Design Studio – Week 2

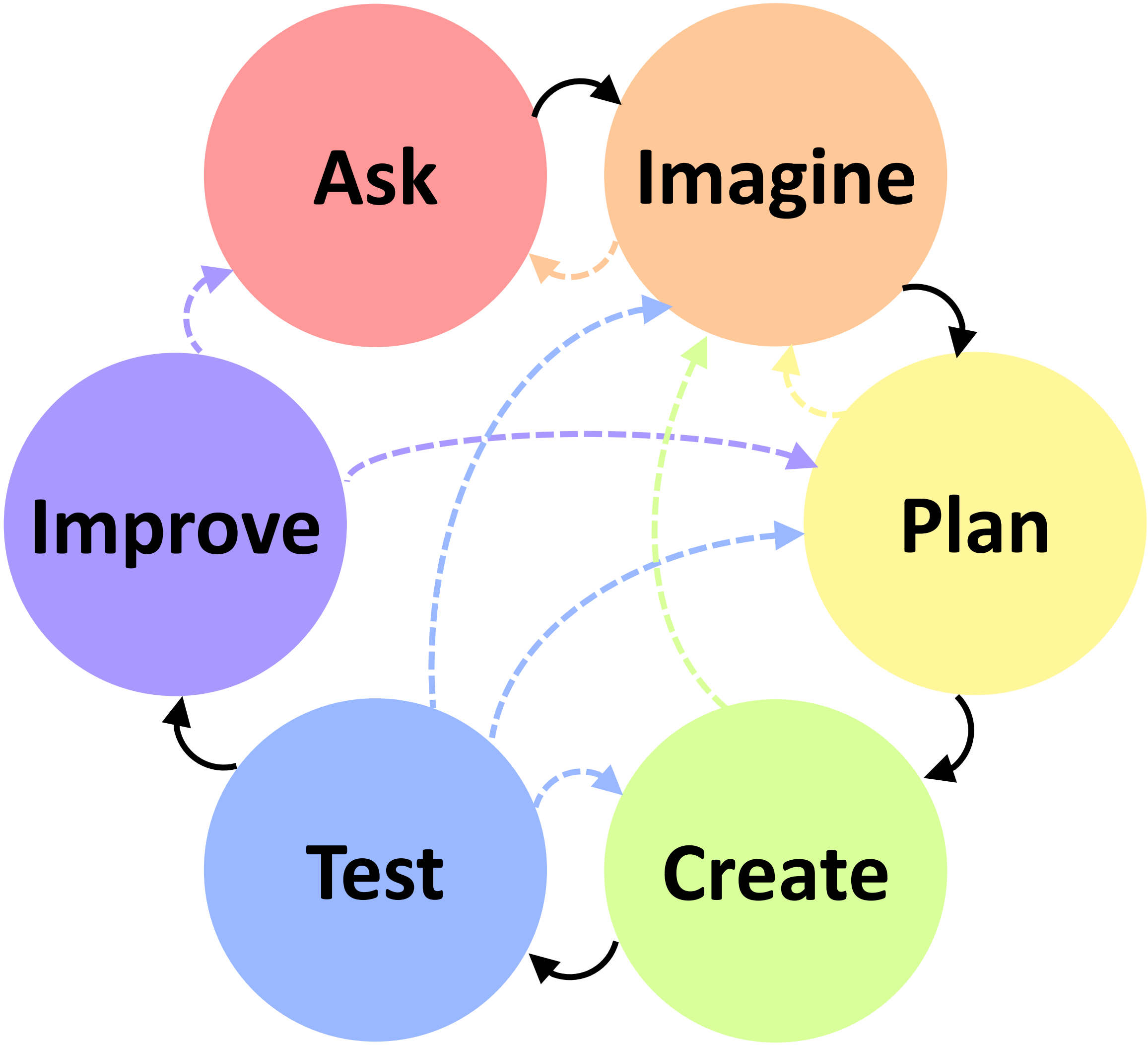
Today you will:

- Learn about iteration in an engineering design process
- Become familiar with basic electronic test equipment
- Build and test a prototype of your circuit design
- Add a new requirement to the design and iterate the process

Assignments:

- Exercise worksheet for modifications to the simple circuit design

Reviewing the Engineering Design Process



Iteration in the Design Process

Engineering design is <u>not</u> a one-time, perfect process – it requires an iterative, learning approach.

