STANDARDS ADDRESSED:

1.1.5. Develop strategies for self-promotion in the hiring process (e.g., filling out job applications, résumé writing, interviewing skills, portfolio development).
1.1.7. Apply problem-solving and critical-thinking skills to work-related issues when making decisions and formulating solutions.
2.1.5. Compare and contrast alternating current (AC) and direct current (DC).
2.1.6. Define the units of measurement for voltage, current, power, and resistance.
2.1.7. Describe the relationships between voltage, current, resistance, and power in circuits.
2.1.8. Determine voltage, current, resistance, and power in circuits using Ohm's Law, Kirchhoff's Law, and Watt's Law.
2.1.9. Describe the purpose of grounding and common methods used for grounding.
2.9.5 Interpret schematics and control diagrams for building a motor circuit.
3.5.2 Calculate flow, head/pressure, and efficiency.

Circuit Monsters

An electricity review project

Project overview and topics covered

- Employability / Review
- Design for given requirements
- Wearable e-textile components
- Basic hand sewing and pattern making
- Electric theory review
  - Schematic review
  - Circuitry
  - Resistance
  - Power
- Efficiency

Day 1: Project Overview

In the spirit of Halloween, you will create a plush (stuffed-animal-style) monster that lights up when “activated”.

The monster can be as scary or cute as you desire.

Project Requirements - The Monster

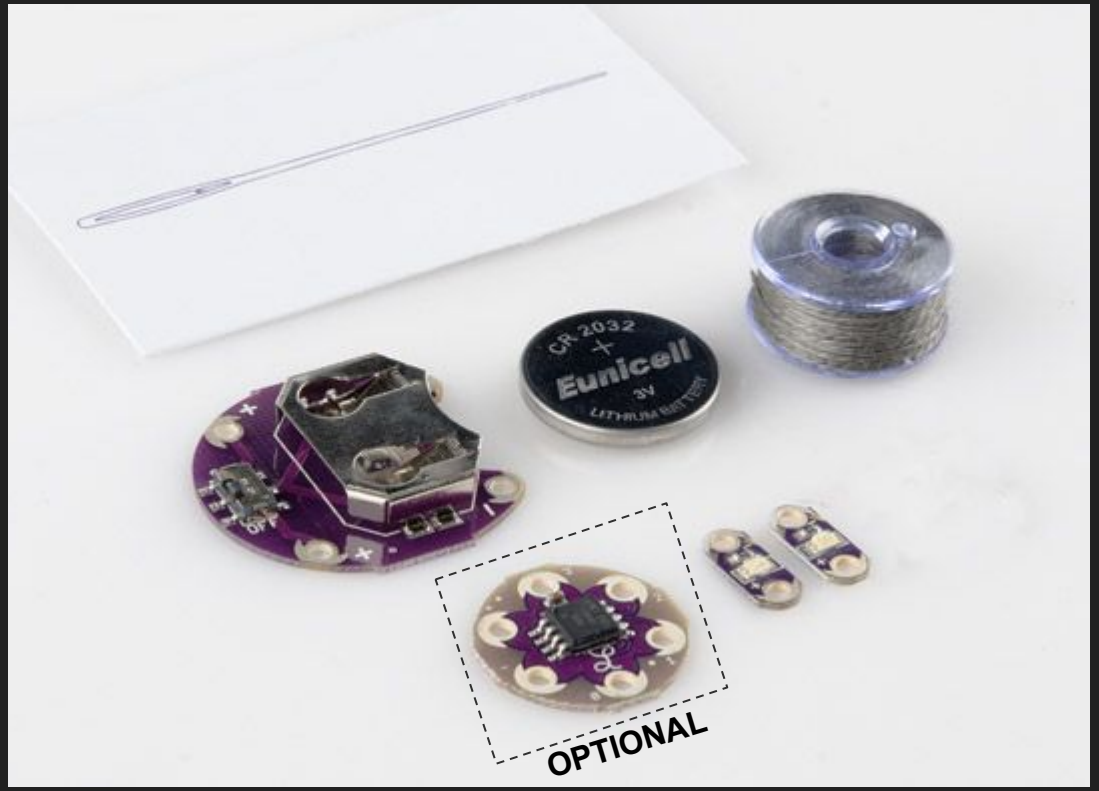
1. The monster should be smaller than 12” x 12” x 4”
2. The pattern for your monster must be approved prior to obtaining additional materials.
3. The monster must have LED’s that, when lit, make the robot more interesting.
4. This monster must be awesome and worthy of the money spent on the components being used to create it.

