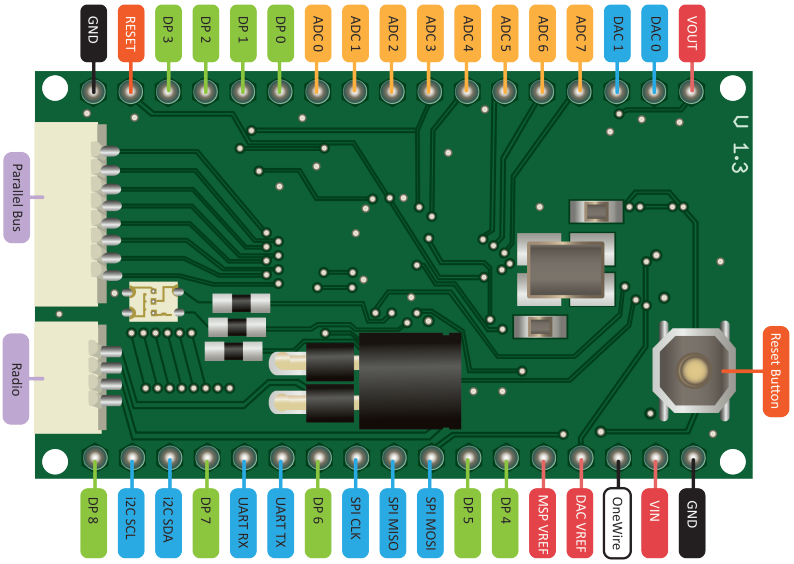
Unit 2 Go with the Electron Flow

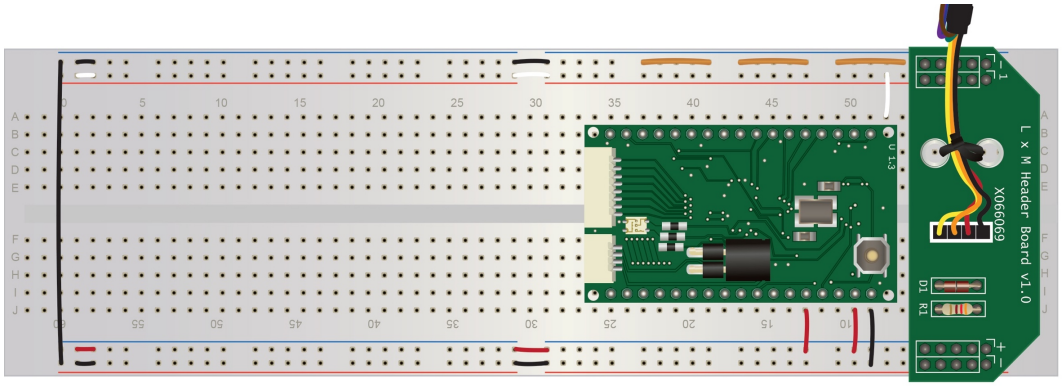
Student Handouts

Visual Hardware Guide

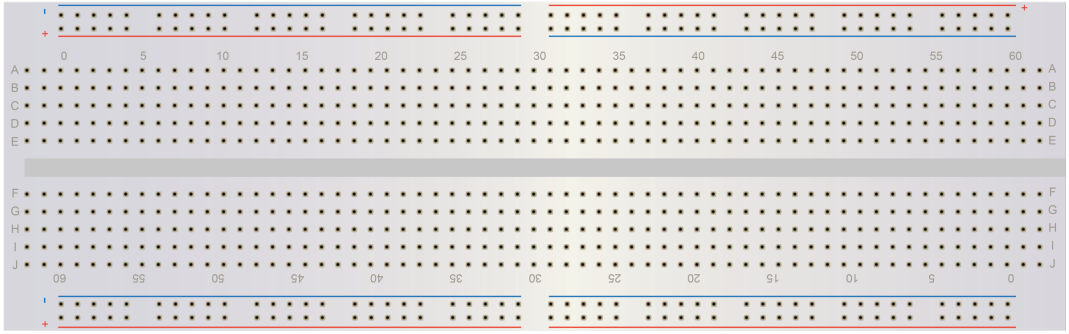
AppBoard



BasicBoard



Breadboard



I **Promise** to **Stay**

GROUNDED

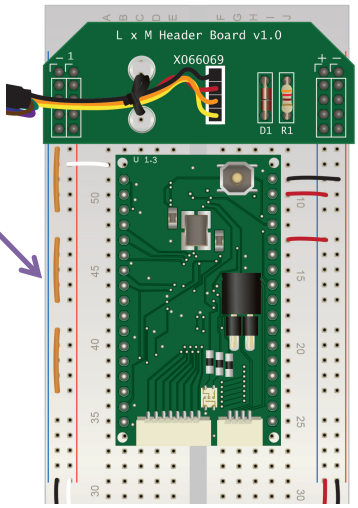
Electrostatic discharge **can** and **will** damage sensitive electronic compontents like the application board. Simple acts like getting up from a chair, walking around on a carpet, or touching objects can induce a charge on your body.

The threshold for you feeling a small shock is much higher than that of the equipment we will be using in this classroom. It is for this reason that you must shed excess electrons from your body before working with the BasicBoard. You must **GROUND** yourself.

What can you do to avoid electrostatic discharge?

- ❑ Wear cotton clothing rather than wool or synthetic fibers
- ❑ Avoid shuffling your feet on carpet
- ❑ Touch unpainted metal with a clear grounded path
- ❑ Keep your components in antistatic bags until you are ready to use them

Touch the copper loops on your BasicBoard **before** you connect new components or touch the AppBoard



I, _____, hereby promise to ground myself before working with sensitive electronics. I will touch the copper loops on the BasicBoard with both my feet firmly on the floor on a **regular** basis.

_____ _____

Signature Date

2.1 Introducing the BasicBoard

Getting Started

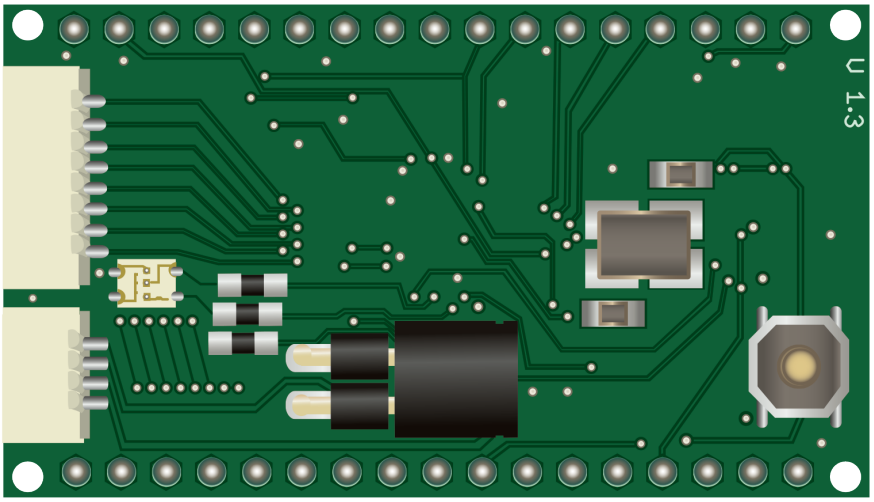
In this class, you will be running experiments using your HP Stream and various electronic sensors.

Electronic sensors can't talk directly to your computer. There needs to be a connector of some sort - a smart linking device that is able to understand and control these sensors.

We call this device the **AppBoard**.

