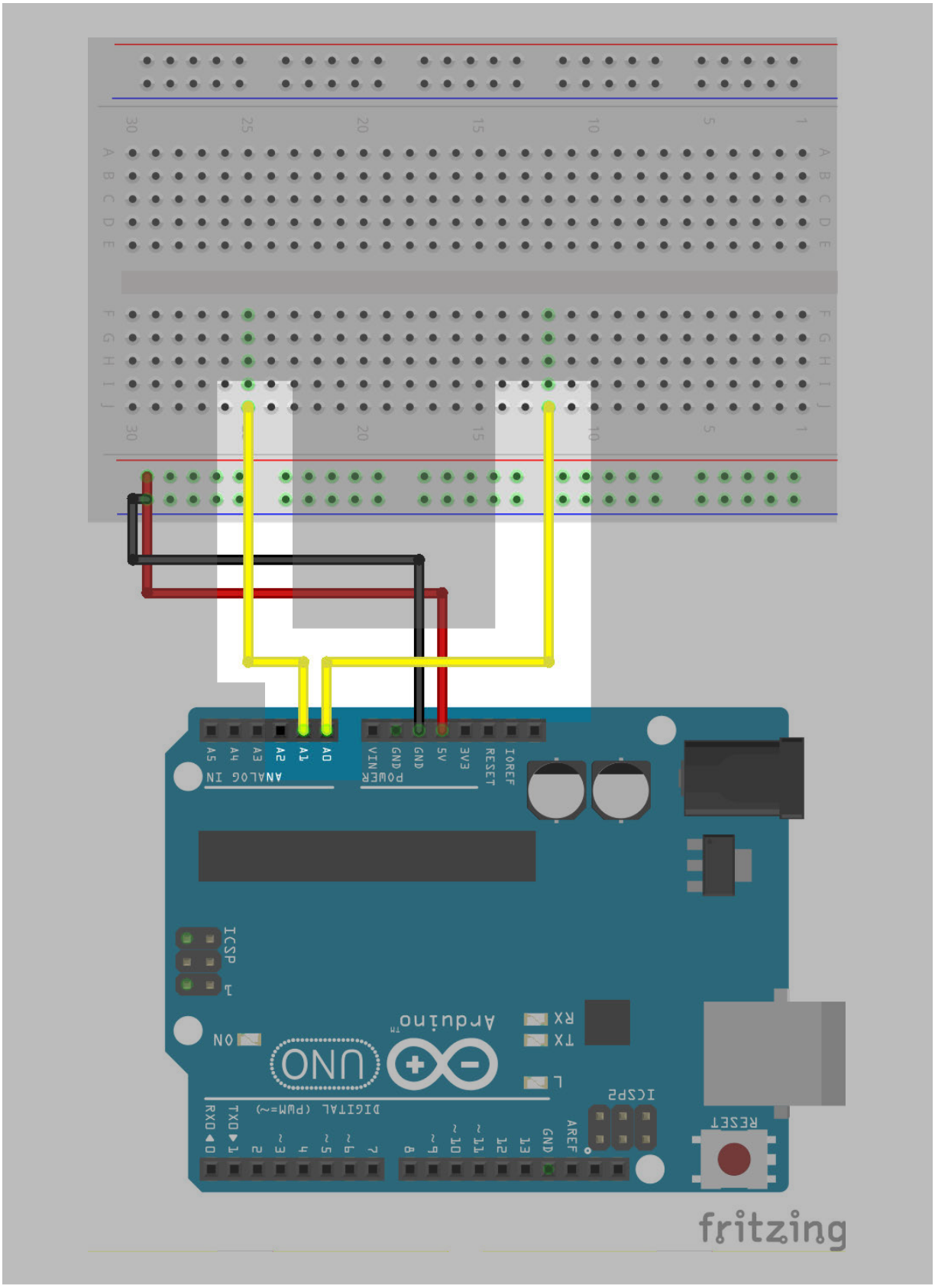
Caution!

The electromagnet can get quite warm, particularly at the terminals, it's ideal to disconnect their batteries at frequent intervals.