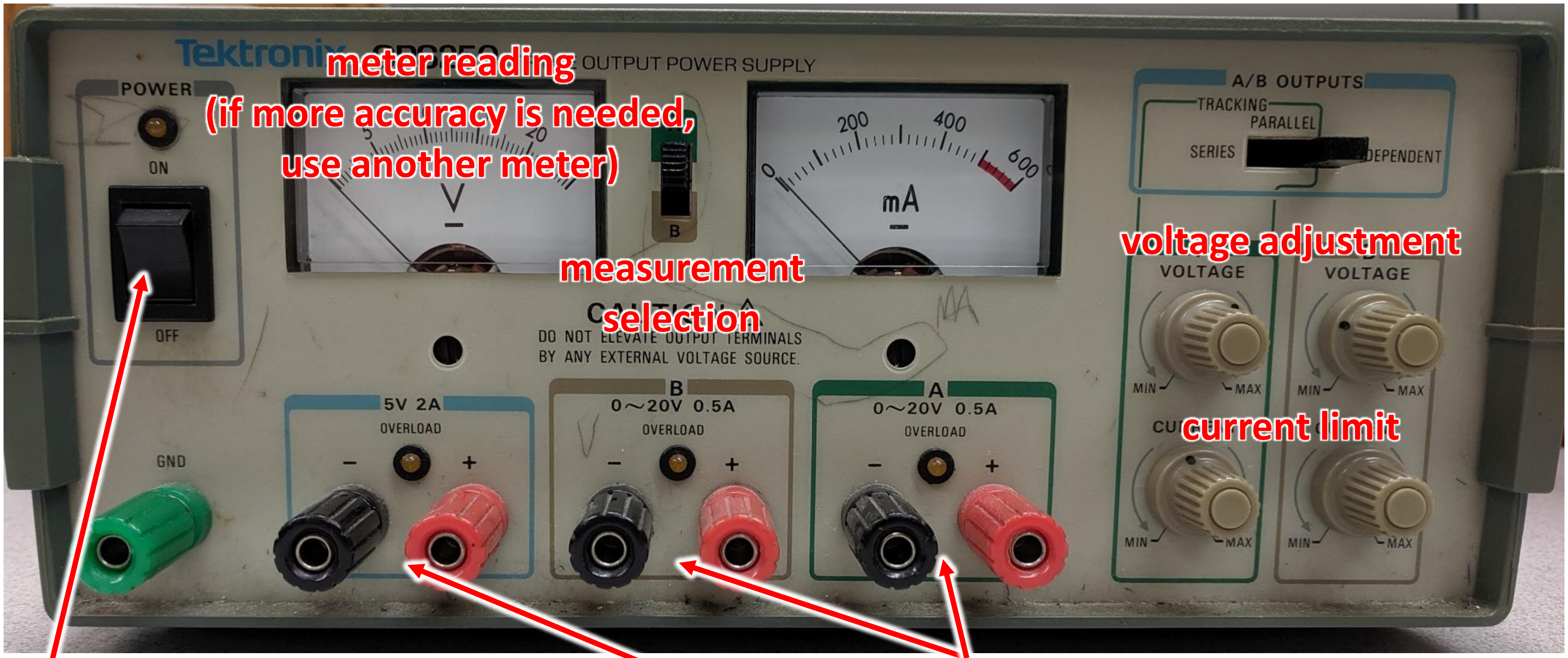
- While the ideal case is that we "make it" to the *Improve* phase with nothing to improve, we don't live in an ideal world.
- You might not even make it to the *Improve* phase at all!
  - If you realize that a previous part of the design has to change, return to that phase of the process as soon as possible.
  - There are many possible reasons you might need to return to any of the previous design phases.

Think back to the phases of our simple circuit design last week. What reasons might exist to return to an earlier phase?

Engineering Tools – Power Supplies

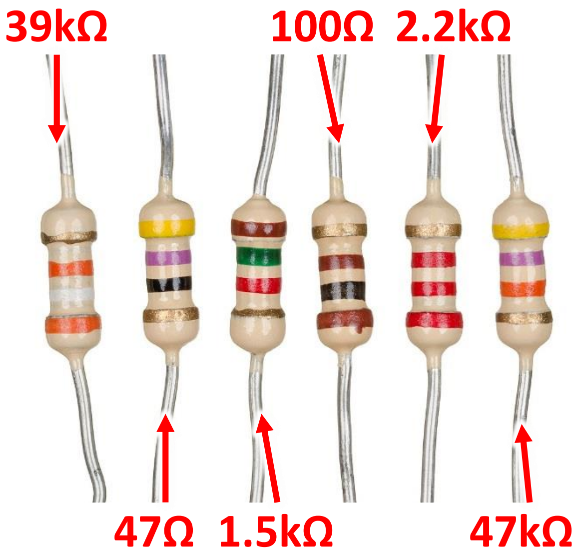
Now that you've modeled your design, let's go build a prototype!

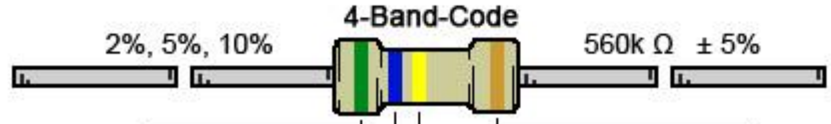
First, we need to learn about the equipment.



