Sensory Substitution

Student Lab Notebook

CENTER FOR
SENSORIMOTOR NEURAL
ENGINEERING

Name: _____

Student Handout 1.1: What is the problem we are trying to solve?

Name:_____ Date:_____

Period:_____

If you lost or damaged your sense of _____….

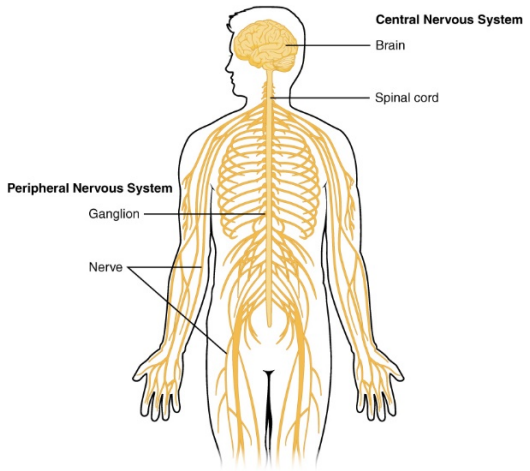
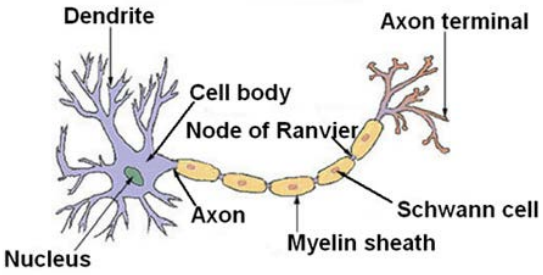
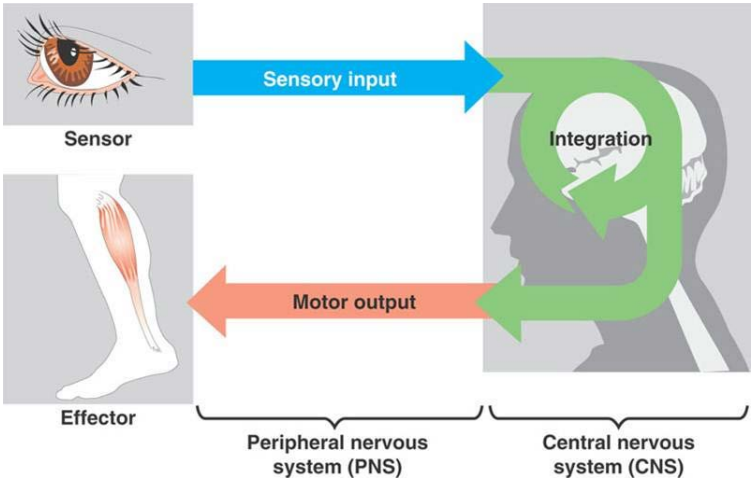
	Sight	Hearing	Touch
….what would you be able to do well or better?			
….what would be more challenging for you to do (but you could still do)?			
….what would be very hard to do?			

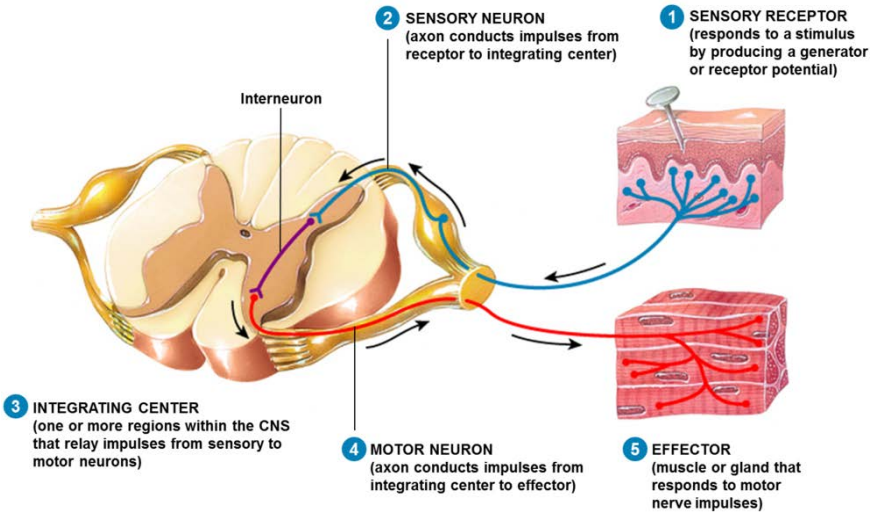
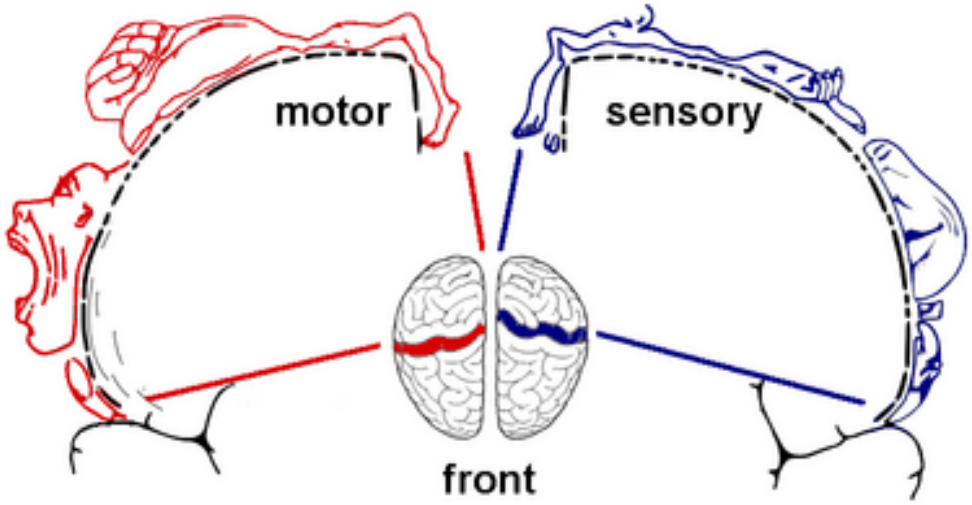
What assumptions are we making about what people need to function daily?