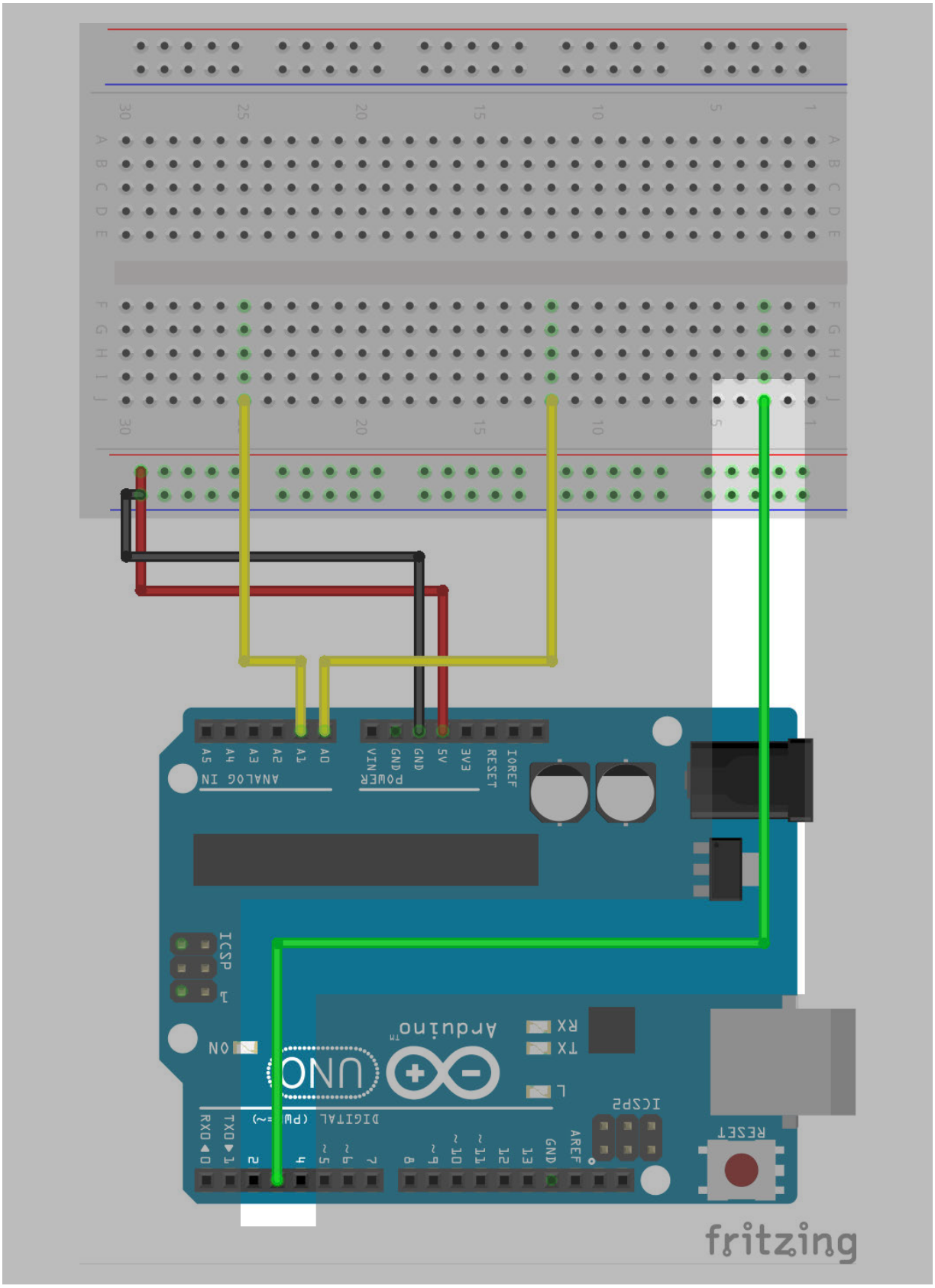
1 Connect a red wire from 5V on your Arduino to your breadboard, and a black wire from GND on your Arduino to your breadboard.