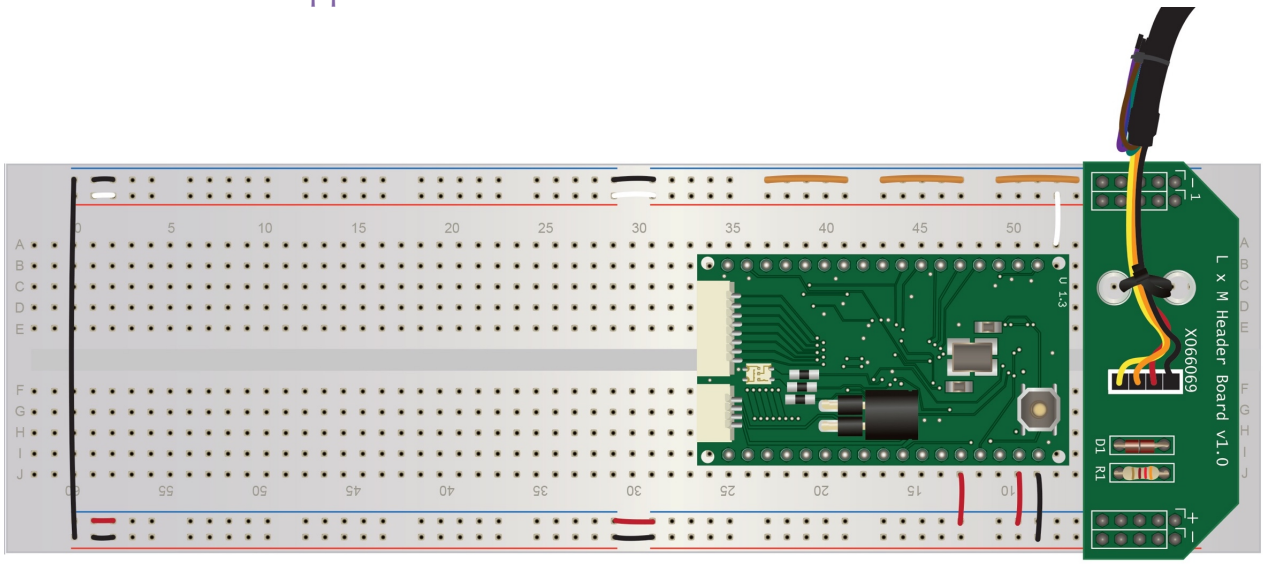
The **AppBoard** can store programs in its own built-in memory.

It can run these programs by sending and receiving signals through 34 metal pins on the perimeter of the board.



The AppBoard is connected to a special **breadboard** with additional wires and components. You will build your experiments on this board. A black FTDI cable connects the board to the computer.

We call the AppBoard and breadboard combination the **BasicBoard**.



Learning Goals

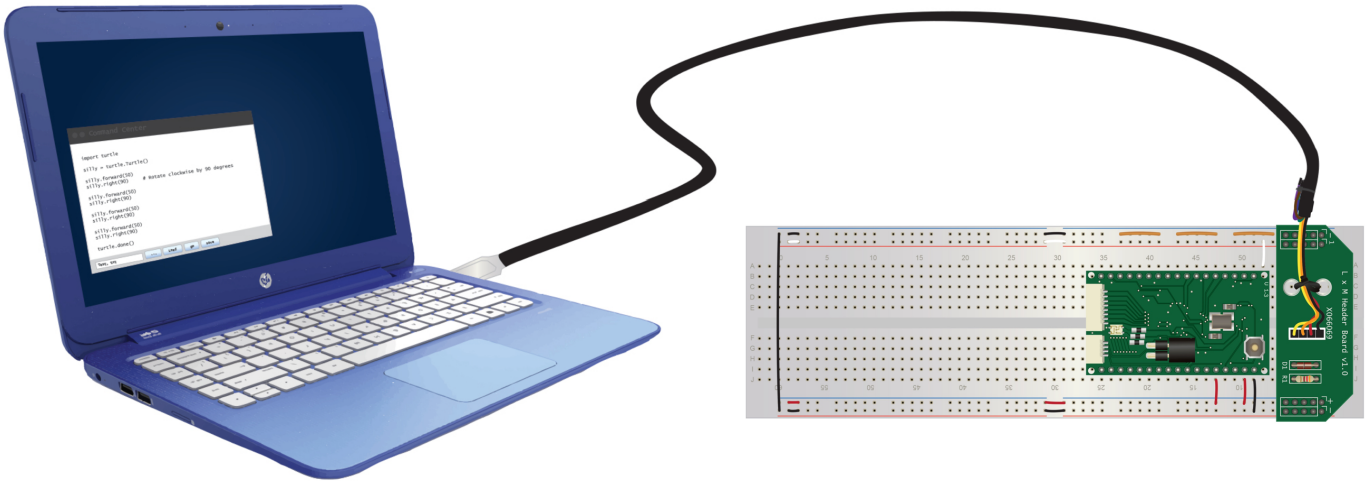
- ✓ Investigate the structure and function of the AppBoard, BasicBoard, and a breadboard.
- ✓ Learn the process of using the HP Stream to send signals to the BasicBoard.

Instructions

Connecting the BasicBoard

1. Turn on your HP Stream and plug in the black FTDI cable of the BasicBoard. This FTDI cable looks like a simple USB cable, but it can do much more.

2. In your notebook, draw a diagram of the entire system. Label the AppBoard, BasicBoard, breadboard, computer, and cable.



Starting the project

3. Your computer should be showing a full screen black window asking the question:
   `Would you like to load an existing experiment? (y/n)`
   Since we are starting a new experiment, answer **`n`** and hit the enter key.

4. Create your own working copy of the experiment called **`LEDs`** by following these steps. If done correctly, a new black terminal window should pop up that says **`Welcome to Logo`**.

   - Answer **`y`** to create a new experiment
   - Select **`LEDs.tar`**
   - Give your experiment the name **`MyLEDs`**
   - Select the version **`solution`**

5. Verify that you have the new window that says **`Welcome to Logo`**. If it did not come up, ask the teacher to restart the full screen experiment startup process.

6. In the black terminal window type the following Logo word, hit the enter key, and wait until a response shows up on the screen. This prepares a Logo program for transfer to the board.

`.compile` *Note: You must include the dot (.) for this step.*

7. Now we need to send the compiled Logo program to the AppBoard via the FTDI cable. Type the following Logo word, hit the enter key, and watch the lights blink on the FTDI cable. Wait until a response shows up on the screen. *If you see `chip not found`, call the teacher over.*

`.download` *Note: You must include the dot (.) for this step.*

8. Every experiment in this course will start with the same launch command. In `TurtleLogo`, that command was `go`. In this system, the command is **`run-once`**. Type the following Logo word, hit the enter key, and watch the green AppBoard. In your notebook, record your observations. What did you see?

`.run-once` *Note: You must include the dot (.) for this step.*

9. Confirm with your teacher that you see the following messages on the terminal screen.

```
Starting LEDs...
Now try to run each light individually
```

10. Enter the following two Logo words, each without a dot and hit the enter key. What happens?

```
redon
redoff
```

Challenge

Credit	Task
◆	The BasicBoard contains three different colored LEDs embedded within the green AppBoard. This device knows more than the words `redon` and `redoff`. Discover how to turn on the remaining green and blue LEDs. Copy and complete the first table on the next page.
◆◆	How many colors can you make by combining these three LEDs? In your notebook, copy and complete the second table on the next page.

Challenge 1 Table

If I use the Logo word(s)…	I can turn …	the following LED
redon	on	red
	off	red
		green
		blue

Challenge 2 Table

Red LED	Green LED	Blue LED	Color
✔			Red
	✔		
		✔	
✔	✔		
✔		✔	
	✔	✔	
✔	✔	✔	

Helpful Hints

If you need to start over, hold down the **ctrl** key and **c** at the same time. Next, type the command **start** and hit the **enter** key.

If you already created the LEDs experiment, answer **y** for **Would you like to load an existing experiment?**

If you see **chip not found**, call the teacher over.

If you see _____ **undefined**, you are trying to run a Logo word on the AppBoard that it doesn't understand.

If you see **I don't know how to** _____ , you are trying to run a Logo word on the HP Stream that it doesn't understand.

If you get an error message, see if you can figure out what you did wrong by asking a classmate for help. If all else fails, ask your teacher.

Watch the FTDI cable during download. If it blinks fast, the AppBoard is working.

Watch the FTDI cable after download. If it slowly blinks red and green, the AppBoard is working.

Going Further

Extra Credit	Task
◆◆	Research one of the following computer programming topics and write a 1-2 paragraph summary: compiler machine code binary
◆◆	Research additive color mixing and subtractive color mixing. Create a flyer, poster, or presentation that demonstrates each of these concepts.