Note: Available Materials

I have materials (electronics, fabric, etc.) for you to use on this project, but you are welcome to bring in any additional materials that you would like to incorporate into this project.

Electronic Components

- Conductive thread (+ needles)
- Battery holder (including ON/OFF switch)
- 3V coin cell battery
- LEDs and/or micro LEDs
- Lilytwinkle (optional)



A quick note on the “LilyTwinkle”

Four LED’s are connected in parallel from this tiny microcontroller to give off a twinkling effect as the LED’s randomly blink.

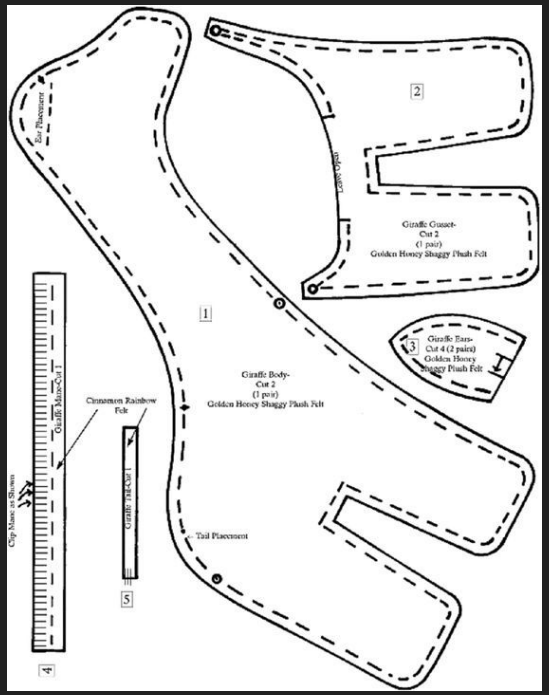
[LilyTwinkle Effect]

Creating your monster pattern

Sketch out your monster on a sheet of paper as a pattern for the material you will cut.

Tips:

- Don’t forget to add a seam allowance all around your sketched pattern (around 1cm)
- Don’t forget about eyes and/or other bling your monster will have.

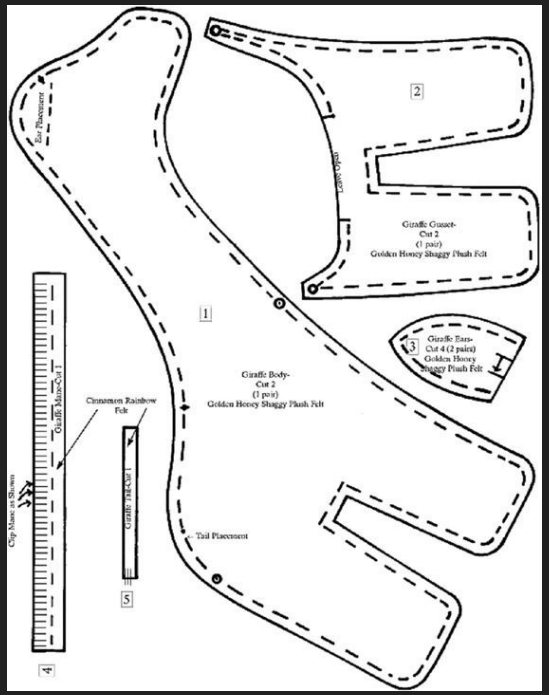


http://allcraftsblogs.com/stuffed_animal_sewing_patterns/giraffe_animal_sewing_pattern/giraffe_animal_sewing_pattern.html

Creating your monster pattern

Tips:

- If you have more than one piece, make sure you have a pattern for each piece.
- Think about what will glow and how your pattern facilitates that.
- Also, make sure you know how the pieces will go together (in what order, how it will be stitched, etc.)



http://allcraftsblogs.com/stuffed_animal_sewing_patterns/giraffe_animal_sewing_pattern/giraffe_animal_sewing_pattern.html