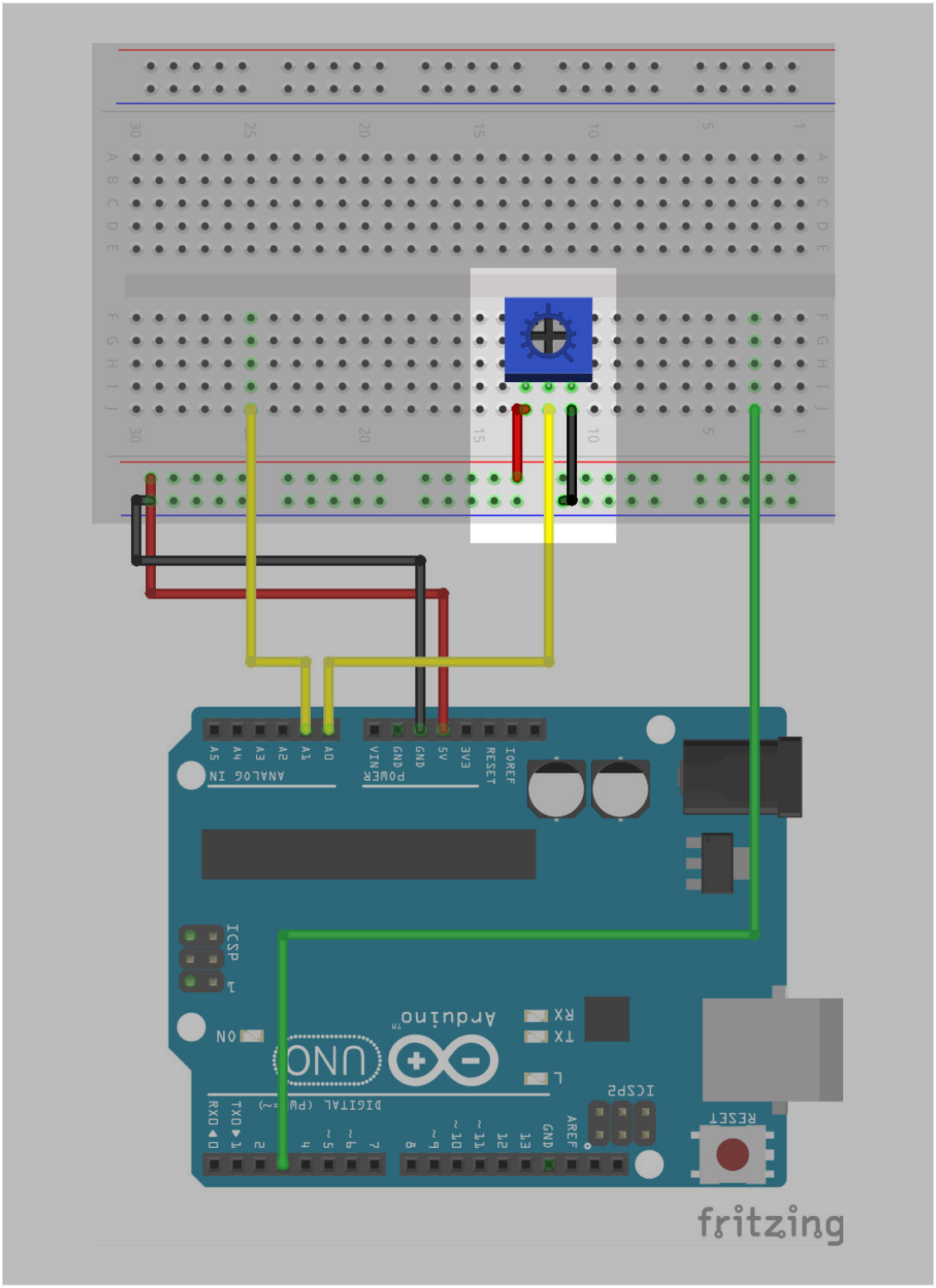
2 Connect a yellow wire from A0 on your Arduino to your breadboard, and another yellow wire from A1 on your Arduino to your breadboard.