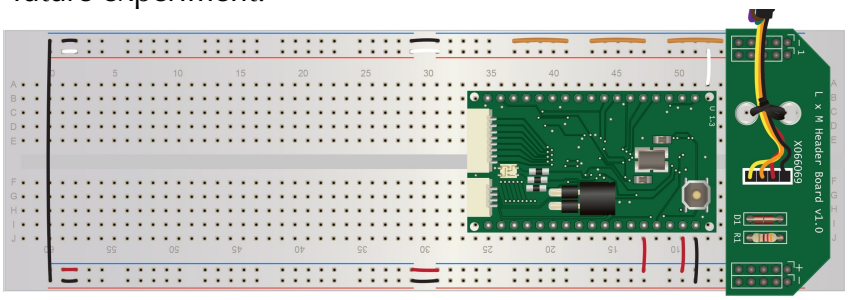
2.2 BasicBoard Anatomy

Getting Started

Electricity is the flow of **electrons**. These electrons need somewhere to flow.

Recall, the **BasicBoard** is a specially wired **breadboard** that houses the **AppBoard**.

Without the wires and breadboard, there is no way to transport electricity *from* the computer *to* the AppBoard or *to* any future experiment.



Each wire serves a purpose –

Some wires allow for data transfer between the AppBoard and computer
Some wires supply power to the AppBoard
Some wires supply power to empty regions of the breadboard
Some wires ground the AppBoard and breadboard
Some wires do nothing at all, but are included as visual guides

Learning Goals

- ✓ Use a digital multimeter to make electronic measurements.
- ✓ Use the concept of electrical resistance to investigate the structure of a breadboard.
- ✓ Explain the function of a breadboard based on gathered evidence.

Instructions

1. Gather the following materials. In your notebook, draw a simple sketch of each object.

- ☐ BasicBoard
- ☐ 1 blank breadboard
- ☐ 1 digital multimeter
- ☐ 1 red multimeter probe
- ☐ 1 black multimeter probe
- ☐ 2 sets of alligator clips
- ☐ wire as needed (approximately 10 cm)
- ☐ 1 wire stripper

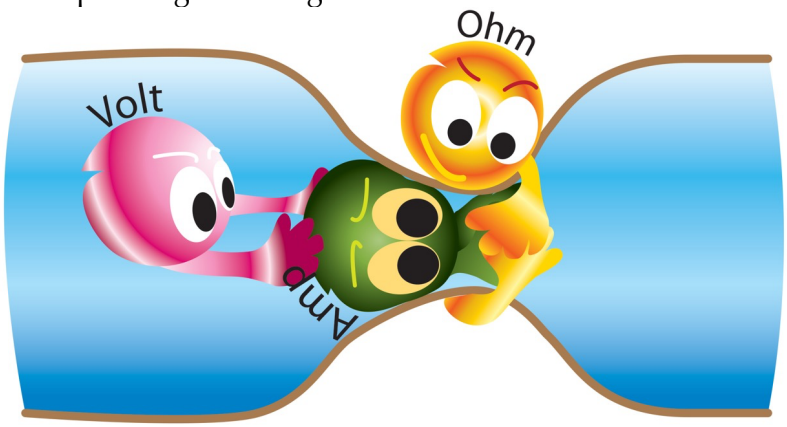
2. Breadboards allow you to make solid electrical connections by plugging wires into holes. They are a tool of convenience. Plug some wires into various holes on the breadboard to see how they click into place.

- Follow your teacher's instructions to cut and strip two small pieces of wire. Strip about 0.5 cm from each end.
- Try plugging your wire into the board.

Note: If you do not strip off enough of the insulation, the wire may not fit properly.

Note: Avoid stripping off too much insulation. Exposed wires may damage circuits or send electrical signals to unintended places.

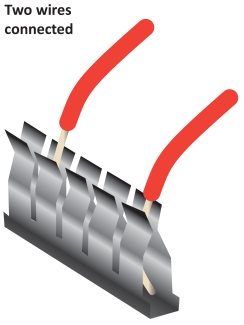
3. Just beneath the plastic of your breadboard are rows and rows of metal clips. Electricity can flow along these small channels of metal. The following image is a cartoon of electricity flowing like water through a tube. Discuss this image and add the following terms to your notebook. Write 2-3 sentences explaining this image.

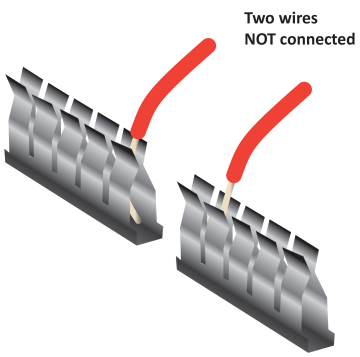


Electricity	A flow of electric charge (electrons)	
Voltage	Pushes electrons through a circuit	Measured in Volts (V)
Current	A flow of charged electrons	Measured in Amps (A)
Resistance	Resists the flow of electrons	Measured in Ohms (Ω)

Note *Ω is the Greek letter Omega*

4. Discuss with your group – The following two images show examples of wires **connected** through the breadboard and wires **not connected** through the breadboard. In which figure is the resistance largest? Explain.





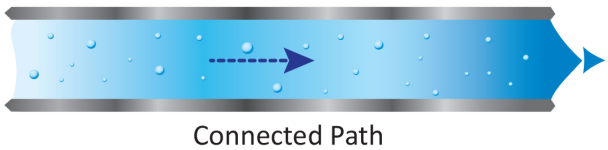
5. A digital multimeter is a tool used to measure properties of electrical circuits. Unfortunately, the probes are too big to fit inside the holes of the breadboard. We need to build an adapter.

- Use alligator clips to attach small bits of wire to your multimeter probes. The color of the wire does not matter. In your notebooks, create a labeled diagram of the digital multimeter.

6. Make a prediction.
If two holes are electrically connected, the resistance measurement will be _____

If two holes are not electrically connected, the resistance measurements will be _____

Resistance


Connected Path

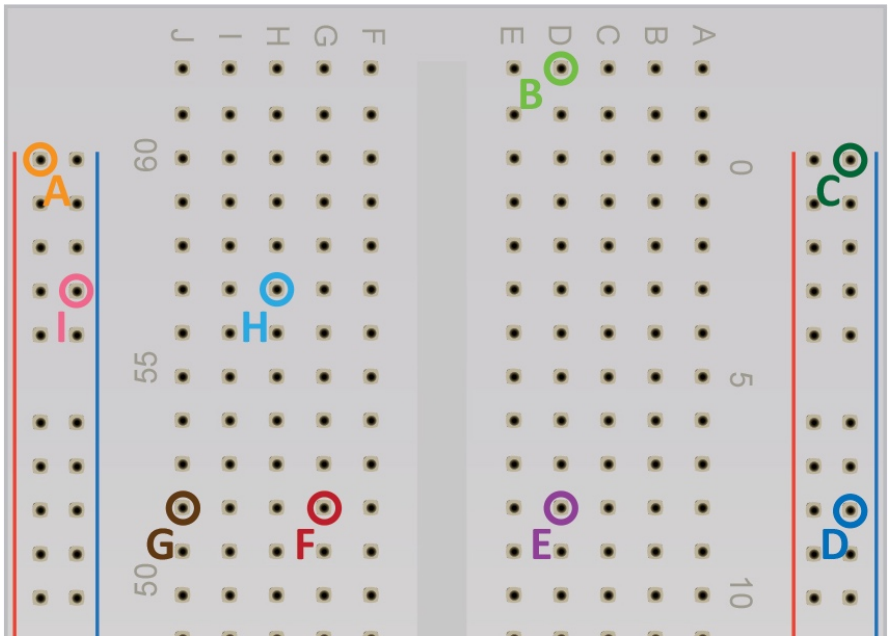

Broken Path

7. Use your multimeter to complete each challenge.

Challenges

Credit	Task
◆	Measure the resistance between each pair of holes listed in the following table. Determine if the two locations share an electrical connection or do not share an electrical connection. Record your results in your notebook.
◆◆	Draw a model of what you believe the inside of the breadboard may look like. Include labels and write 2-5 sentences explaining your diagram. Describe the patterns or relationships that you can infer from your measurements. As a group, present your findings and explanation to the class.
◆◆◆	Examine your BasicBoard once again. Wires allow you to join together previously unconnected regions of a breadboard. Wires create connected paths. Some wires allow for data transfer between the AppBoard and computer Some wires supply power to the AppBoard Some wires supply power to empty regions of the breadboard Some wires ground the AppBoard and breadboard Some wires do nothing at all, but are included as visual guides What can you infer about the function of each wire on your BasicBoard? Add labels to your BasicBoard diagram to identify various wires. Which wires are still a mystery? In 1-2 paragraphs, justify your labels.