Day 2: The Circuitry

1. You must submit a schematic of the circuit your monster will feature prior to receiving any new components. (The schematic must be in legitimate schematic form - not just a sketch.)
2. Reminder: you must use 2 to 4 LED's.
   a. These LED's can be placed in series or parallel.
   b. These LED's can be used to light up eyes, hearts, or anything else you may want to make glow.
3. You may choose to use a LilyTwinkle microcontroller or not.
4. Your circuit must contain a button to stop and start the flow of current through your monster.
5. Prior to sewing, you need to wire up your circuit to prove it works (using alligator clips as wires to connect the components)

Schematic symbols

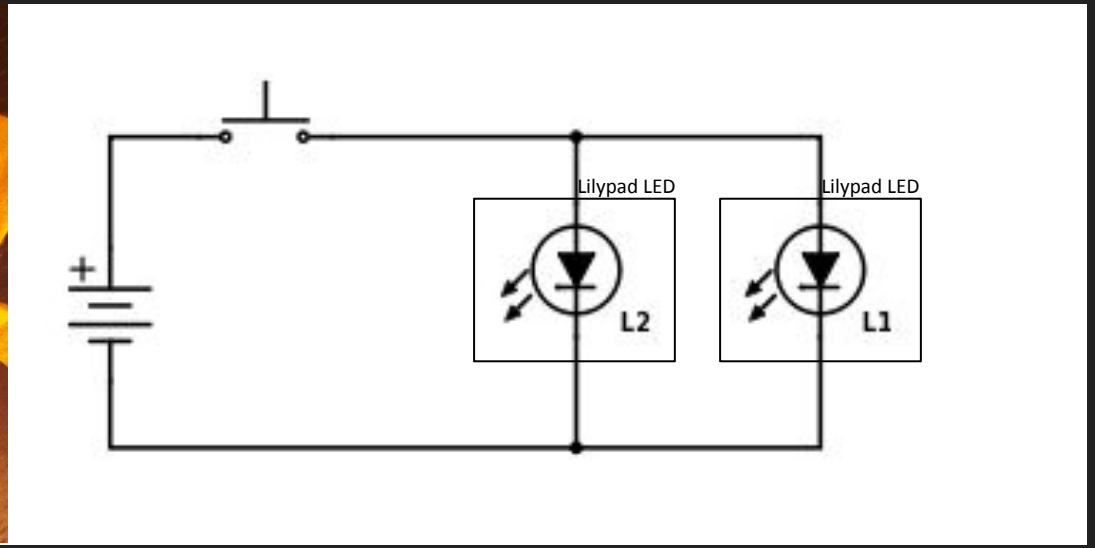
Power / Battery / Cell		 
Ground		
Resistor (Colored bands indicate resistive strength - see cheatsheet for details)		
Diode		
Light Emitting Diode (LED)		
Switch		

Schematic Refresher

Just in case you have forgotten any of the schematic symbols we used, here is a quick refresher game in Quizlet:

https://quizlet.com/235918639/electricity-unit-schematic-review-flash-cards/

Schematic Review Question



Series or parallel?

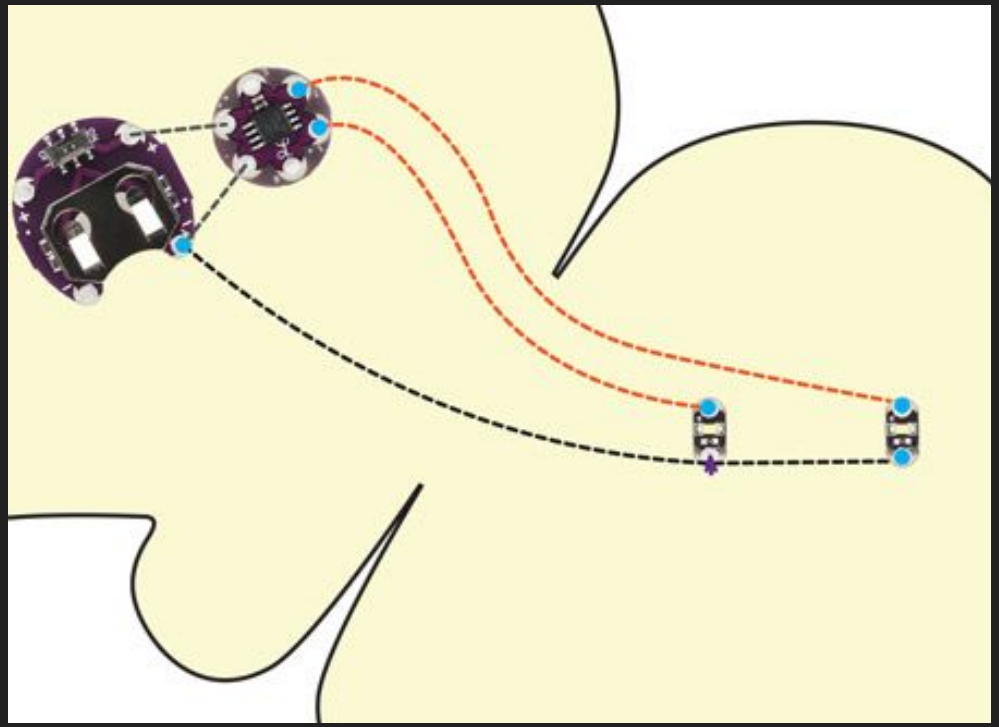
What's missing from this circuit?