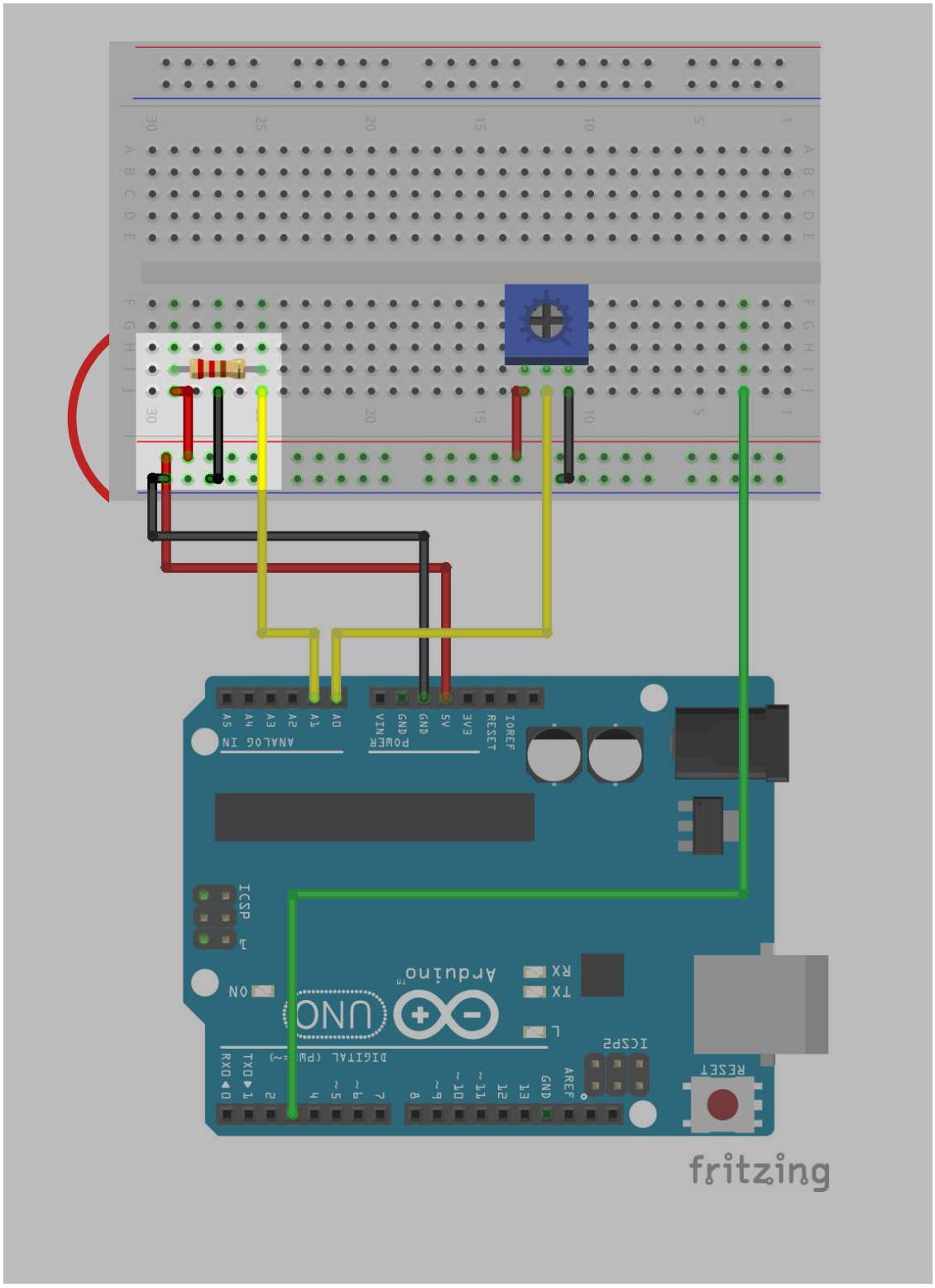
3 Connect a green wire from ~3 on your Arduino to your breadboard.