Student Handout 1.2: Nervous System Diagrams

Name:_____ Date:_____

Period:_____

A.	 By OpenStax - https://cnx.org/contents/FPtK1zmh@8.25:fEI3C8Ot@10/Preface, CC BY 4.0,
B.	 https://upload.wikimedia.org/wikipedia/commons/b/bd/Neuron.jpg
C.	 http://www.proprofs.com/flashcards/upload/a7106439.jpg

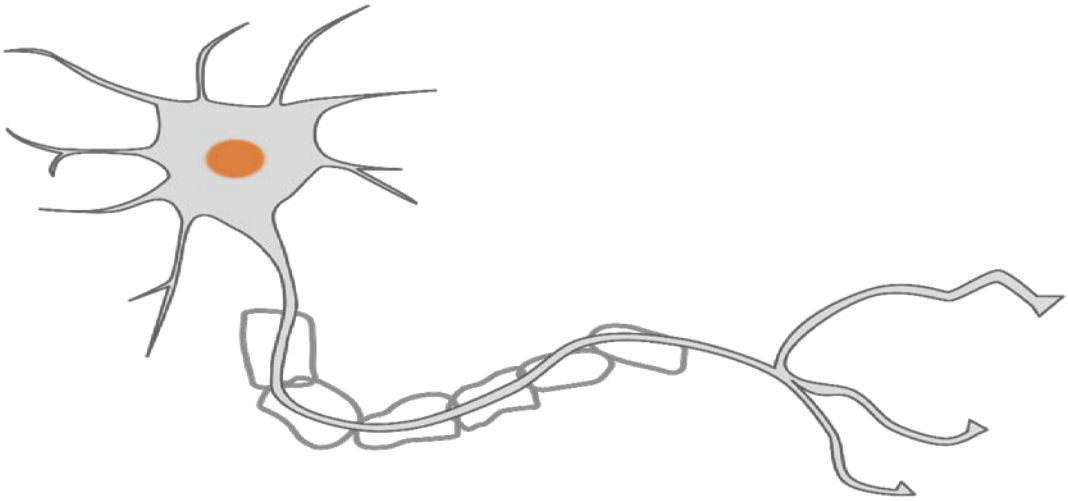
D.	 http://images.rapgenius.com/15bbff4d8aca800d8f495444dbcee8c8.1000x594x1.png
E.	 https://neuwritesd.files.wordpress.com/2013/08/homunculi.png

Main Take-Aways:

Student Handout 1.3: The Neuron

Name:_____ Date:_____

Period:_____



Part of Neuron	Why it's important	How you'll remember where it is and what it's for
Dendrites		
Cell Body		
Nucleus		
Axon		
Myelin		
Axon Terminal		

The Synapse

https://pixabay.com/en/science-neuron-synapse-biology-305773/

The **synapse** is the _____ between two _____ (or between a neuron and a muscle/gland).

When the _____ signal that traveled through the _____ reaches the axon terminal, _____ are released. These neurotransmitters are a _____ signal that travels across the _____. Receptors for the neurotransmitters are located on the _____ of the next neuron (or muscle or gland)

To summarize:

- _____ signals travel _____ a neuron.
- _____ signals (neurotransmitters) travel _____ neurons.

Word Bank: Electrical Chemical Space Between Across Dendrites Axon Synapse Neurons Neurotransmitters

Student Handout 3.1: Prosthetic Fingers

Name:_____ Date:_____

Period:_____

Day 1: Making a Prosthetic Finger

Brainstorm

What are different types of functions a hand can perform? If you didn't have a hand, what could you not do? Describe/diagram.

If you were to design a prosthetic hand, what considerations would you prioritize? What would it look like? What would it do?

Procedures

1. Combine 100 mL of alginate powder and 90 mL of warm water in a small Dixie cup.
2. Stir with popsicle stick.
3. Use popsicle stick to apply alginate over one whole finger. Be sure to cover all holes and apply an even layer about 1.0-1.5 cm thick.
4. Allow to dry for a few minutes, then carefully remove finger.
5. Place mold in film canister.
6. Obtain silicone mixture from your teacher (2.0 mL Cure Accelerator, 5.0 mL Curing Agent, 40 mL Silastic Rubber Base).
7. Pour silicone into mold. Allow to sit overnight.
8. Use a dry paper towel to wipe off your finger, then wash with soap and water.
9. The next day, peel off alginate mold to reveal the cast of your finger!