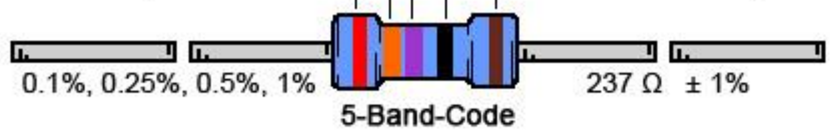
Engineering Tools – Resistors

Physical resistors come in many shapes and sizes.





COLOR	1ST BAND	2ND BAND	3RD BAND	MULTIPLIER	TOLERANCE
Black	0	0	0	1Ω	
Brown	1	1	1	10Ω	± 1% (F)
Red	2	2	2	100Ω	± 2% (G)
Orange	3	3	3	1KΩ	
Yellow	4	4	4	10KΩ	
Green	5	5	5	100KΩ	± 0.5% (D)
Blue	6	6	6	1MΩ	± 0.25% (C)
Violet	7	7	7	10MΩ	± 0.10% (B)
Grey	8	8	8		± 0.05%
White	9	9	9		
Gold				0.1Ω	± 5% (J)
Silver				0.01Ω	± 10% (K)



Not all values of resistors are easy to find –

if the application requires it, you can combine resistors to achieve the desired resistance

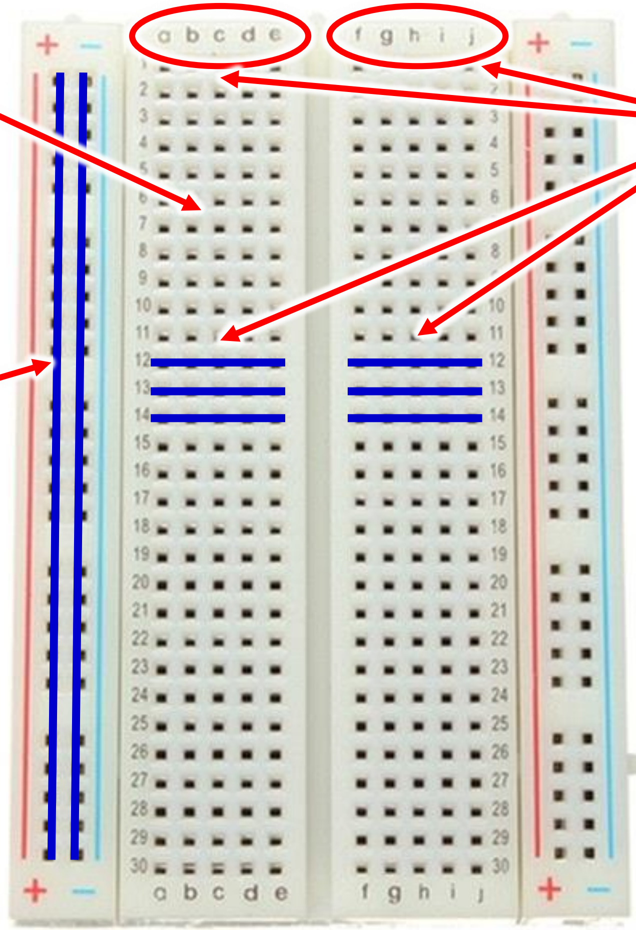
Engineering Tools – Breadboards

Breadboards allow you to physically connect parts of a circuit in a quick, safe, and often temporary manner.

Individual holes can be filled with wires and part leads

The columns on the left and right of the breadboard are also connected.

These are useful for supplying voltage to multiple parts.



The breadboard connects a-e of each numbered row and f-j of each numbered row

Adding wires and parts to the same row connects them.

Engineering Tools – Multimeters

Breadboard circuit performance is usually measured with a multimeter, which can measure both voltage and current.

The measurement reading is shown here. Use the range setting for the best resolution of your measurement.

Turning the dial to this region will measure constant (DC) voltage.

Voltage readings are done "in parallel" and do not interrupt the circuit wiring.

Turning the dial to this region will measure constant (DC) current.

Current readings are done "in series" and interrupt the circuit wiring to insert the meter between two components.