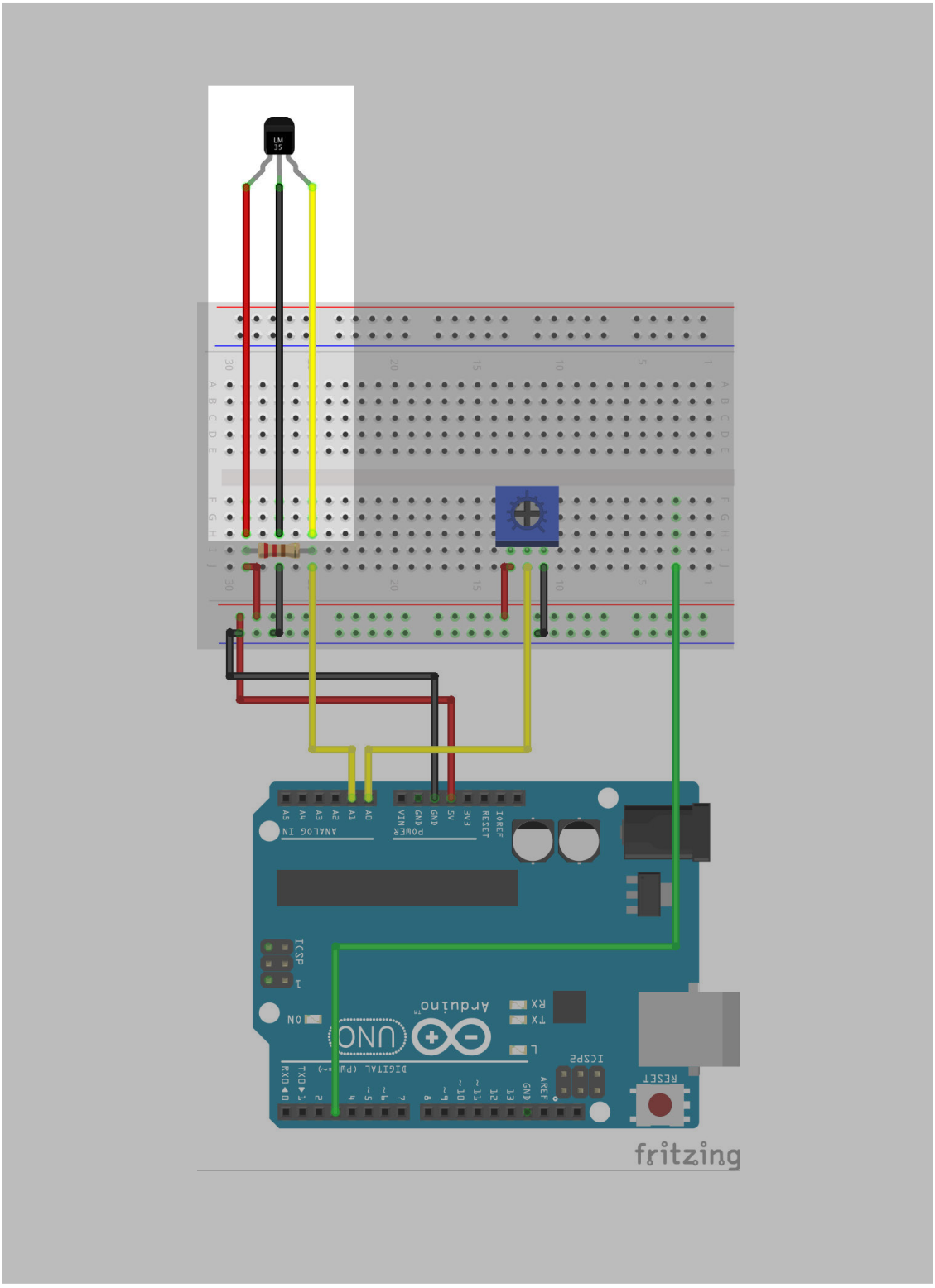
4 Place the potentiometer on the breadboard, so that the middle leg is on the same vertical line as the yellow wire connected to A0. Connect a red wire from the first potentiometer leg to the second row of the breadboard, and a black wire from the third potentiometer leg to the first row of the breadboard.