Day 2: Observations of Prosthetic Finger

Sketch and **label** and/or **describe** your prosthetic.

How is your prosthetic **similar** to your real finger?

How is your prosthetic **different** from your real finger?

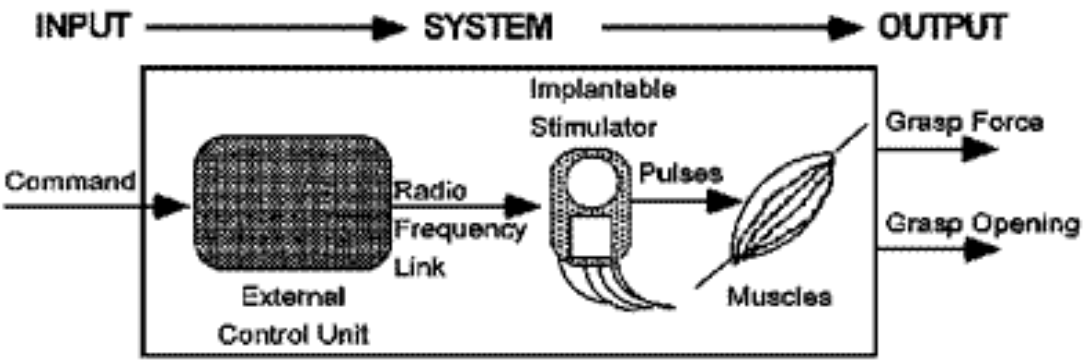
Brainstorm some **modifications** that would make this prosthetic finger more "real." Think of both **functional** and **structural** modifications.

Student Handout 4.1: Assistive Devices v. Neuroprosthetics

Name:_____ Date:_____

Period:_____

Definition	Examples
Assistive Device -	
Neuroprosthetic -	



http://www.rehab.research.va.gov/jour/00/37/1/memberg.htm

Sensory Substitution

Notes	Questions

https://pixabay.com/en/toys-mr-potato-head-fun-happy-cute-488397/

Brainstorm of Ideas for Sensory Substitution Devices

Impaired or Absent Sense	Substituting/ Replacement Sense	Description of Device

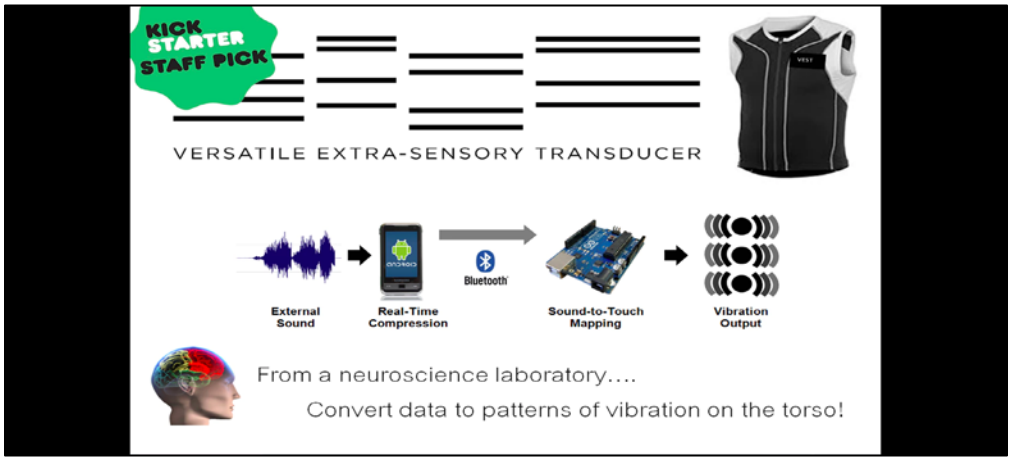
Student Handout 4.2: Sensory Substitution Video and Questions

Name:_____ Date:_____
Period:_____

The VEST by David Eagleman and Scott Novich

Watch this video: https://www.youtube.com/watch?v=kbKzF8gKxT4 (3:13 minutes)

Background information: David Eagleman is a neuroscientist at Stanford. Scott Novich is his graduate student. Together they are working on VEST (Versatile Extra-Sensory Transducer).



Citation: From Kickstarter.org

Questions to answer in your lab notebook as you watch the video:

1. What are the senses involved in the VEST?

2. What is the input of the VEST? What is used to process the information? What is the output?

3. Explain how this is an example of a sensory substitution device.

4. What are the advantages of this device over the cochlear implant?

5. What disadvantages can you imagine for this device?

6. Can you think of other sensory substitution devices that could be designed to do similar things?

7. Can you think of other senses for which you can design a sensory substitution device?

Student Handout 5.1: Stella Young's TED Talk

Name:_____ Date:_____
Period:_____

Before watching the video, answer the following questions. Don't worry about right or wrong answers. Be honest and answer to the best of your ability.

1. What does it mean to be *normal*?

2. What role does our society/culture play with regards to persons with disabilities?

3. What are some examples of how persons with disabilities use technology?

4. What do you think the role of technology *should* be regarding persons with disabilities?

5. Do you know anyone with a disability? If so, what type(s) of disability?

After the video:

When considering the person for whom you are designing a sensory substitution device, what assumptions might you be making? What questions would you want to ask that individual or group of individuals?