Schematic Review Question:

Draw the schematic for this setup.

Note: For the small microcontroller, LilyTwinkle, use the following symbol:

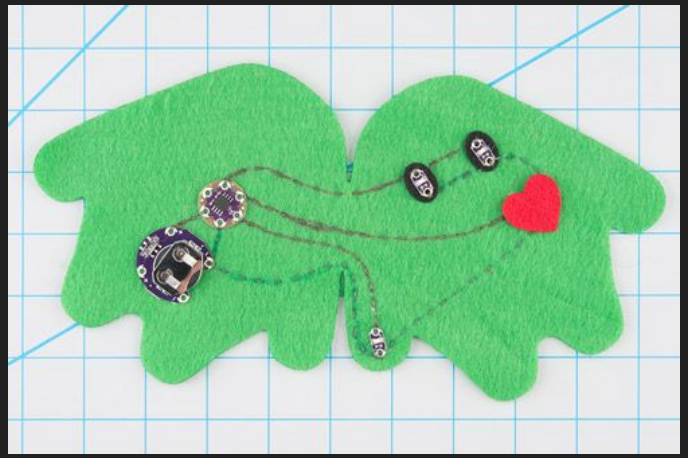
No need to include additional resistors in your schematic (since they are already contained within the LED's)



2014. https://learn.sparkfun.com/tutorials/lilytiny-plush-monster?_ga=1.66649262.1473012636.1478227346

Create your circuit plan

a. Think about what you want to light up and/or blink.
b. Create a fundamental circuit that will achieve that goal on paper (schematic)
c. Test the circuit (unattached to the fabric) to make sure it works.
d. Layout the electrical components on your pattern to ensure it will properly fit
e. Draw the path your conductive thread should follow to correctly connect your circuit.



Example using a lilytwinkle and no button

2014. https://learn.sparkfun.com/tutorials/lilytiny-plush-monster?_ga=1.66649262.1473012636.1478227346

Review activity:

(Please put your name on the top of a paper and answer the following questions.)

1. Draw the schematic symbol for the following:
   a. LED
   b. Battery
   c. Fuse

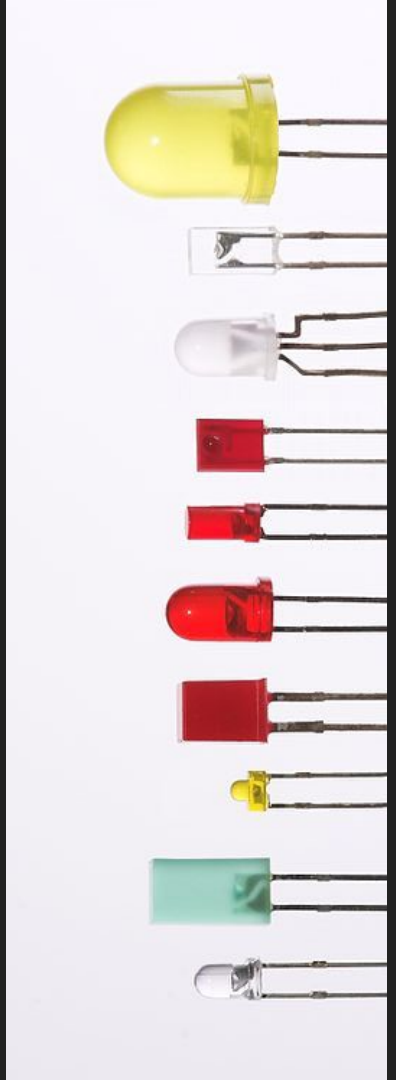
2. LED's have low _____.
3. For a given voltage, this results in a high _____.
4. This relationship exists because of _____.