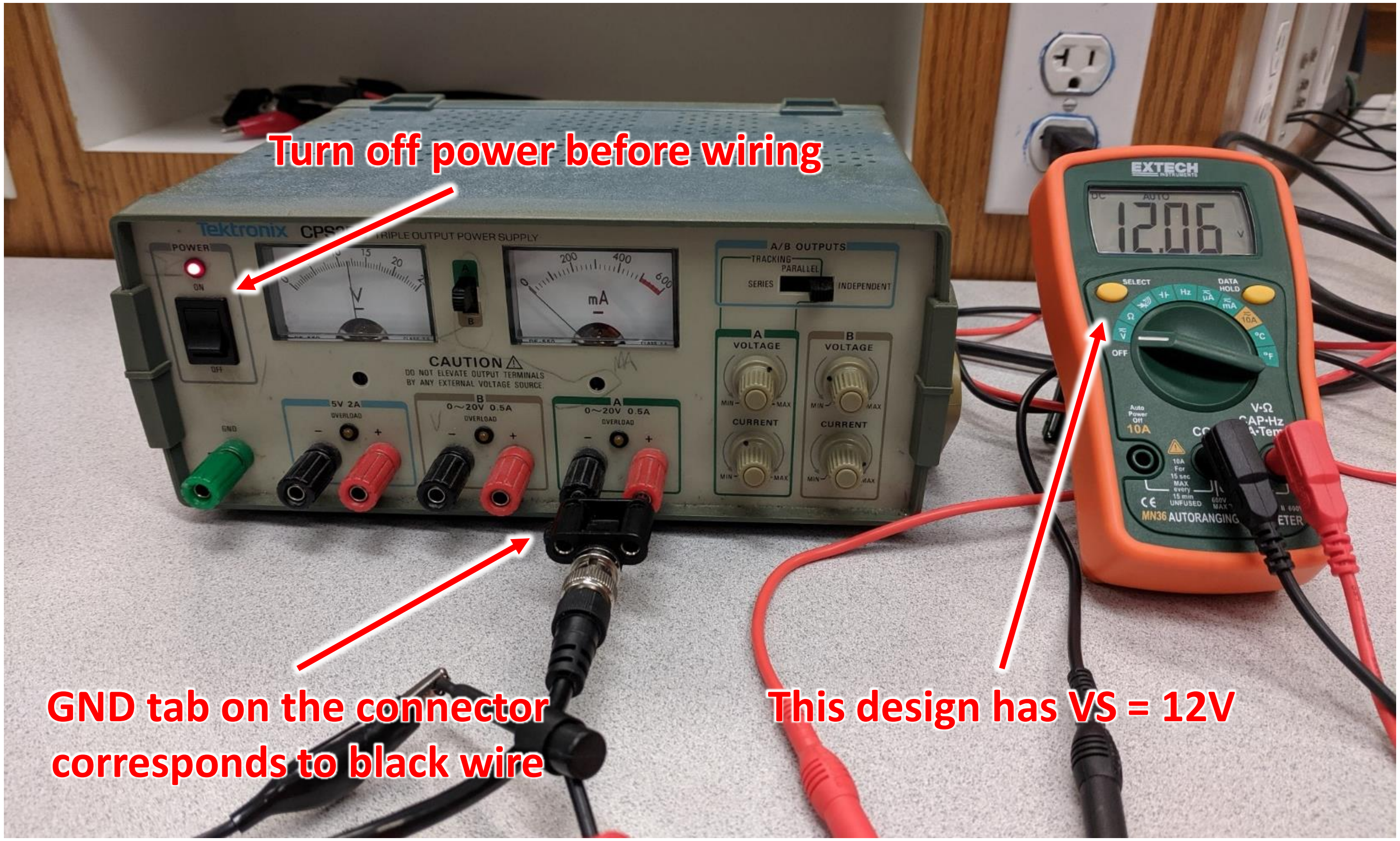
The test probes connect to the multimeter here.

Iteration 1 – Prototyping

Create

Follow along these steps to build and test your design.

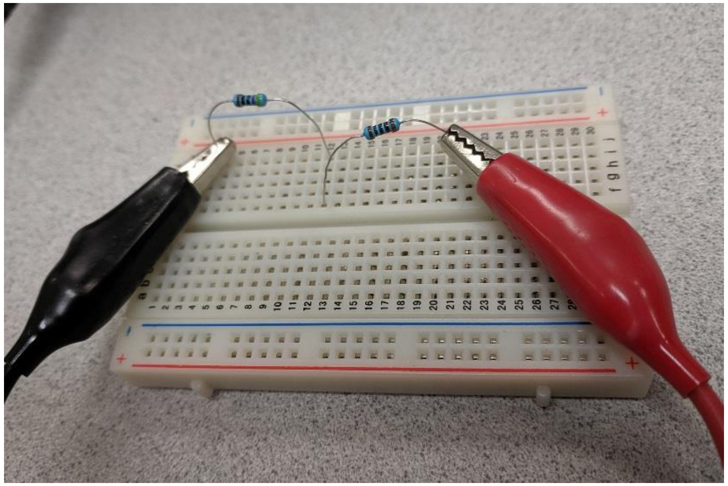
1. Set and measure the power supply voltage:

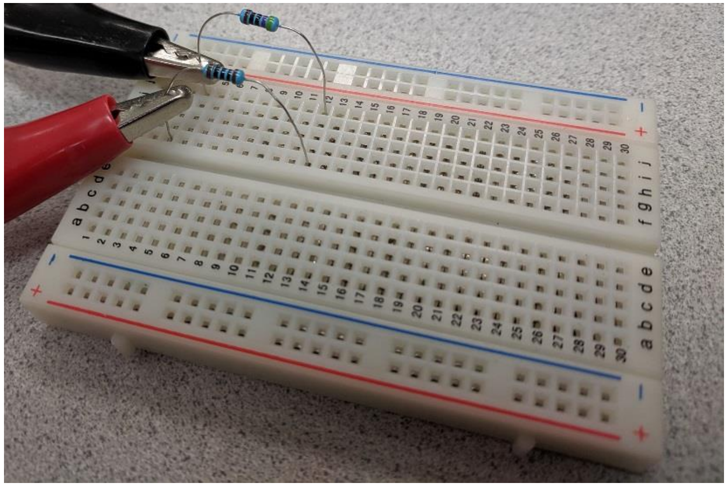


Iteration 1 – Prototyping

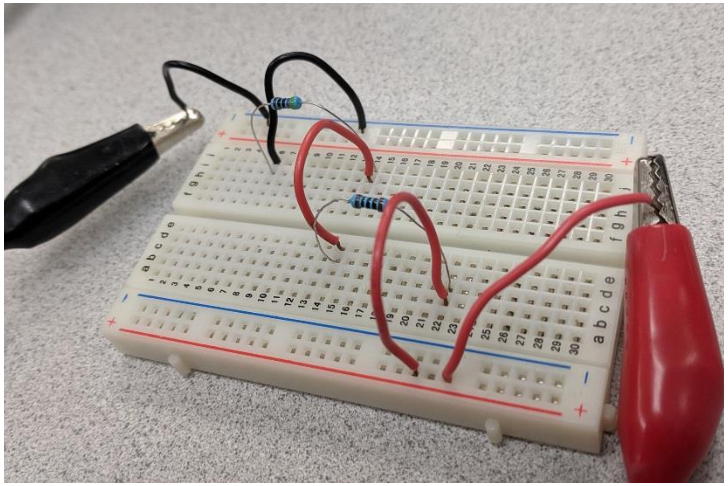
Create

There is no one correct way to layout a circuit on a breadboard.





These are all the same circuit!