Assumptions	Questions

Student Handout 6.1: Exploring Circuits

Name:_____ Date:_____

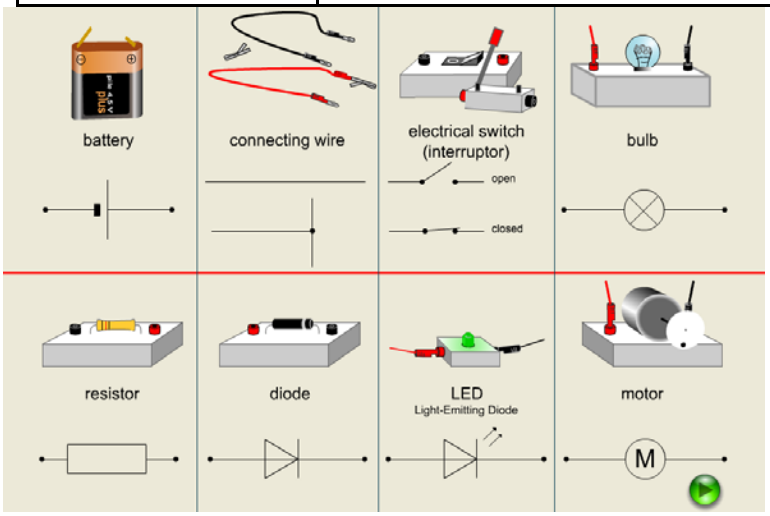
Period:_____

Go to the website: http://www.physics-chemistry-interactive-flash-animation.com/electricity_interactive.htm

Go through the Basic Circuits animations (1-6) and write/draw your observations.

Animation	Observation/Notes/Diagrams
1 - Simple Circuit	
2 - Parallel or Series Circuit	Series Parallel
3 - Short Circuit Activity	

4 - Short Circuit - Why it's dangerous	
5 - Circuit Diagram (see below for symbols)	
6 - Conductors v.Insulators	<u>Conductors</u> <u>Insulators</u>



Student Handout 6.2: Snap Circuit Components

Name:_____ Date:_____

Period:_____

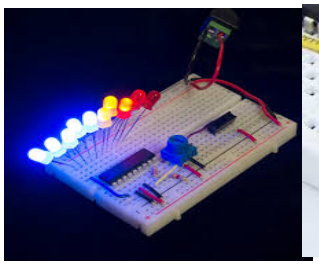
What does each do?

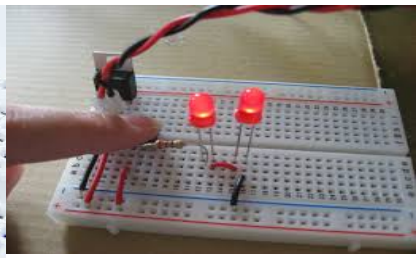
Component			Notes
B1	Battery Holder - uses 2 1.5V type AA (not included)		
S1	Slide Switch		
S2	Press Switch		
RP	Photoresistor		
R1	100Ω Resistor		
RV	Adjustable Resistor		
L1	2.5V Lamp Socket 3.2V Bulb (3.2V, 0.2A) Type 14 or similar		
D1	Red Light Emitting Diode (LED)		
M1	Motor Fan		

Student Handout 7.1: Introduction to Breadboards

Name:_____ Date:_____

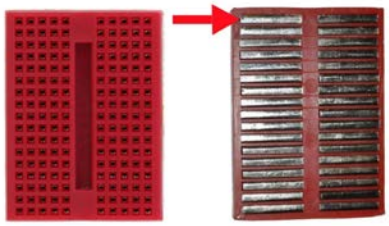
Period:_____



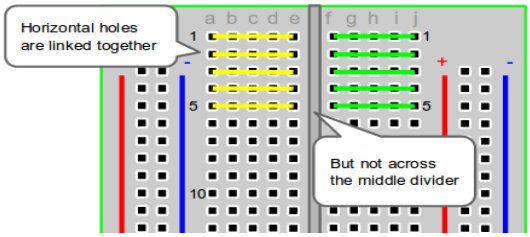


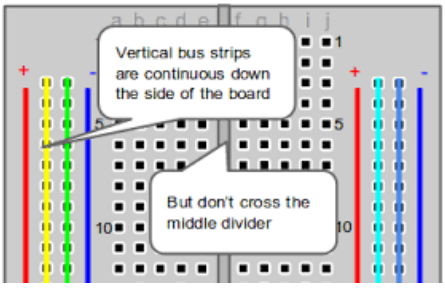
What is a breadboard?

A breadboard is a device that allows you to build basic to intricate circuits. Here is how it works…



If we open up a breadboard and look inside, this is what you will find (left). Metal rows, which means every row is connected. Each column is not!



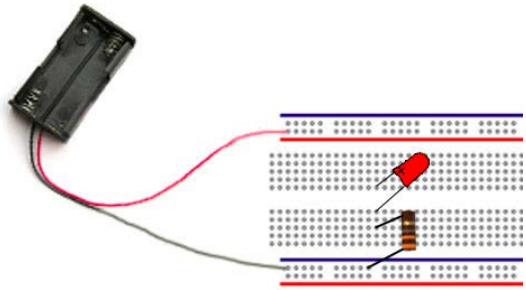


The two columns along the side are for powering the board. You will notice a (+) on one side and a (-) on the other. When connecting a battery pack, the red wire goes to (+) and the black wire goes to (-).