HOLE 1	HOLE 2	CONNECTED?
A	C	
G	F	
B	E	
E	F	
C	E	
F	H	
B	C	
I	A	
C	D	
D	F	



Helpful Hints

Check that the multimeter knob is set to measure resistance. You cannot measure resistance for any components within a powered circuit. Unplug all power sources.
Do not let metal pieces from one probe/alligator-clip/wire system touch the other.
Your bodies conduct electricity. Make sure you don't insert yourself into a circuit by touching the metal portion of any probe.
Use needle nose pliers to hold small wires while you cut and strip them.

Going Further

Extra Credit	Task
◆	Create a guide for cutting and stripping wires.
◆◆	Create a poster which explains the structure and function of breadboard. Your poster must include labeled diagrams of the inside and outside of a breadboard. Your poster must include a discussion of electricity and resistance.
◆◆◆	Use the digital multimeter to measure resistance across different objects found in your classroom. Are there any similarities between objects that have high resistance? Are there any similarities between objects that have low resistance? Write 1-3 paragraphs about your investigation.

2.3 Powering the BasicBoard

Getting Started

In the previous lesson, you investigated the inner workings of the breadboard. Armed with a digital multimeter you mapped out the paths of least resistance.

In this lesson, you will explore how electric charge flows through these breadboard and wire "metallic highways" in order to power the BasicBoard. You are going to measure **voltage**.

Voltage is a type of electrical force that makes electricity move through a wire. This force is usually provided by a battery. Measured in units of **volts**, this quantity tells you how much energy each individual electric charge carries throughout a circuit.

Learning Goals

- ✓ Use a digital multimeter to make electronic measurements.
- ✓ Explain how voltage measurements can be used to trace communication signals between the computer and the BasicBoard.
- ✓ Explore the precision and accuracy limits of digital multimeter measurements due to human error and mechanical uncertainty.

Instructions

1. Gather the following materials:
   - ☐ HP Stream
   - ☐ BasicBoard
   - ☐ Digital Multimeter
   - ☐ Multimeter probes (with alligator clip and wire extensions)

2. Turn on your HP Stream and plug in the FTDI cable of the BasicBoard.

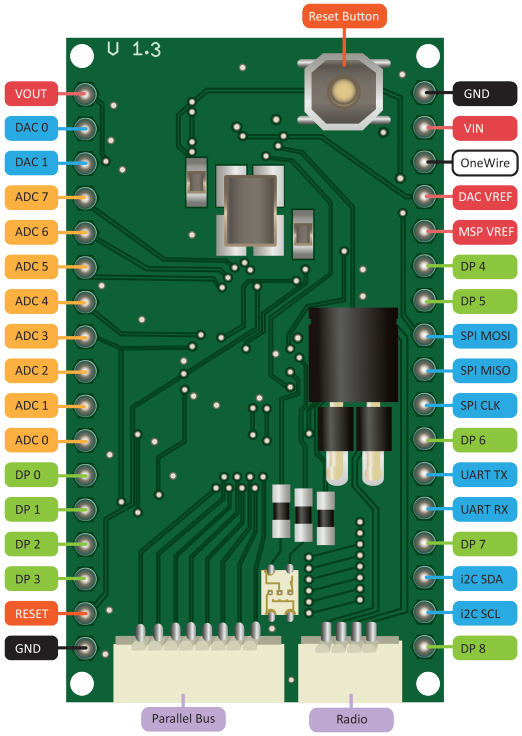
3. Reload your existing project, **`MyLEDs.`** If you do not see a black full screen window with questions, ask your teacher for help.

```
Would you like to load an existing experiment? (y/n)
> y
Which experiment would you like to load?
> MyLEDs
```

4. Verify that you have the new window that says **`Welcome to Logo`**. If it did not come up, ask the teacher to restart the full screen experiment startup process.

5. Compile and download the LED project. Run the program with the command `run-once`. Test that your program is running by using the Logo words `redon` and `redoff`.

```
.compile
      Compiling...
      XXXX bytes
.download
      XXXX bytes
.run-once
      Starting LEDs...
      Now try to run each light individually
redon
redoff
```



6. **Mandatory**: touch the bare copper wires on the BasicBoard to discharge your static electricity.

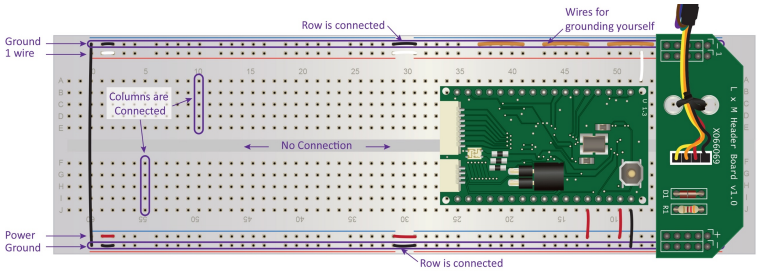
7. Examine the following diagram. This is a blown-up view of the AppBoard with all 34 pins labeled.

Locate DP 0. All of the pins labeled DP# are **digital pins**. Digital pins can send on/off signals and only on/off signals.

In your notebook, draw a simple diagram that will help you locate and identify DP 0 in the future.

8. Turn on your digital multimeter and set the dial to V.

9. Attach the extension wire of your **black** multimeter probe to one of the **ground** rails. This is the outermost rail on either side of the breadboard. It should be marked with black wires.



10. Attach the extension wire of your **red** multimeter probe to the **power** rail. This is the inner rail on one side of the BasicBoard. This rail should be marked with red wires.

11. Voltage pushes electrons around. A circuit with a 9V battery provides 9 Joules of energy for each unit of charge. That's quite a push! A circuit with a 1.5V battery only sends along 1.5 Joules of energy with each unit of charge.

How much energy is being used to transport charge between the black **ground** rail and the red **power** rail? In your notebook, write 2-5 sentences that explain how your multimeter can be used to answer this question.

12. Turn on digital pin 0 by entering the Logo word, **`dp0on`**, in the terminal window. How much voltage is pushing charges through digital pin 0? Turn off digital pin 0 by entering the Logo word, **`dp0off`**. What is the new voltage reading? Record your result in your notebook. Your teacher will collect the measurements for the entire class.

Warning
if you touch the reset pin, it will turn ALL pins off.
*Enter **`dp0on`** again to reactivate digital pin 0.*

13. Complete the BasicBoard challenges.

Challenges

Credit	Task
◆	Activate Digital Pin 1. Deactivate Digital Pin 0. Record the voltage between: • Ground to Ground • Ground to DP 0 • Ground to DP 1 What is the function of the Logo words `dp0on`, `dp0off`, `dp1on`, `dp1off`? Write 2-3 sentences explaining the connection between your voltage measurements and these Logo words.
◆◆	Do all digital pins output the same signal when activated? Is there a right way to use the digital multimeters? As a class, gather all of the voltage measurements on the digital pins. Are any measurements noticeably high or low? If so, ask the group who made those measurements to demonstrate their procedure. Within your own group, find three physical ways to alter the voltage reading on your digital multimeter. Write down 1-3 sentences and include sketches to explain each process.
◆◆◆	Within your group, create a list of three reasons for which you might get a bad voltage reading and that are entirely out of your hands. In other words, think of other things that may influence voltage readings that you cannot fix by being more careful or more precise. Your teacher will introduce the concept of **uncertainty**. Write a 2-5 sentence reflection on uncertainty.

Helpful Hints

If you need to start over, hold down the **ctrl** key and **c** at the same time. Next, type the command **start** and hit the **enter** key.
If you see **chip not found**, call the teacher over.
If you get an error message, see if you can figure out what you did wrong by asking a classmate for help. If all else fails, ask your teacher.
Watch the FTDI cable after download. If it slowly blinks red and green, the AppBoard is working.
Check that the multimeter knob is set to measure voltage.
Do not let metal pieces from one probe/alligator-clip/wire system touch the other.
Your bodies conduct electricity. Make sure you don't insert yourself into a circuit by touching the metal portion of any probe.