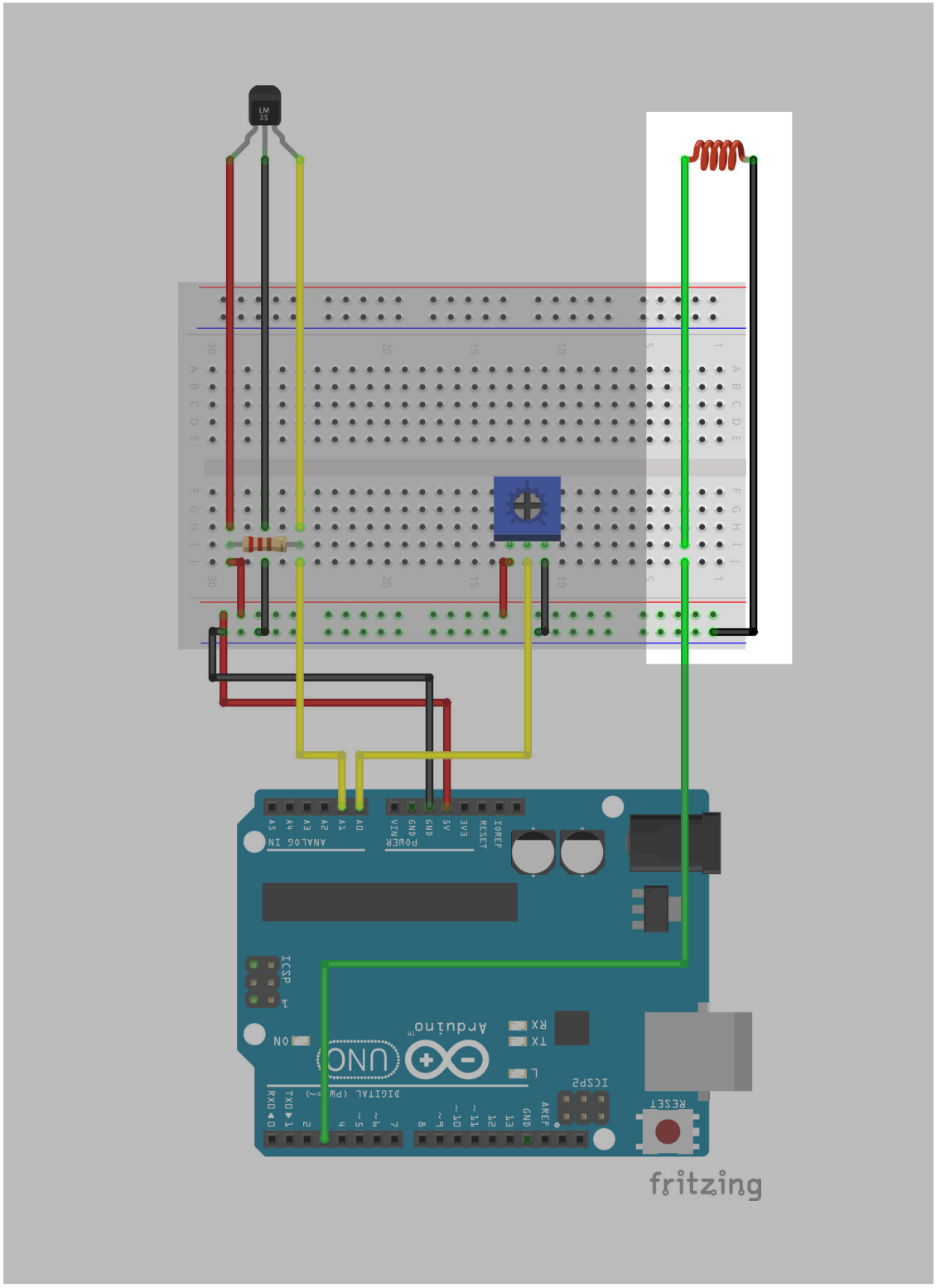
5 Place the resistor so that its right leg is on the same vertical line as the yellow wire connected to A1. Connect a red wire from the first left resistor leg to the second row of your breadboard, and a black wire from the middle of resistor to the first row of the breadboard.



6 Place one red jump wire, one black jump wire and one yellow jump wire before the resistor, on the same vertical line as the wires you just added. Connect them to your hall effect sensor using matching colored alligator clip wires. Make sure the curved side of the sensor is facing you.

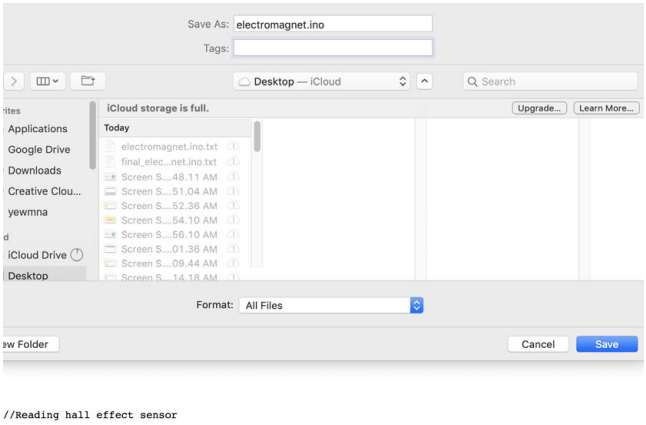


7 Place another green wire on the same vertical line as the green wire connected to ~3 and a black wire on the first row of the breadboard. Connect one side of the electromagnet to the green wire using a matching green alligator clip and the other end to the black wire using a matching black alligator clip.