Connect any wire from the power columns to the board to power your circuit. You can watch this detailed how-to video for more explanation. The first six minutes are best! How to Use a Breadboard from Science Buddies TV: https://www.youtube.com/watch?v=6WReFkfrUIk.

You will often need a resistor to make sure your circuit works**.** A resistor is a component that reduces the voltage traveling through the circuit. This is important because different pieces need different amounts of power even when they are in the same circuit! If you don't use a resistor, you can damage components, like burn out an LED, or your circuit simply just won't work! It can be hard to determine what resistor to use for your circuit. Each resistor reduces electricity by a certain amount. The best method is to do some research and find out what is best based on your project.

Do this: On the diagram to the right,



1. Label the battery pack, (+) column, LED, resistor, and (-) column.

2. Is the circuit open or closed? How do you know?

3. What might you add to the circuit to make it work? Draw it in and label.

TASK 1:

Let's try using it! You will need: two AA batteries, a battery holder, 1 LED, 330 ohm (Ω) resistor, and jumper wires

Step 1: Power your bread board by connecting the red wire to the **positive column** and the black wire to the **negative column**.

Step 2: Place your LED in the breadboard. Be sure to place the two leads into different **rows.**

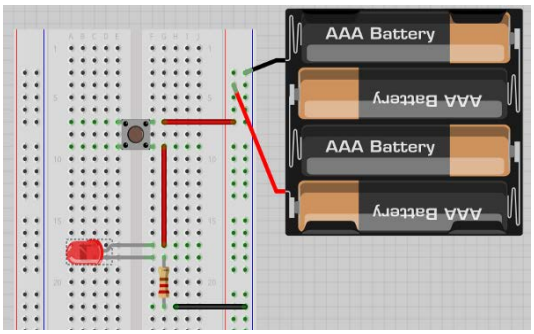
Step 3: Use a red wire to connect the **positive column** to the **positive lead** (the longer one!) of your LED.

Step 4: Connect one end of the resistor on the same row as the **negative lead** (the shorter one!) of your LED, and the other end in a different row (NOT the same row as the positive lead of the LED).

Step 5: Use a black wire to connect the resistor to the **negative column** of your bread board.

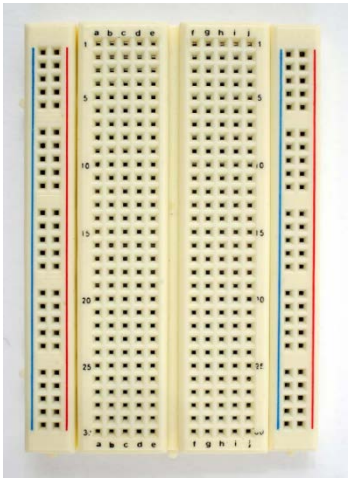
Congratulations! Your light should be on, you have successfully used a breadboard to complete a circuit!

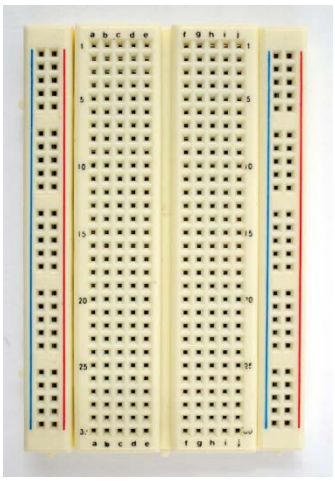
TASK 2: Try building the circuit diagrammed below! Gather your supplies (LED, resistor, push button, battery pack - it's okay to use two batteries only), then build the circuit.



TASK 3: Instead of an LED, can you attach a motor to your circuit so that the button turns the motor on and off (a motor requires more current than an LED)? Or can you connect multiple

LEDS to your breadboard (try in parallel and in series)? Draw your breadboard set-up(s) below and label.





TASK 4: Instead of a button, can you connect a potentiometer to your circuit? A potentiometer acts like a dimmer switch, changing the brightness of your light! Here is a helpful guide: Dimmer Switch Step by Step Guide, available at: http://www.instructables.com/id/How-to-control-the-brightness-of-a-LED/

Reflection

1. How does a breadboard work? Explain its layout and how its construction makes it a helpful tool.

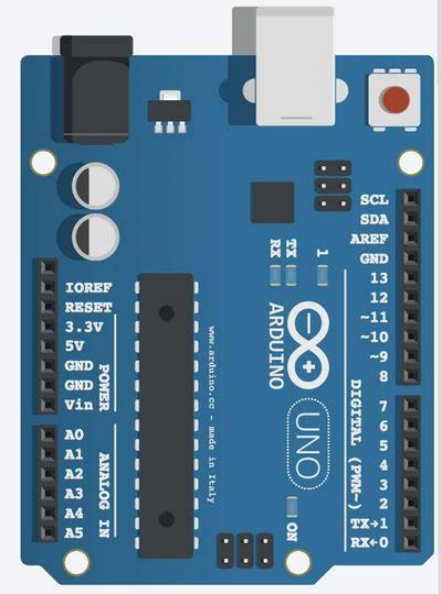
2. Explain the role of each of the following components:

Battery	
Wires	
Push Button	
LED	
Resistor	
Potentiometer	

Student Handout 8.1: Introduction to Arduinos

Name:_____ Date:_____
Period:_____

Label the parts in the diagram below.