5. True/False: The current in our e-textiles circuits is very low and therefore we can use LED's without resistors.

Day 3: LED’s in detail

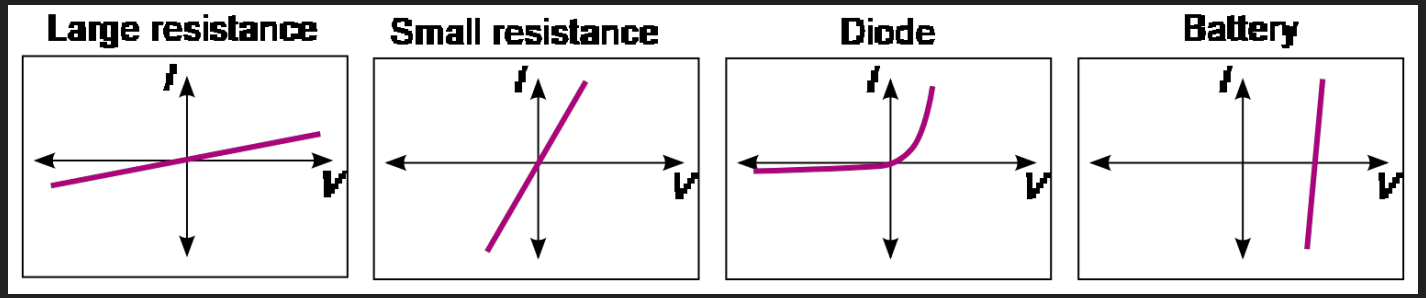
- When using LEDs, you place a resistor in series with the LED to limit the current that can flow through the LED.
- This is because the LED has quite a low resistance and a maximum current.
- You can run LEDs without resistors, but they can get dangerously hot because you are allowing more current than the LED is designed to handle to flow.
- This overloading also caused LED’s to burn out quickly.

Do we need to add a resistor to our LED’s? Why or why not?



A seemingly scary detail about LED's

Ohm's Law and non-ohmic devices



Which graph above represents a non-ohmic device?

(A non-ohmic device simply means a device that does not follow the proportionality in Ohm's Law.)

Non-ohmic device calculations

Seriously? We can't even use the formulas we learned for this nonsense??

Don't worry.

Non-ohmic devices come with data-sheets and graphs that give you the information you need (voltage and current) without having to try to (unsuccessfully) measure it within an actual circuit.

Our LED Data Sheet

Given this information, what resistor is needed for a circuit containing this LED (assuming we are using a 5V battery)?