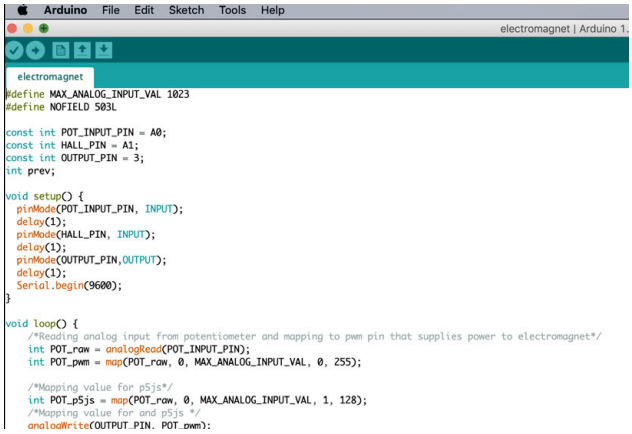


Upload Arduino Code

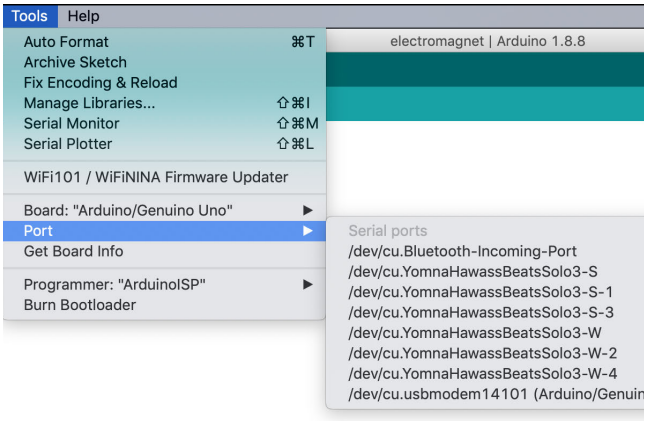
1 Download the Arduino IDE from https://www.arduino.cc/en/Main/Software



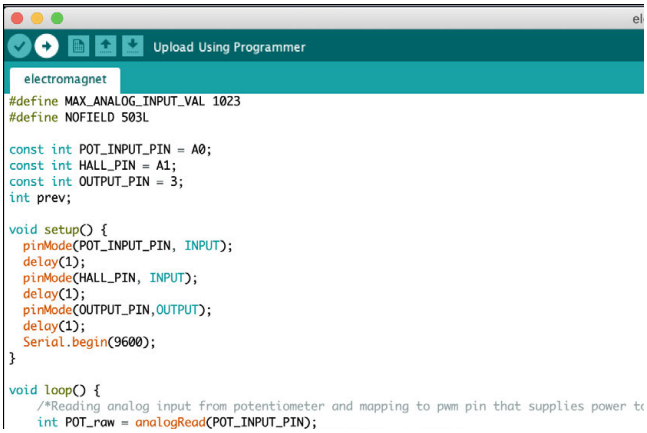
2 Download the Arduino by visiting http://electrocrane.fun/electromagnet.ino and pressing ctrl + s



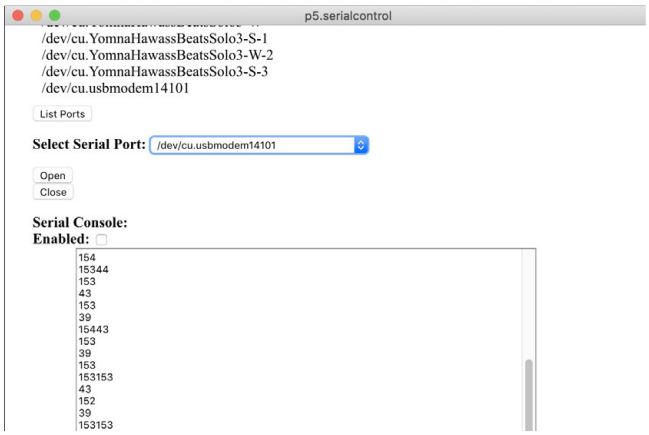
3 Open the file you just downloaded.