https://cdn.instructables.com/F6R/IPAP/HQF9H5IO/F6RIPAPHQF9H5IO.MEDIUM.jpg

Label the parts in the basic Arduino sketch below.

```
/*
  Blink
  Turns on an LED on for one second, then off for one second, repeatedly.

  Most Arduinos have an on-board LED you can control. On the Uno and
  Leonardo, it is attached to digital pin 13. If you're unsure what
  pin the on-board LED is connected to on your Arduino model, check
  the documentation at http://www.arduino.cc

  This example code is in the public domain.

  modified 8 May 2014
  by Scott Fitzgerald
 */


// the setup function runs once when you press reset or power the board
void setup() {
  // initialize digital pin 13 as an output.
  pinMode(13, OUTPUT);
}

// the loop function runs over and over again forever
void loop() {
  digitalWrite(13, HIGH);   // turn the LED on (HIGH is the voltage level)
  delay(1000);              // wait for a second
  digitalWrite(13, LOW);    // turn the LED off by making the voltage LOW
  delay(1000);              // wait for a second
}
```

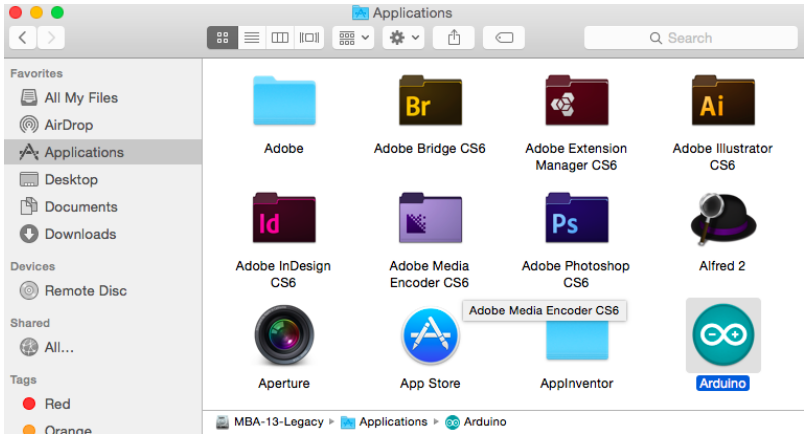
What can you conclude about what the following code does?

```
/*
 Conditionals - If statement

 This example demonstrates the use of if() statements.
 It reads the state of a potentiometer (an analog input) and turns on an LED
 only if the potentiometer goes above a certain threshold level.

 The circuit:
 * potentiometer connected to analog pin 0.
 Center pin of the potentiometer goes to the analog pin.
 side pins of the potentiometer go to +5V and ground
 * LED connected from digital pin 13 to ground

 * Note: On most Arduino boards, there is already an LED on the board
 connected to pin 13, so you don't need any extra components for this example.

 created 17 Jan 2009
 modified 9 Apr 2012
 by Tom Igoe

This example code is in the public domain.
http://www.arduino.cc/en/Tutorial/IfStatement

 */

// These constants won't change:
const int analogPin = A0;    // pin that the sensor is attached to
const int ledPin = 13;      // pin that the LED is attached to
const int threshold = 400;   // an arbitrary threshold level that's in the range of the analog input

void setup() {
 // initialize the LED pin as an output:
 pinMode(ledPin, OUTPUT);
```

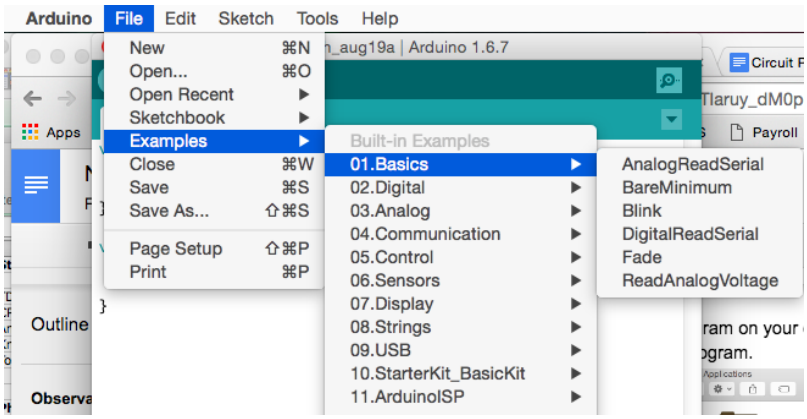
```
}

void loop() {
 // read the value of the potentiometer:
 int analogValue = analogRead(analogPin);

 // if the analog value is high enough, turn on the LED:
 if (analogValue > threshold) {
   digitalWrite(ledPin, HIGH);
 } else {
   digitalWrite(ledPin, LOW);
 }

}
```

How to use the Arduino program on your computer

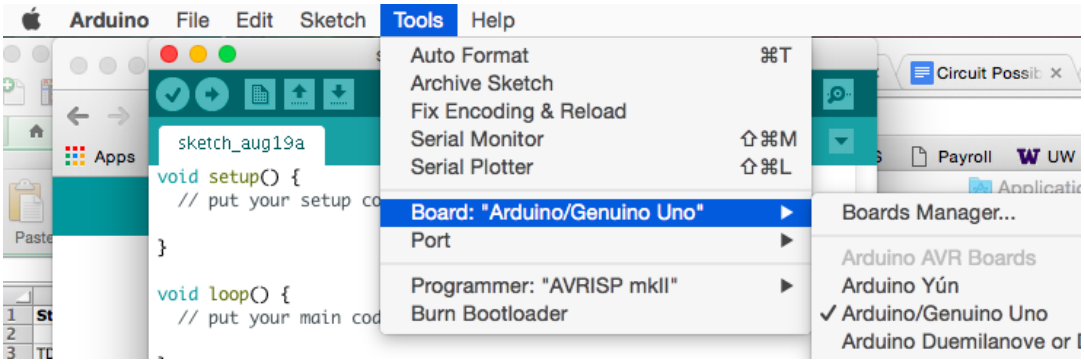
1. Open the Arduino Program.