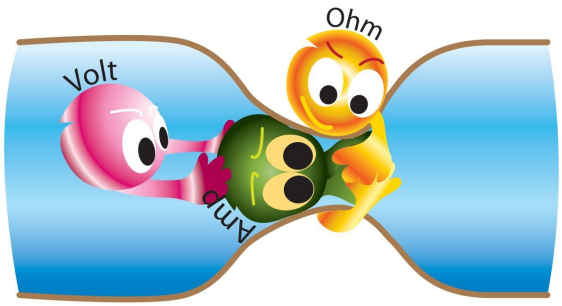
Going Further

Extra Credit	Task
◆	Create a guide for using a multimeter to measure voltage.
◆◆	Measure the voltage difference between positive and negative terminals of various batteries (9V, A, AA, watch battery, etc.). Is there a correlation between physical appearance and the electrical properties of these batteries? Why might it be useful to have batteries of different sizes and shapes? Create a table with your results. Write a 1-3 paragraph summary of your findings.
◆◆◆	Ohm's law describes how charges flow within a circuit based on the amount of voltage applied to push them around and the amount of resistance included to slow them down. Complete the Ohm's Law Worksheet for extra credit.

Ohm's Law Worksheet

Ohm's law describes the relationship between resistance, current, and voltage in a circuit.

A power source provides a voltage that can drive a current. A resistor impedes a current flow by removing energy from electrons. This energy is dissipated as heat, light, or sound.



Resistance measures how much a material reduces the flow of electric current.
- Quantity: **R**
- Unit: Ohm, **Ω**
- Example: R = 300 Ω

Current is the flow of charged particles.
- Quantity: **I**
- Unit: amp, **A**
- Example: I = 20 A

Voltage is a measure of the difference between high and low electric potential energy.
- Quantity: **V**
- Unit: volt, **V**
- Example: V = 1.5 V

1. Ohm's law is typically written as $V = I \times R$. If you know the current and resistance you can calculate the voltage. Answer a and b then fill out the table to the right.

   a. How would you rewrite this equation to solve for current if you know voltage and resistance?

      I =

   b. How would you rewrite this equation to solve for resistance if you know voltage and current?

      R =

V	I	R
120 V	0.5 A	
15 V		200 Ω
	30 A	10,000 Ω
3.0 V	1.2 A	

2. A flashlight runs on 2 D-cell batteries. Each battery provides 1.5 V. The flashlight bulb is rated for 0.7 amps of current. What is the bulb's resistance?

3. A car battery is a 12V source. There is a fuse in the car that trips (breaks) if the current ever rises above 5 A. What is the smallest resistor you need in the circuit to stop the fuse from tripping?

4. Given a 9 volt battery and a 100 Ω resistor, what current must flow through the circuit?

5. A power source is hidden behind a closed panel., Your multimeter measures a current of 0.5 A and you know your light bulb has a resistance of 200 ohms. What is the voltage of the mystery power source?

2.4 Digital Pins and LEDs

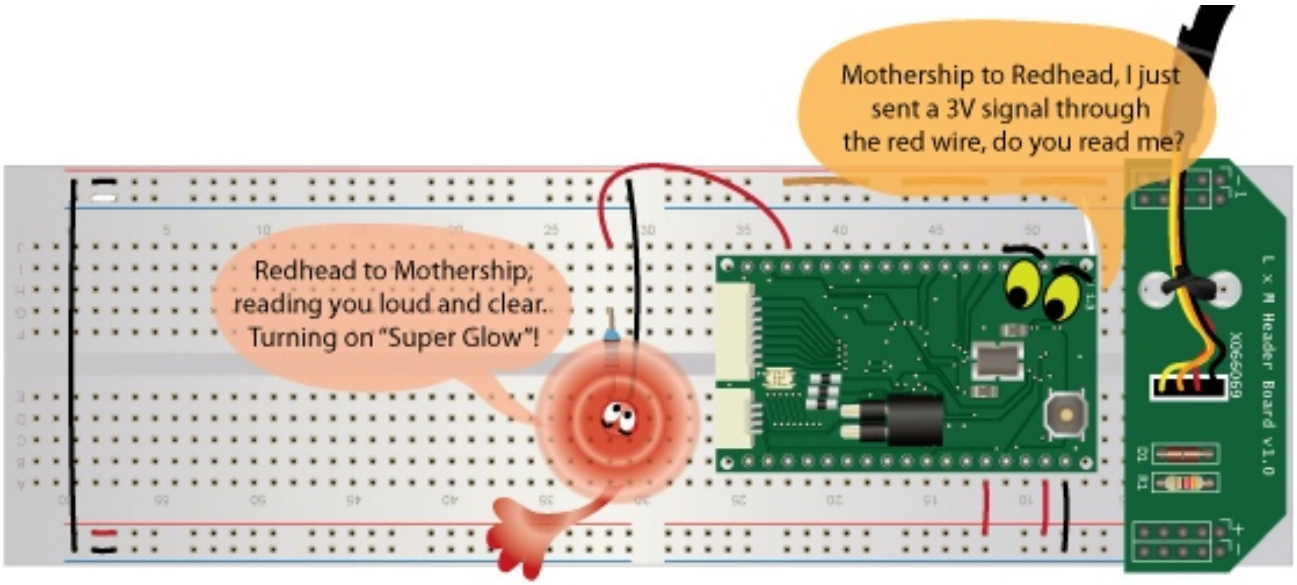
Getting Started

This cartoon shows the AppBoard communicating with an LED on the BasicBoard.

What is going on here? Make observations.

How does this system work? Infer explanations.

Observations are what you notice
Inferences are your reactions, thoughts, or explanations



In this lesson, you will explore how the AppBoard transfers information and energy throughout the BasicBoard.

Learning Goals

- ✓ Measure voltage and resistance in circuits that include LEDs and resistors
- ✓ Identify the function of resistors and LEDs
- ✓ Recognize the structure of LEDs

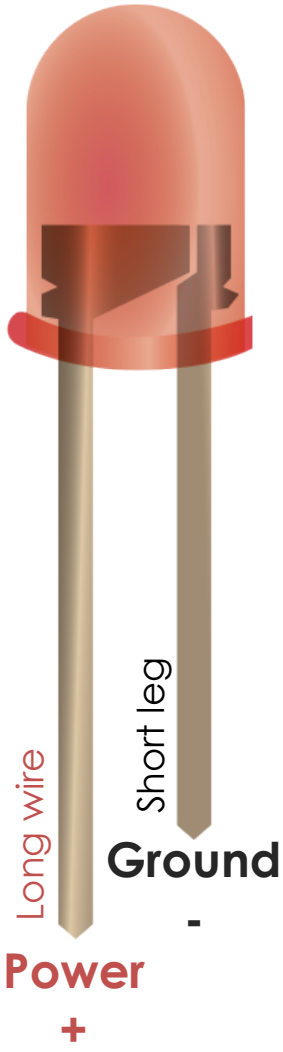
LED Guide

Light
Emitting
Diode

LEDs are devices that emit light once enough *voltage* is applied across their leads.

If the *voltage* is too high, they may burn out.

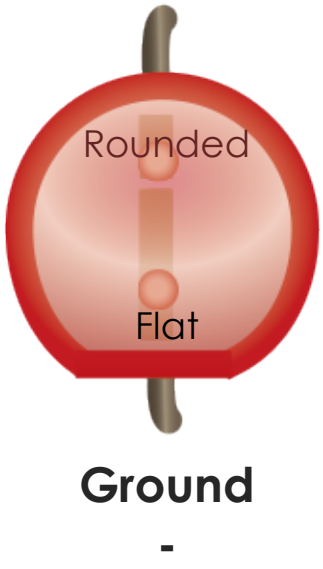
LEDs are <u>not</u> incandescent light bulbs.



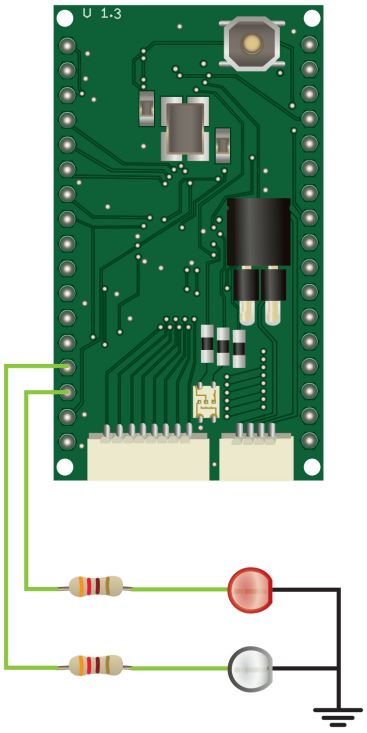
LEDs are **polar**.