4 Select Tools > Port, then click on the port that has the word Arduino in it.

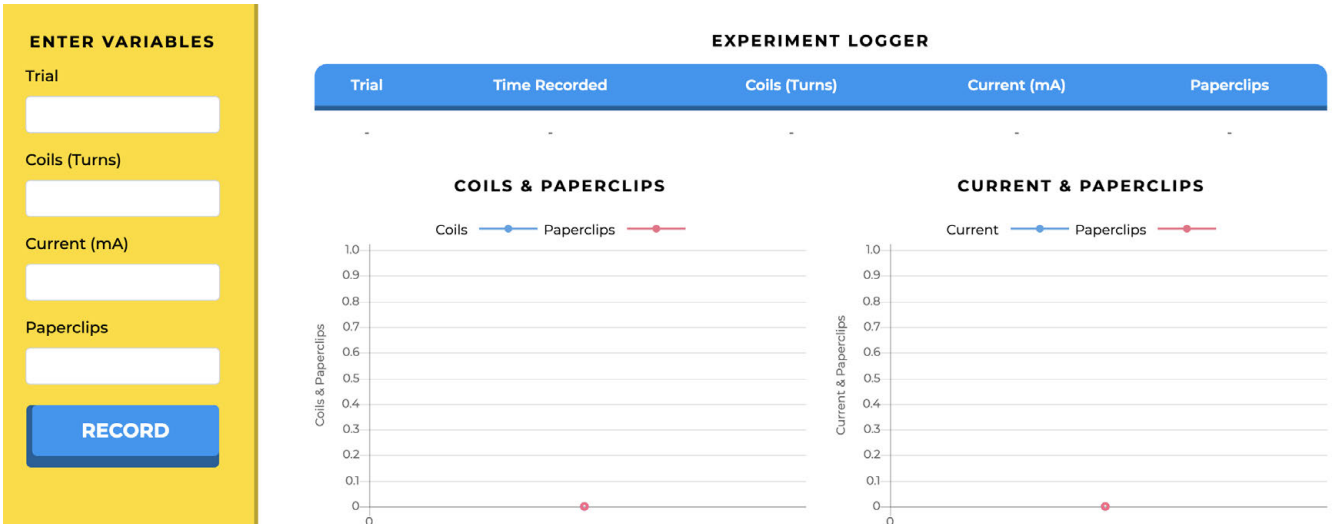


5 Click on the circular right arrow button.

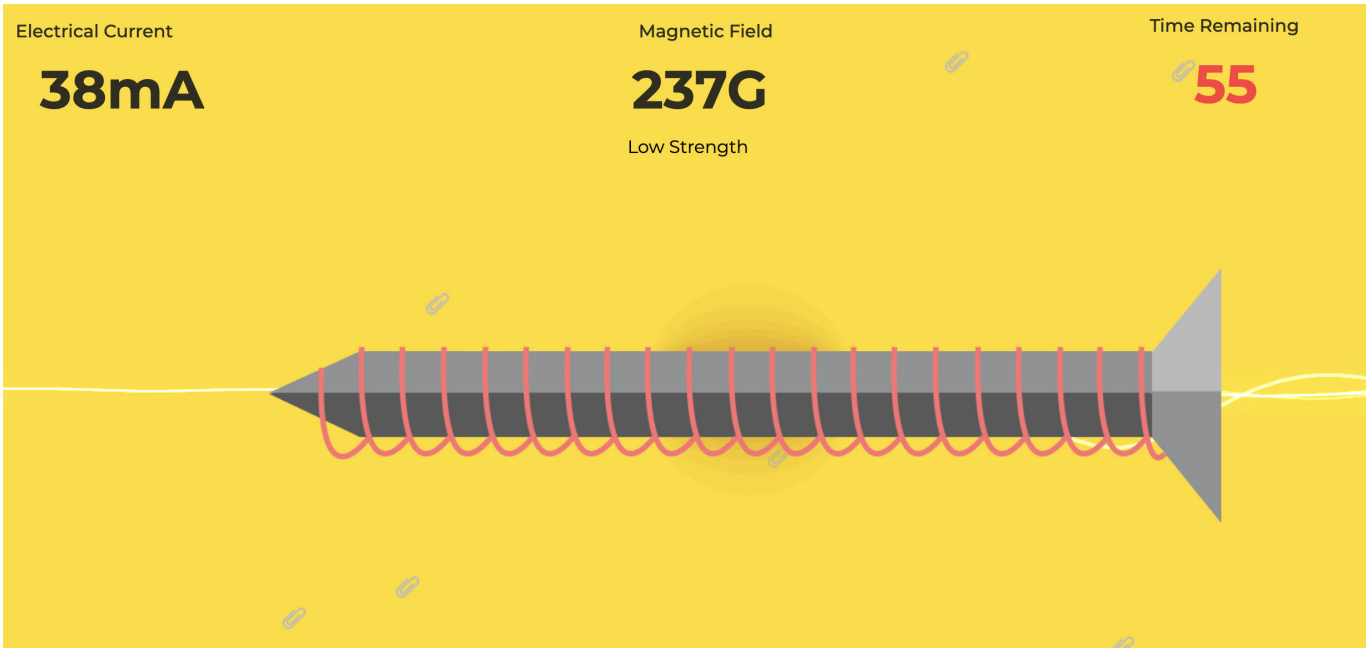


6 Download & install the serial port opener from https://goo.gl/dm2ihw .Open the same port you chose in Step 4.

Start Experimenting



1 Visit electrocrane.fun on your laptop to log the results of your experiments.



2 Visit electrocrane.fun on your phone to see real-time feedback about the strength of your electromagnet.