Electrical / Optical Characteristics at TA=25°C

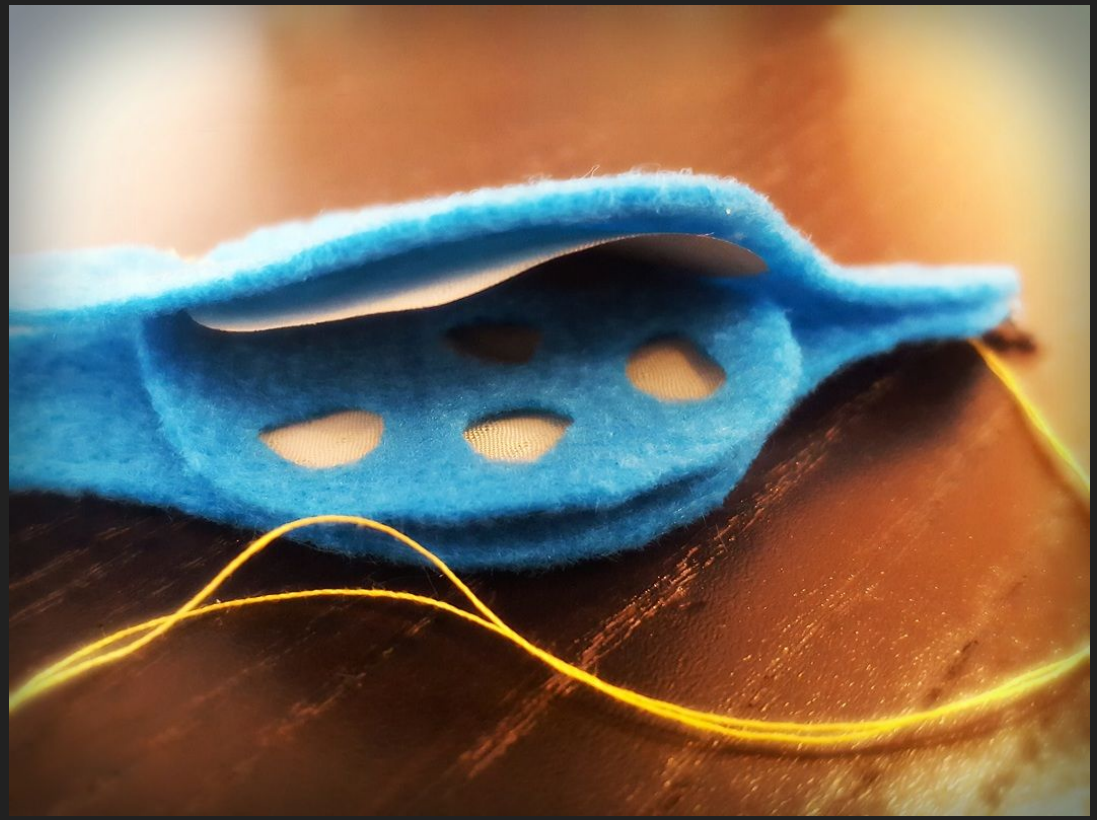
Symbol	Parameter	Device	Typ.	Max.	Units	Test Conditions
V_F [1]	Forward Voltage	White	3.3	4.0	V	I_F=20mA
I_R	Reverse Current	White		10	uA	V_R = 5V
X [2]	Chromaticity Coordinates	White	0.31			
Y [2]			0.31			
C	Capacitance	White	100		pF	V_F=0V;f=1MHz

Notes:
1. Forward Voltage: +/-0.1V.
2: Measurement Tolerance Of The Chromaticity Coordinates Is ±0.01.

Hint: What is the total voltage for a series circuit?

R (Required) = V / I = (5-3.3)V / 0.02A = 90 ohms

Day 4: Create a button



This is one piece of the project I expect you to take some initiative to figure out.

I have posted a link to a few tutorials from sparkfun.com below for your reference:

- Basic e-textiles tutorial
- LilyTwinkle tutorial
- E-textiles button tutorial

Review Questions

The opposition to current is measured in what unit?

Electromotive force is measured in what unit?

Efficiency

Efficiency = Output / Input

If you supply a complicated system with 10W of power and only 8W is output, what is the efficiency of the system?

Review Questions:

The three basic principles:

- _____ is the difference in charge between two points.
- _____ is the rate at which charge is flowing.
- _____ is a material's tendency to resist the flow of charge (current).