Components with **polarity** have a **positive** side and a **negative** (or **ground**) side.

LEDs will not work if they are plugged in **backwards!**



Instructions



1. Look through your handouts and notes from the previous lessons. How do you make the LEDs light up? Dig through your notes from earlier lessons. Figure out how to:

   - Connect the BasicBoard to the computer
   - Start your **`myLEDs`** project
   - Identify the AppBoard pin connected to the red LED on the breadboard
   - Turn on the red LED

   Record the procedure in your notebook.

2. <u>Show your teacher that you successfully turned on the red LED before moving on.</u>

3. Using your handouts and notes from prior lessons as a guide, measure **voltage** at the following locations:

   - Signal sent to the digital pin connected to the red LED
   - Signal between each of the two legs of the red LED
   - Signal across the resistor

   Where do you place each probe? Draw a diagram in your notebook.

LED Circuit #1	Digital Pin	LED	Resistor
Voltage			

4. **Important: Turn off the digital pin or unplug your BasicBoard!** Resistance measurements cannot be done on powered circuits. Measure the resistance across the resistor.

   LED Circuit #1 Resistance _____

5. Find a way to turn on the 2nd LED on your breadboard. Repeat the same measurements as above.

LED Circuit #2	Digital Pin	LED	Resistor
Voltage			

   LED Circuit #2 Resistance _____

6. Complete the LED challenges.

Challenges

Credit	Task
◆	Fill out the following table based on your measurements.

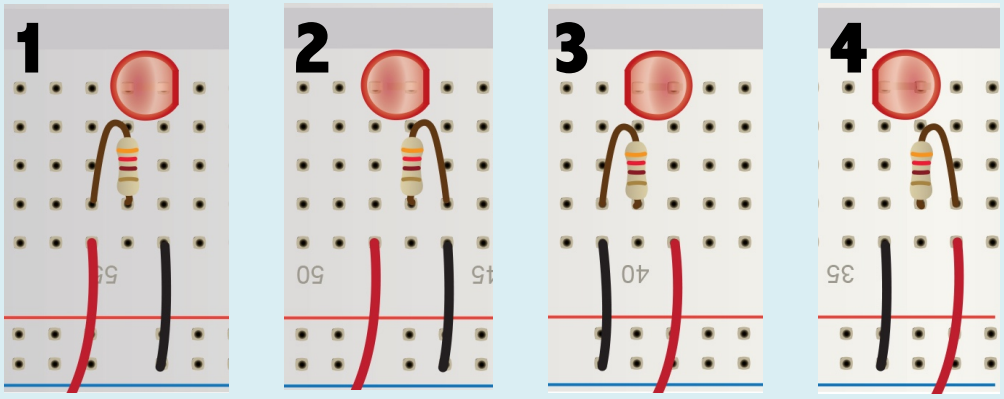
Word	Signal	Turn on or off?
	3.2 Volts from the AppBoard to pin DP 2	On
dp2off	_____ from the AppBoard to pin DP 2	Off
dp3on	_____ from the AppBoard to pin DP 3	
	0 Volts from the AppBoard to pin DP 3	

How do various hardware components interact with each other? How do they communicate? write 2-3 sentences describing how the computer, AppBoard, and LED circuits work together in this system. Include measurements to support your claims.

◆◆

The LED Guide explains the structure and function of LEDs. Which of these circuits are wired properly? In other words, which circuits will light up? Draw each circuit.

- Label the positive and negative sides of the LED
- Label the power and ground wires
- Label the resistor



◆◆

LEDs burn out if too much voltage is applied across the leads. These circuits include objects called **resistors** to lower the voltage. The function of a resistor is to remove energy from the circuit, usually in the form of heat. Measure the voltage drop across both resistors.

How does this voltage drop compare to your measurements at the digital pin? How does this voltage drop compare to the voltage drop across the LED?

Helpful Hints

If you get an error message, see if you can figure out what you did wrong by asking a classmate for help. If all else fails, ask your teacher.
Watch the FTDI cable after download. If it slowly blinks red and green, the AppBoard is working.
Check that the multimeter knob is set to either voltage or resistance.
Do not let metal pieces from one probe/alligator-clip/wire system touch the other.
Your bodies conduct electricity. Make sure you don't insert yourself into a circuit by touching the metal portion of any probe.

Going Further

Extra Credit	Task
◆	Find another way to wire a circuit with an LED and a resistor on the BasicBoard. Connect your new circuit to one of the active digital pins to test it out.
◆◆	How do LEDs work? Research LEDs and write a 1-page report.
◆◆◆	An LED only lights up when enough voltage is applied across its leads. What minimum voltage do you need to turn on the red LED and the white LED? Are these minimum voltages the same for each LED? Why or why not? *Hint: Use resistors of different sizes to drop the voltage.*

2.5 Logo Programming

Getting Started

Until this point you have only interacted with the AppBoard through the terminal window. Now it's time to dive into the underlying computer program.

But first, we need to let you in on something you may have already suspected…
There are multiple versions of the Logo programming language!

This begs the question:
Why are there different flavors of the Logo programming language and how does each work?

TurtleLogo

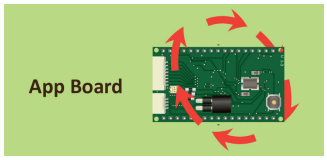
A visual program that **runs on your Stream 11** via the Command Center and Drawing Field.

jLogo

A text based program that **runs on your Stream 11** via the terminal window. `jLogo` words start with a dot (.) when typed in the terminal window.

uLogo

A text based program that **runs on your AppBoard** but can be controlled via the terminal window. `uLogo` words do not require a dot (.) when run from the terminal window.



Learning Goals

- ✓ Use `jLogo` on the HP Stream to open a `uLogo` file. Modify and save this `uLogo` code.
- ✓ Use `jLogo` as a tool to compile, download and run `uLogo` code on the AppBoard.

Instructions

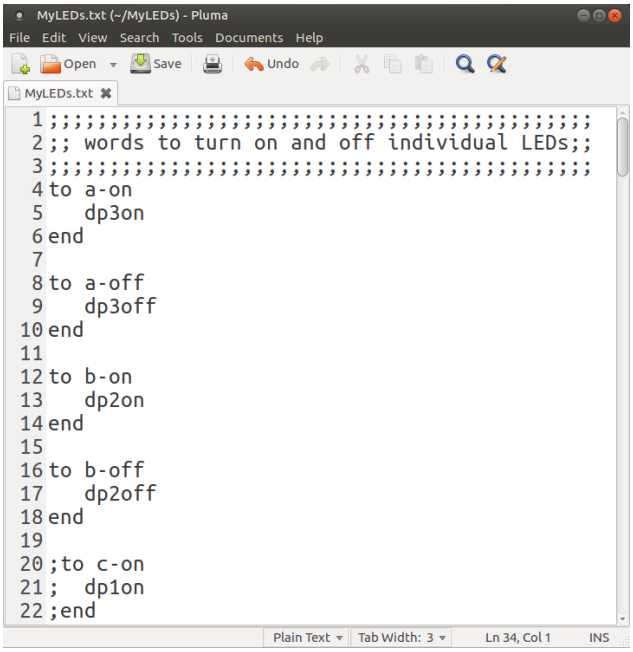
1. Turn on your HP Stream and plug in the FTDI cable of the BasicBoard.
2. Follow your notes from earlier lessons to do the following:
   - Load your **`MyLEDs`** project
   - Compile, download, and run the project

- Turn on the red and white LEDs

3. From the terminal window, enter the following command and hit the enter key:

`.edit-ulogo` *Note: You must include the dot (.) for this step.*

This should open a file called `MyLEDs.txt` in a text editor window.



4. `MyLEDs.txt` is the code that you compile, download, and run from the terminal window.

- Examine this file. Based on what you see, find a way to use the logo words **`a-on`** and **`a-off`**.
- In your notebook, describe the function of the logo words `a-on` and `a-off`.
- In your notebook, describe how these words compare to `TurtleLogo` words.