2. Open up an existing sketch.

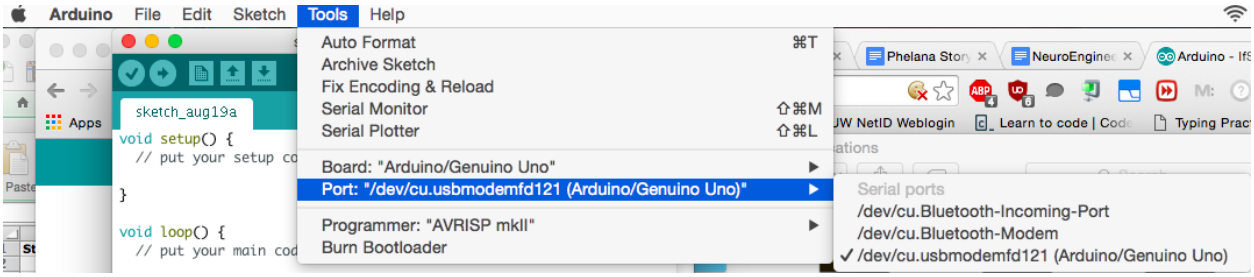


3. Select the correct Arduino Device. We are using the Arduino Uno.



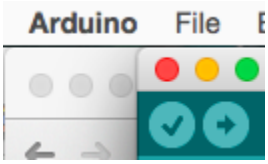
4. Plug in the USB cord to the Arduino and to your computer.

5. Make sure the correct port is connected.



6. Verify your code by clicking on the check button. A message will occur at the bottom of the window to show whether there are any errors in the code.

7. If your code is good to go, you can upload your code by clicking on the right arrow button.



8. Save your code by renaming it if you modified it.

Student Handout 9.1: Engineering Design Sketchpad

Name:_____ Date:_____

Period:_____

Brainstorm

What is engineering? What do engineers do?

Diagram of Engineering Practices

Designing a Sensory Substitution Device - Making a Plan

Big Ideas - Dreams/Things I wish could exist

_____

_____

_____

_____

Flip your big ideas into possible design challenges.
How might we…..

_____

_____

_____

_____

What are the end goals? What will I work to produce?

 _____

 _____

 _____

 _____

How will I know if it's successful? What measures and indicators will inform me of success of design?

 _____

- _____
- _____
- _____

What constraints will I need to manage?

- _____
- _____
- _____
- _____

Define your end-users. Who will you be building this design for?
Who will be your primary users?

_____

Who might be other end-users?

_____

_____

_____

What do you already know/understand in starting your design?

- _____
- _____
- _____
- _____
- _____
- _____

What else do you need to know/understand to start your design? How might you acquire this knowledge?

 _____ _____

 _____ _____

 _____

Design Sketchpad

Write out as many "If… then..." statements for your sensory substitution device as possible.

_____

_____

_____

_____

_____

Sketch out your basic ideas for what how you might connect different parts of the circuit for your sensory substitution device.

Basic Components:
- ❑ Sensory/Input
- ❑ Motor/Output
- ❑ Power supply

Which types of Arduino sketches might you use to copy and paste portions of the code?

Initial Design

Use this space to draw your design, take notes on what worked, what didn't work, what changes you made, etc.

Sketchpad 2

Expand your "If… then..." statements for your sensory substitution device to include the use of logic gates (AND, OR, NOT). For example, you can write statements such as "If not…. and… then…." or "If…. or….. then…." or "If…. then…. and …."

_____

_____

_____

_____

_____

_____

_____

_____

Sketch out more ideas for what how you might connect different parts of the circuit for your sensory substitution device to include at least one logic gate.

Basic Components:
- ❑ Sensory/Input
- ❑ Motor/Output
- ❑ Power supply

Additional Component(s):
- ❑ Switch
- ❑ Additional sensor
- ❑ Additional output
- ❑ AND gate
- ❑ OR gate
- ❑ NOT gate

Which types of sketches might you use to copy and paste portions of the code?

Modified Design

Use this space to draw your design, take notes on what worked, what didn't work, what changes you made, etc.

Review your design plan. What else do you need to consider and incorporate?

Prototyping & Testing: Design Notebook

Use this page to document the things you tried, what worked, what didn't work, what you modified, and the feedback you received.

Design Reflection

What are you most proud of in designing your sensory substitution device?

What was one of the biggest challenges you encountered? Why was it challenging? How did you feel initially?

How did you overcome your challenges? What resources did you seek to help you through your challenges?

How did you and your teammate(s) work together? What interactions were you proud of? What interactions would you like to improve?