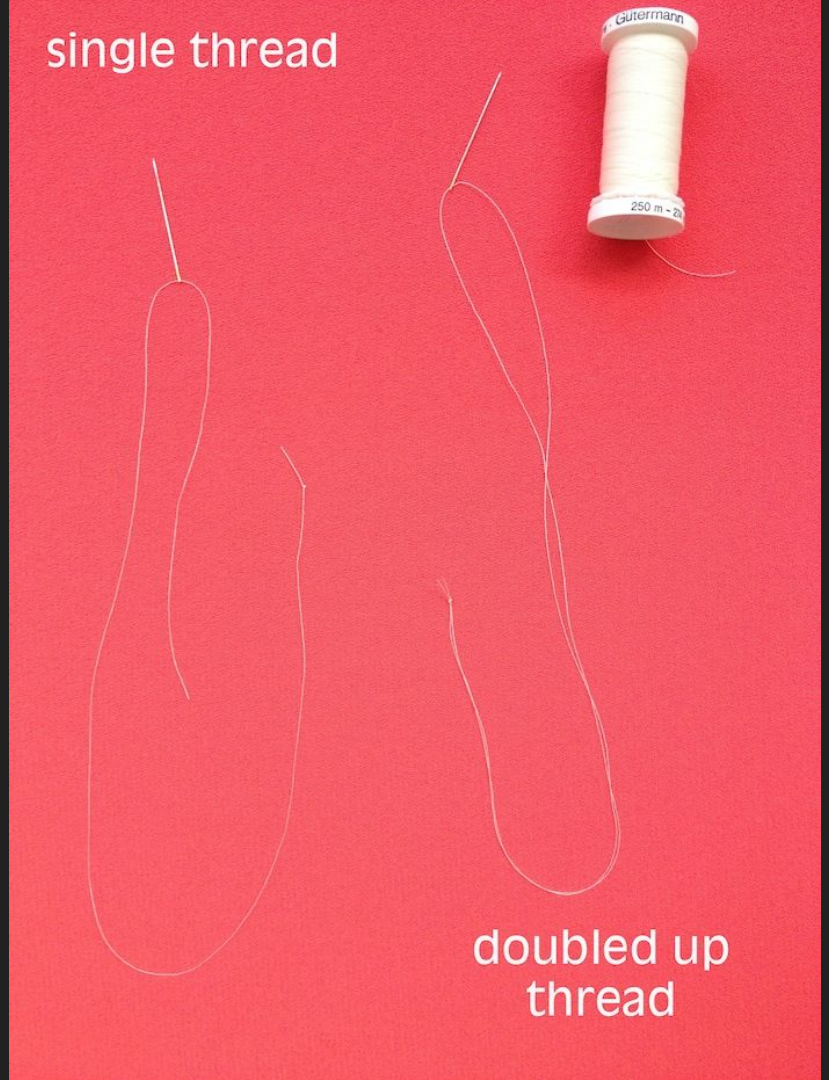
Review Questions:

What is the resistance in a circuit if it is supplied by a 5V battery and has 0.2Amps of current?

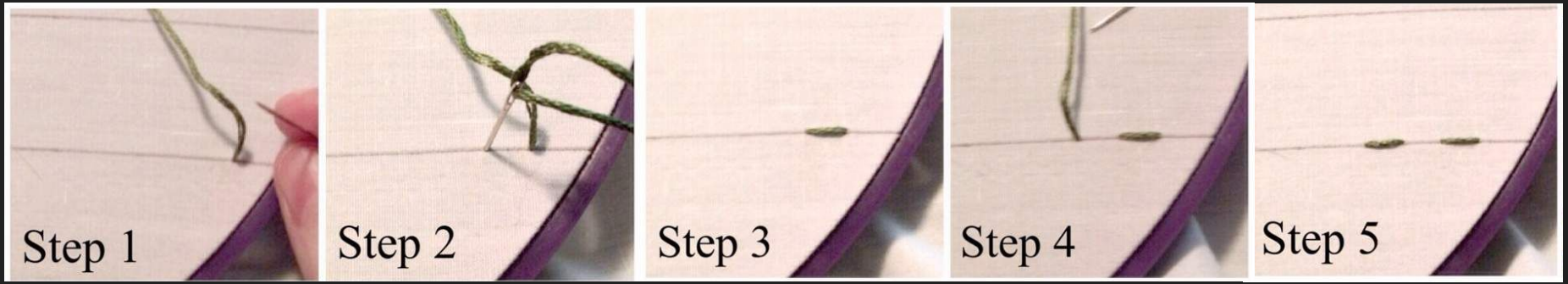
What power is supplied by a circuit with a 100 ohms of resistance and 1.5V battery supply?

Day 5: Understanding Sewing

Getting started - HOW TO THREAD A NEEDLE



How to use your conductive thread as wire: RUNNING STITCH



Cut fabric pieces from your pattern

That’s it.

Cut out the pieces so we can see how they will look all together as an official monster.

Make sure you cut 2 pieces of any component that will need a front and back.

Power Review

What is Power?

DC (Direct Current)

- Current flows in one direction
- Supplied from a charge storage device (battery, etc.)

AC (Alternating Current)

- The flow of electricity changes/reverses direction
- Supplied from an outlet (plugged in)

Review Questions:

What kind of power is being supplied to the Arduinos?

How much power is required for a circuit that has a 5V (USB) and 150 ohms of resistance?