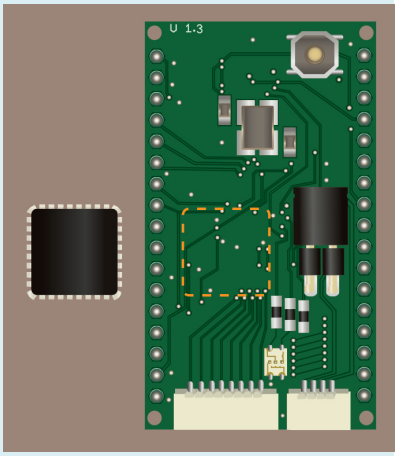
5. The file `MyLEDs.txt` is a program written in the **uLogo** language. You can run any word defined in your `uLogo` program by typing it in the terminal window *without a dot*. Some of the commands that you type in the terminal window begin *with a dot*. Commands that begin with a dot are **jLogo** commands.

In your notebook, write down <u>two</u> examples of `uLogo` commands and <u>two</u> examples of `jLogo` commands that you have used.

6. Complete the LED challenges.

Challenges

Credit	Task
◆◆	Create a word that turns on both LEDs at once. • Use **`.edit-ulogo`** to open your `ulogo` program. • Determine what you need to do fix the file. • Save your modified file. • In the terminal window, compile, download, and run the MyLEDs project. • In the terminal window, use your new word.
◆◆	`uLogo` and `jLogo` are quite similar. Both languages follow the same rules, or **syntax**. Words from both languages can be called from the terminal window. Code for both languages can be saved in text files. They key difference - `uLogo` runs on a tiny **microchip** soldered to the back of your AppBoard. If you could lift your AppBoard up, you would see the small square chip pictured here. As a consequence, `uLogo` must be simpler and smaller than `jLogo`. • In the terminal window, enter each of the following lines *exactly* including all dots and spaces as shown. • What happens after you type each line? • In 2-5 sentences, explain the output of each line. How is `jLogo` math different from `uLogo` math? Why might `jLogo` and `uLogo` need to work differently with numbers?



```
.print 12.34

.print 1.6  +  2

print 12.34

print 1.6  +  2
```

Helpful Hints

If you get an error message, see if you can figure out what you did wrong by asking a classmate for help. If all else fails, ask your teacher.

Watch the FTDI cable after download. If it slowly blinks red and green, the AppBoard is working.

If a text file is modified but has not been saved, you should see a star symbol (*) on the top of the text editor window.

jLogo commands must begin with a dot. **uLogo** commands do not begin with a dot.

Every time you make a change to your program, you must run the following three jLogo commands:

```
.compile
.download
.run-once
```

Going Further

Extra Credit	Task
◆	Certain math symbols are already included in the Logo language: - + / * Determine how to use these symbols to perform mathematical calculations in the terminal window.
◆◆	Find a way to coordinate the color of the internal LED with the color of the external LEDs. *hint: review lesson 2.1 and your notes on color mixing*
◆◆	Does `jLogo` follow mathematical order of operation rules? Does `uLogo`? Investigate both languages through the terminal window. Create a guide for performing mathematical calculations in both Logo languages.
	`uLogo` uses integer arithmetic. Research integer arithmetic and its applications. In what situations is this useful? In what situations would this cause problems? Write a 1-3 page report.

2.6 Let There Be Light!

Getting Started

What good is a BasicBoard if you can't build on it? Let's make your boards bigger and better!

In this lesson, you will add more circuits to your BasicBoard and write code to make them work.

Learning Goals

- ✓ Use diagrams as visual instructions for adding two additional LED circuits to the BasicBoard.
- ✓ Write `uLogo` code to turn on the two additional LEDs on the BasicBoard.

Instructions

1. Gather the following materials:

- ☐ HP Stream
- ☐ BasicBoard
- ☐ 1 blue LED
- ☐ 1 green LED
- ☐ 2 resistors
- ☐ Wire
- ☐ Wire stripper

2. Use the diagrams on page 3 as a guide to add two additional LED circuits to the BasicBoard. You can place the LEDs wherever you like on the breadboard, but each circuit must include a resistor to protect the LED from burning out.

3. Plug your BasicBoard into the computer and reload your `MyLEDs` project.

4. Identify the digital pins controlling the blue and green LEDs. Use this information to turn each LED on from the terminal window.

Challenges

Credit	Task
◆◆	Use **`.edit-ulogo`** to open your `ulogo` program. This file already contains instructions for turning the blue LED on. **Why doesn't this word work when you type it in the terminal window?** a. Determine what you need to do fix the file. b. Save your modified file. c. In the terminal window, compile, download, and run the `MyLEDs` project. d. In the terminal window, use this word to turn on the blue LED.

Credit	Task
◆	Modify the `uLogo` code so that you can turn the blue LED off. Run your new word.
◆◆	Modify the `uLogo` code so that you can turn the green LED on and off. Run your new words.

Helpful Hints

If you get an error message, see if you can figure out what you did wrong by asking a classmate for help. If all else fails, ask your teacher.

Watch the FTDI cable after download. If it slowly blinks red and green, the AppBoard is working.

If a text file is modified but has not been saved, you should see a star symbol (*) on the top of the text editor window.

`jLogo` commands must begin with a dot. **`uLogo`** commands do not begin with a dot.

Every time you make a change to your program, you must run the following three jLogo commands:

```
.compile
.download
.run-once
```

Going Further

Extra Credit	Task
◆◆	Find a way to coordinate the color of the internal LED with the color of the new external LEDs. *hint: review lesson 2.1 and your notes on color mixing*
◆◆◆	The AppBoard has 8 digital pins that can be used to send on/off signals. Use the AppBoard diagram to add more LED circuits to your BasicBoard. Write code to turn these new LEDs on and off. This task is more challenging than it sounds. Digital pins 4 through 8 are not initialized. Somewhere in `MyLEDs.txt`, there is a word that activates digital pins 0 through 3. Identify this word and use it as a template to activate the remaining digital pins.

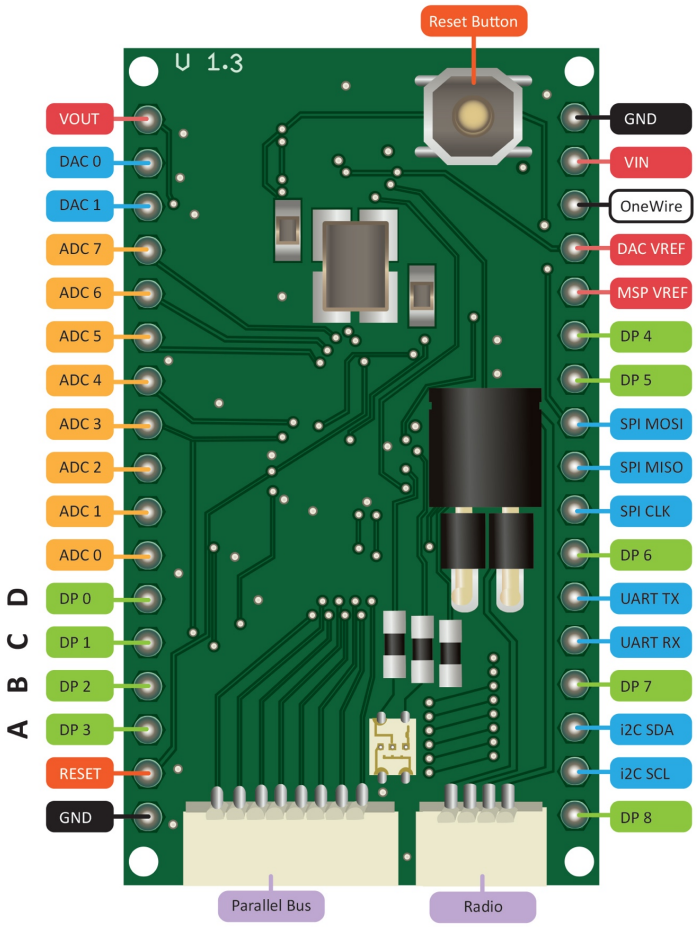


Diagram 1: The AppBoard showing digital pins for each LED.