What tips would you give to a student who will be learning the same things you did to design your sensory substitution device?

Student Handout 9.2: Making it Real

Name:_____ Date:_____
Period:_____

Pick one or two of the following areas to explore further for your sensory substitution device.

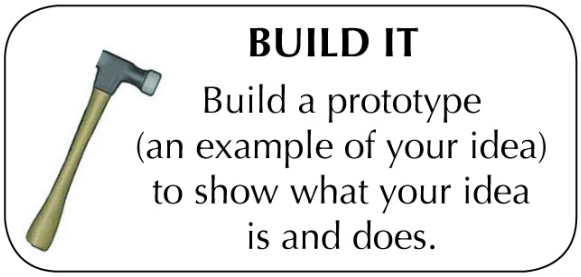
- What are the requirements of testing this device on users before making it available for public use?
- What materials should be used to build/encase the device?
- What aesthetic considerations should you take into account so that someone wants to use it?
- How can you scale down/up the device so it is more convenient for the user?
- What is the budget for making a complete prototype?
- How fast can a single device be produced?
- What safety concerns might be involved in using this device?
- Do any devices like this already exist? If so, how is yours alike or different?
- If you were to patent your design, what steps do you need to take?
- Who would you market the device to? Who would be selling this device?
- What's the history of the development of devices like yours?
- If you needed a battery to power your device, what type of battery is best? How long would your battery last before you needed to change it?
- Anything else you can think of?

Find a creative way to present your sensory substitution device, along with your one or two "Making It Real" ideas.

Teacher Resource 9 .1: Engineering Design Process Cards

Print and cut the following cards (one set per pair/group). Have students come up with an order for these cards. Discuss afterwards about the non-linearity of the engineering design process.

Steps in engineering design process acquired from Tch Teaching Channel.

Identify Need or Problem 	Research Criteria/Constraints 
Brainstorm Possible Solutions 	Select Best Solution 
Construct Prototype 	Test 
Present Results 	Redesign 

Student Handout 10.1: Presenting your Sensory Substitution Device—Presentation Guidelines

Name:_____ Date:_____
Period:_____

In this class, your group will be designing a poster/video/slide show of your design. Your presentation must include large headings, bullet points, and the following sections:

- Design problem: What is name of device and how does it substitute a sense? Who is the user?
- Criteria and Constraints: What requirements did the design need to fulfill and what limitations were there?
- Methods: How did you build your model?
    - Diagrams: What components did you use in your model and how were they connected in a circuit? What was/were the input(s), how was the information processed, and what was/were the output(s)?
        - Circuit Diagram of electronic components
        - Arduino Program - describe the major elements of your program which processes the input to result in an output
- Imagining the actual device: How does the user wear the device? When is it used? Does it have a switch? What materials would make this device even more usable?
- Modifications: What changes did you make and how did they improve your model?
- Ethics: How did you consider ethics in this design?
- Future work: With more time and resources, how might you further improve your design and why?
- Further information: If you completed any of the extension research from the Making It Real handout, you can include that in your presentation

Your poster can (doesn't have to!) have the following layout:

Name of your SSD

Your names

Introduction

- what need does your SSD seek to address?

- how does your SSD address this need?

- ?

Draw your final SSD circuit

Explain in words how your circuit functions. Be specific but brief.

Conclusion

- what are some of the more important changes you made as you worked, and why?

- what would be your next steps or improvements now?

- ?

Student Handout 10.2: Pugh Charts

Name:_____ Date:_____
Period:_____

Pugh Charts are used to help engineers decide which design solution is "best." "Best" may have different definitions based on what is values different people place on certain criteria. Let's look at the following example.

You're choosing between 3 pairs of shoes, and you can only buy one.

1. What are some **criteria** you might consider in choosing the one pair you buy? List them in the first column in the chart below.
2. What value or **weight** do you place on each criterion? For the most important criterion, give a weight of 3. Less important criteria can be given a weight less than 3 (1 for not very important at all, 2 for somewhat important). Two or more criteria can have the same weight (they are of equal importance).
3. Look at each of the three shoes. Give each shoe a **score** for each criteria based on the maximum weight allowed. *For example, one of your criteria is comfort and you gave it a weight of 3. When you try the shoe on, it's not comfortable at all. You would give it a score of 1 out of 3 for comfort. If you need a shoe for playing basketball and give that a weight of 3, you might give a dress shoe a 1 out of 3 for matching its function.*
4. After going through all the criteria for each shoe, add up the **total** for each shoe. The shoe with the highest total score is the best choice.

Criteria	**Weight**	**Design 1**	**Design 2**	**Design 3**
Total				

5. Compare your "best" with another person's or group's. Why might you have different results? How might this be advantageous or disadvantageous when designing a solution to a problem?

Student Handout 10.3: Presentation Simplified—
Your Sensory Substitution Device

Name:_____ Date:_____
Period:_____

What is the name of your device? _____

Who is the user of your device? _____

How will your device help your user? _____

_____

Describe/draw your final sensory substitution device here (or print, tape in, and label a picture).

Student Handout 10.4: Sensory Substitution Device Pugh Chart

Name:_____ Date:_____

Period:_____

Criteria	Weight	Design 1	Design 2	Design 3	Design 4	Design 5	Design 6	Design 7	Design 8
Total									

Reflect: Based on the total score, which design was the "best"? Are you surprised by this? Why or why not?