Day 6: Hand-sew your circuit

Series vs. Parallel Circuits Review

Resistances

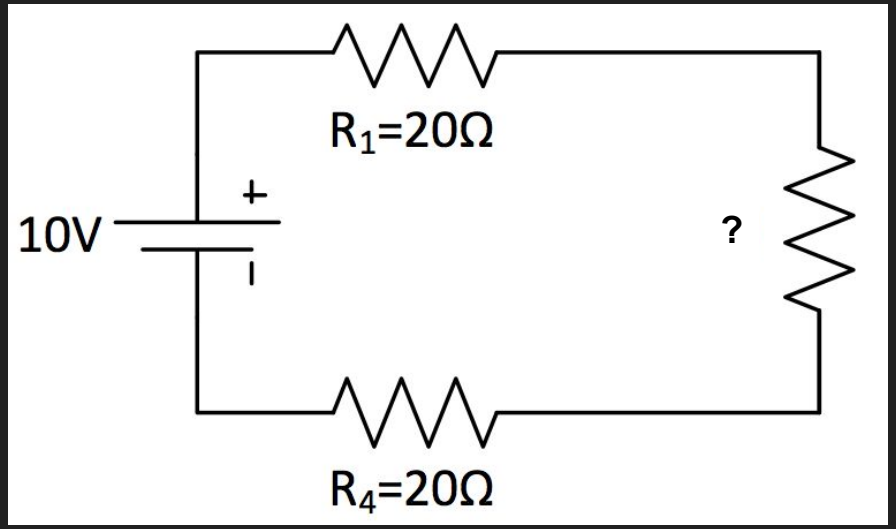
$$R_{series} = R_1 + R_2 + \ldots R_n$$

$$R_{parallel} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \ldots \frac{1}{R_n}}$$

Need a little refresher: Series and parallel resistance calculation Kahoot

Review:

For the given DC series circuit with 3 resistors, a 10V supply, and 0.125 amps of current, calculate the value of the unknown resistor.



Project tips and reminders:

- Do not sew any components in with the battery installed. There is no risk of getting hurt, but you will drain the battery.
- Any time you make a connection between a component and the thread, make a few loops through the connection hole. The section of metal on the outside of the connection hole is where current will flow between the thread and the component. Often, if there is a short or break in your circuit it is because the conductive thread does not always touch this pad on the component.
- If you have two threads that need to cross, there must be an insulator between them, otherwise the circuit will not work. Try a piece of fabric or a layer of glue.
- There are other conductive e-textile materials such as buttons, fabric, yarn, paint and velcro. There are many different ways to use the materials as switches, sensors and more. Have fun and experiment!

More Sewing Tips and Reminders

- Make sure to pull your thread all of the way through your fabric to eliminate loose sewing traces.
- Be sure to cinch each stitch tight to keep a solid connection.
- Loop your thread around each pin 2-3 times to make a secure connection.
- Keep your stitches close together, and make sure the gaps aren't too big.
- Cut your knots down to keep your ends from touching each other. The cleaner you keep your stitching (circuitry) the higher the chances are of getting your project to work on the first try.
- There's a tendency to hide stitches, and hidden stitches are hard to troubleshoot. If you're going to hide a stitch within the fabric make sure to check the trace before covering it up with other fabric.

Day 7: Troubleshooting / Confirm your circuit operation

Is everything lighting up that you think should be?

Is it lighting up as you expected?

Will it create the “glowing” effect you are hoping for?

Troubleshooting and common problems

Step one (ALWAYS): Identify the problem

What is actually going wrong? Without understanding the problem, it's impossible to know where to start to fix it!

Most common problem:

- Loose sewing traces: Pull everything tight with tweezers or your sewing needle to tighten up the sewing traces. You may also sew over the top of an existing trace.

Troubleshooting and common problems

Step one (ALWAYS): Identify the problem

Other common problems:

- Running out of thread: Loop around the existing thread about three to four stitches back. Follow that sewing trace so that the two lines are parallel and touching.
- Bypassing the switch: Use a piece of wire or integrated circuit hooks to jump individual components directly to the battery or the microcontroller. This will tell you if the stitch or the component is the problem.
- LEDs not working? Double check your polarity. (Did you sew into the positive when you meant to sew to the negative?)

Day 8: Stitch and stuff your monster

If you will need to flip your monster inside out to complete the project, make sure you leave enough space UNSTITCHED for the flipping.

Employability Skills - Resume review

After this project, what will we have we done in this class that you could add to your resume?

- Experience building and using VEX robots
- Experience with an Arduino control system
- Experience programming in C++
- Experience with e-textiles and related electronics