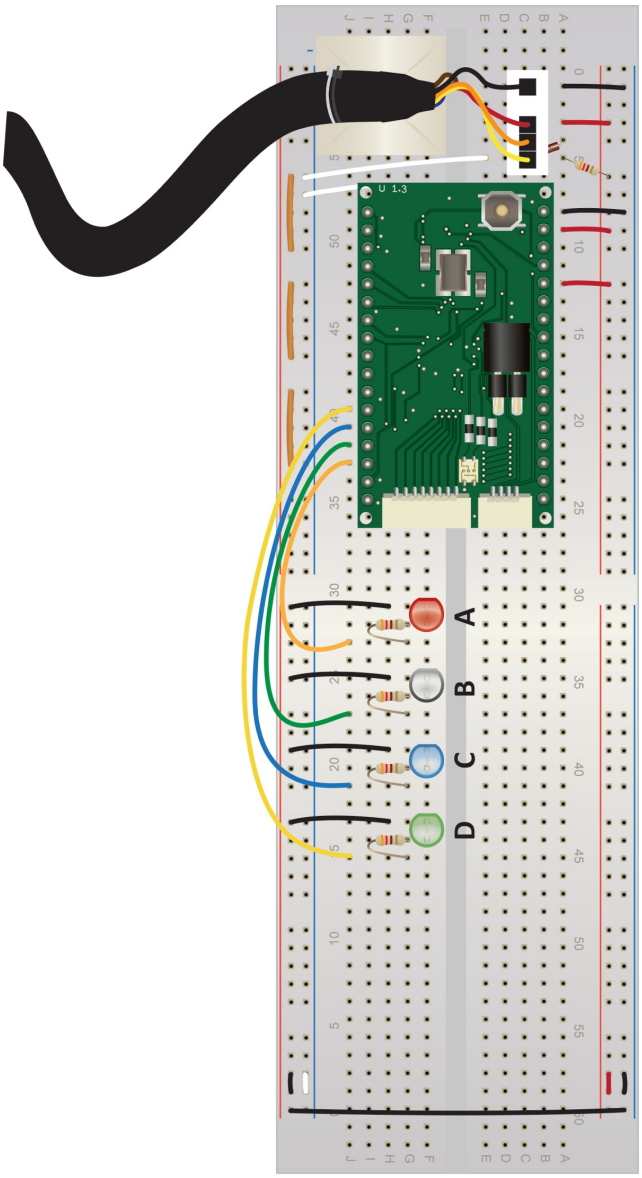


Diagram 2: Example BasicBoard with four LED circuits.

2.7 Blinking LEDs

Getting Started

Fact A
In `TurtleLogo` the following word nudged the turtle forward in brief bursts.

```
to turtle-wait
     repeat 10 [ fd 20 wait 10]
end
```

Fact B
In `TurtleLogo`, you had the ability to make your program more flexible using variables.

```
to box
     repeat 4 [ fd 100 rt 90 ]
end
to draw-box :n
     repeat 4 [ fd :n rt 90 ]
end
```

Fact C
All three Logo programming languages use `repeat`, `wait`, and variables.

In this lesson, you will use these facts to build and solve LED puzzles.

Learning Goals

- ✓ Use the Logo words repeat and wait to create blinking light patterns
- ✓ Create and solve blinking light puzzles with fellow classmates

Instructions

1. Gather the following materials:
- ☐ HP Stream
- ☐ BasicBoard

2. Use notes from earlier lessons to accomplish the following:
- Connect the BasicBoard to the computer
- Start your **`myLEDs`** project
- Turn on all four LEDs
- Open the file `MyLEDs.txt`

3. The `uLogo` program, `MyLEDs.txt` already includes two words to make the red LED blink.
- Based on what you see in this program and your understanding of Logo, run both of these words. Recall, `wait 10` means wait for 10 tenths of a second.
- In your notebook, record your procedure and explain the structure and function of the two logo words.

4. Complete the LED challenges.

Challenges

Credit	Task
◆	Create single blink words for the remaining 3 LEDs and demonstrate that you can run these words from the terminal window.
◆	Create repeating blink words for the remaining 3 LEDs and demonstrate that you can run these words from the terminal window. The command `wait 1` will pause something for a single tenth of a second. Logo also knows the word **`mwait`**. How long of a pause is `mwait`? Use `wait` for one LED and `mwait` for another. Find a way to match their blinking rate.
◆◆	Create a new Logo word called `blink-puzzle`. Your word must include instructions for blinking your 4 LEDs in a unique sequence. a) Pair up with another group. b) Without viewing the other groups' program, reproduce their blinking sequence. c) In turn, ask the other group to reproduce your sequence

Helpful Hints

If you get an error message, see if you can figure out what you did wrong by asking a classmate for help. If all else fails, ask your teacher.

Watch the FTDI cable <u>after</u> download. If it slowly blinks red and green, the AppBoard is working.

If a text file is modified but has not been saved, you should see a star symbol (*) on the top of the text editor window.

`jLogo` commands must begin with a dot. **`uLogo`** commands do not begin with a dot.

Every time you make a change to your program, you must run the following three jLogo commands:

```
.compile
.download
.run-once
```

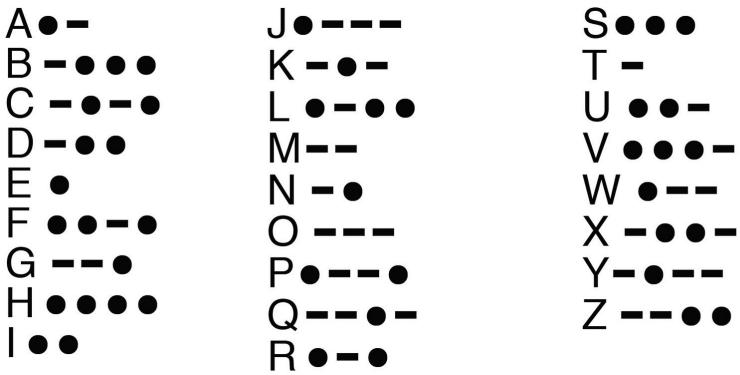
Going Further

Extra Credit	Task
◆	Create additional Logo words for performing complex blinking patterns with both the internal LEDs (AppBoard) and the external LEDs on the BasicBoard.
◆◆	How fast does something need to blink to appear continuous rather than discrete? Write a `uLogo` program to test this out with your LEDs.

2.8 Coded Communications

Getting Started

Morse Code is a method of communicating using a series of short and long pulses. These are typically referred to as "dots" and "dashes".



Morse Code Rules

- ☐ The length of a dot is one unit
- ☐ The length of a dash is three units
- ☐ The space between dots and dashes for a single letter is one unit
- ☐ The space between letters is three units
- ☐ The space between words is seven units

Learning Goals

- ✓ Write a Morse Code communication program in Logo
- ✓ Test and refine a Logo program based on peer feedback
- ✓ Present your Morse Code communication device with a demonstration and explanation

Instructions

1. Gather the following materials:
- ☐ HP Stream
- ☐ BasicBoard

2. Use notes from earlier lessons to accomplish the following:
- Connect the BasicBoard to the computer
- Start your **`myLEDs`** project
- Turn on all four LEDs
- Open the file `MyLEDs.txt`

3. Complete the Morse Code challenges.

Challenges

Credit	Task
◆◆	Write a blinking LED Morse Code program. In your notebook, explain how you decided to represent dots and dashes with your LEDs. • Spell SOS • Spell SECRET MESSAGE
◆◆◆	Without sharing your `uLogo` code or your dot/dash display method, do the following: • Send a coded message to another group in your classroom. • Decipher a coded message from another group in your classroom. Share your `uLogo` code with the other group. Discuss the strengths and weaknesses of each implementation and then work together to improve your programs.
◆◆	Present your Morse Code system to the class. Be as creative as you'd like with your presentation. Credit will be awarded based on your clarity, effort and creativity. Here are some presentation suggestions: • Make a poster • Make a flyer • Write an instruction manual • Demonstrate using your HP Stream and a projector • Make an instructional video

Helpful Hints

If you get an error message, see if you can figure out what you did wrong by asking a classmate for help. If all else fails, ask your teacher.

Watch the FTDI cable after download. If it slowly blinks red and green, the AppBoard is working.

If a text file is modified but has not been saved, you should see a star symbol (*) on the top of the text editor window.

`jLogo` commands must begin with a dot. **`uLogo`** commands do not begin with a dot.

Every time you make a change to your program, you must run the following three jLogo commands:

```
.compile
.download
.run-once
```

Going Further

Extra Credit	Task
◆◆	Any number can be represented by a sequence of binary digits – 1's and 0's. It only takes 4 binary digits to represent the decimal values 0 through 15. • Research binary numbers • Turn your 4-LED BasicBoard system into a binary display.