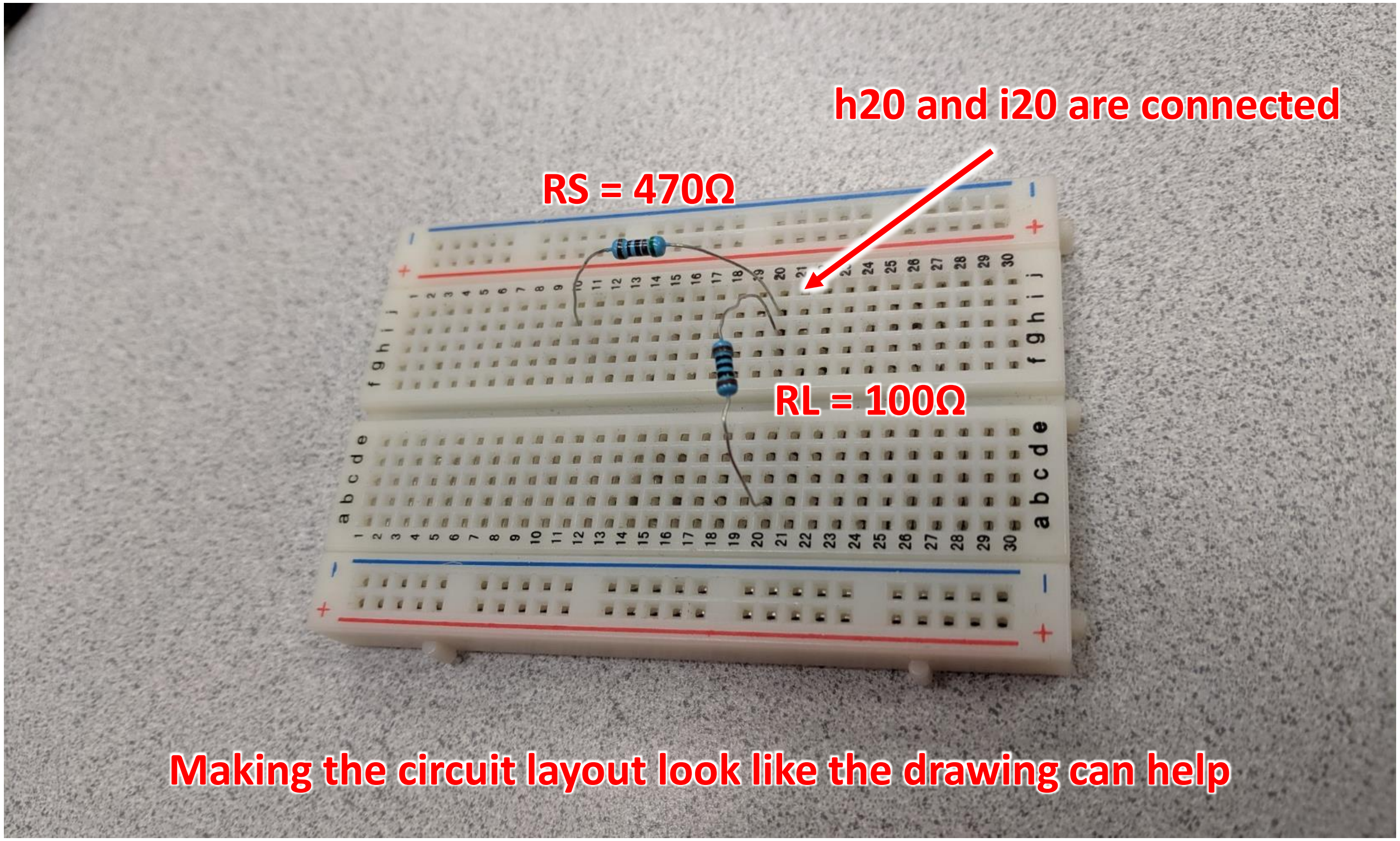


Choose a layout that is easy to follow and troubleshoot.

Iteration 1 – Prototyping

Create

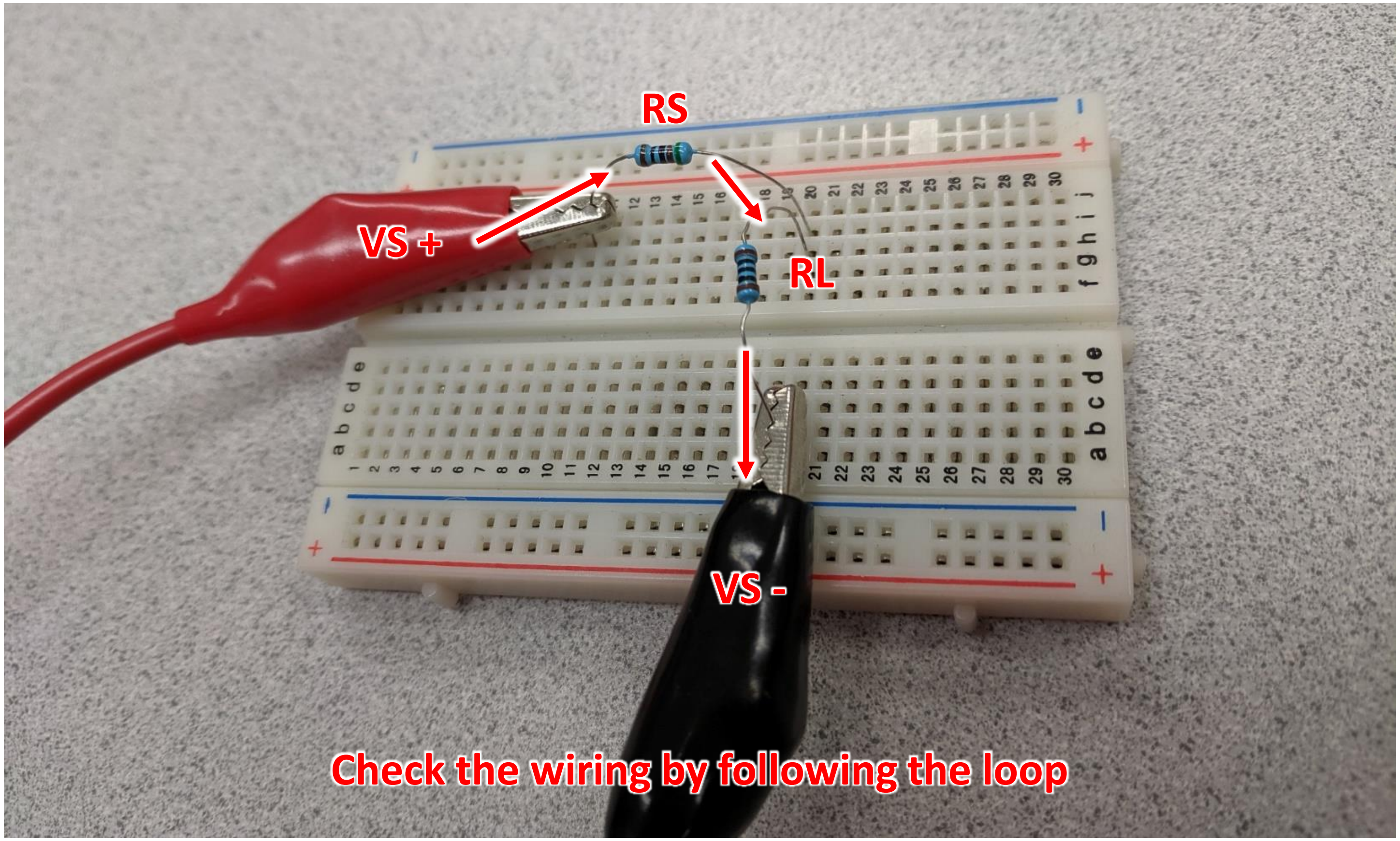
1. Set and measure the power supply voltage: ✓
2. Place the circuit components:



Iteration 1 – Prototyping

Create

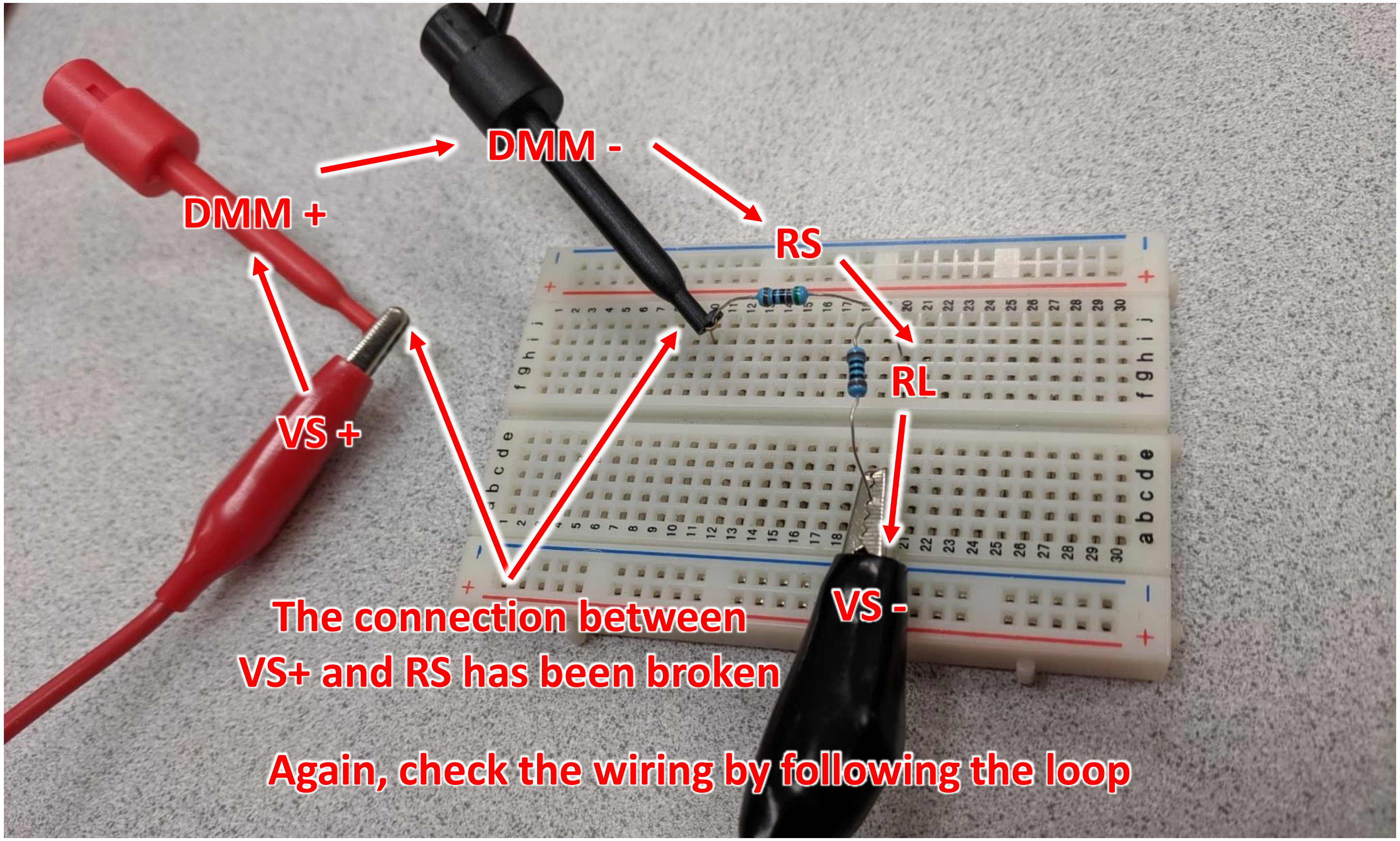
2. Place the circuit components: ✓
3. Connect the power supply:



Iteration 1 – Testing the Prototype

Test

3. Connect the power supply: ✓
4. Connect the multimeter in series:

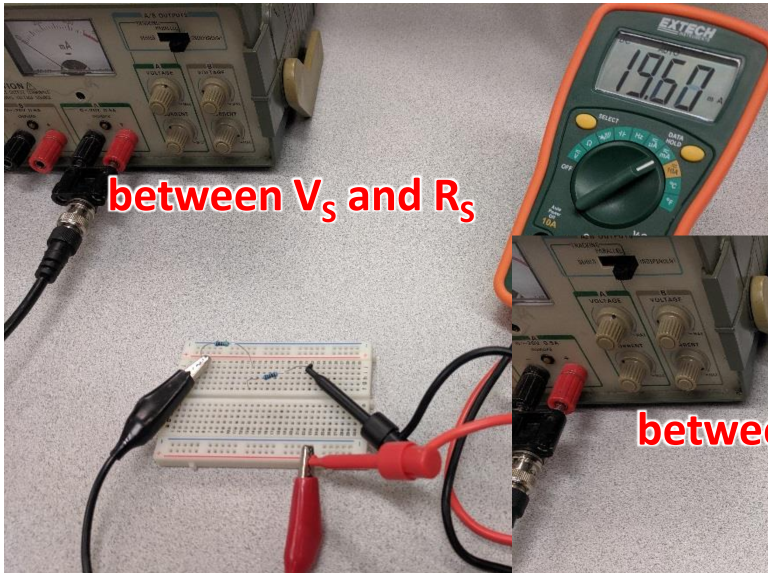


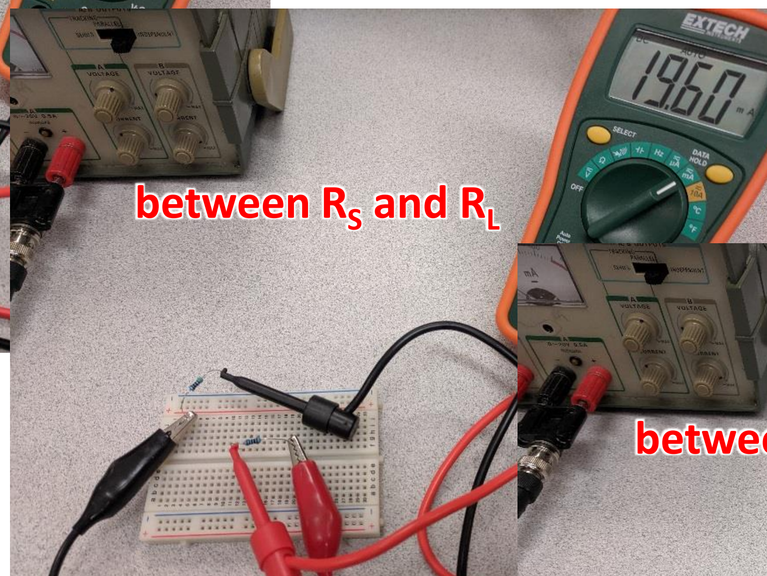
Iteration 1 – Testing the Prototype

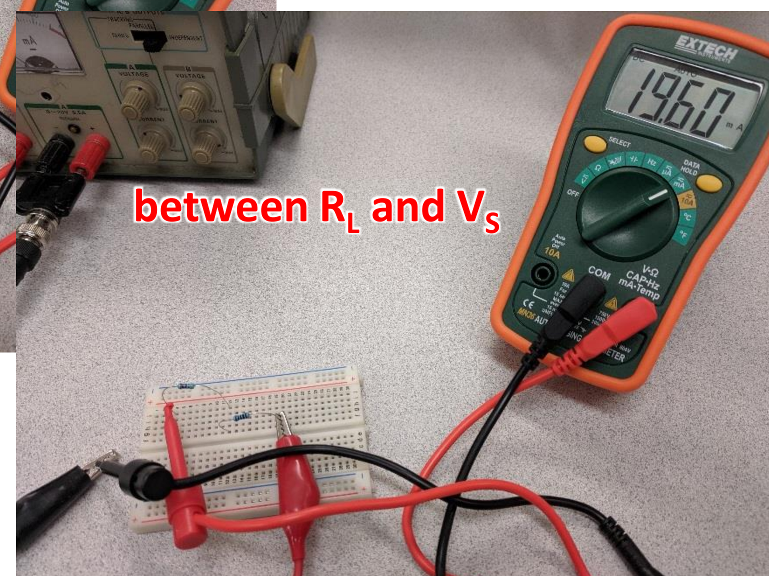
Test

There is no one correct place to measure current.

Anywhere along the path works!







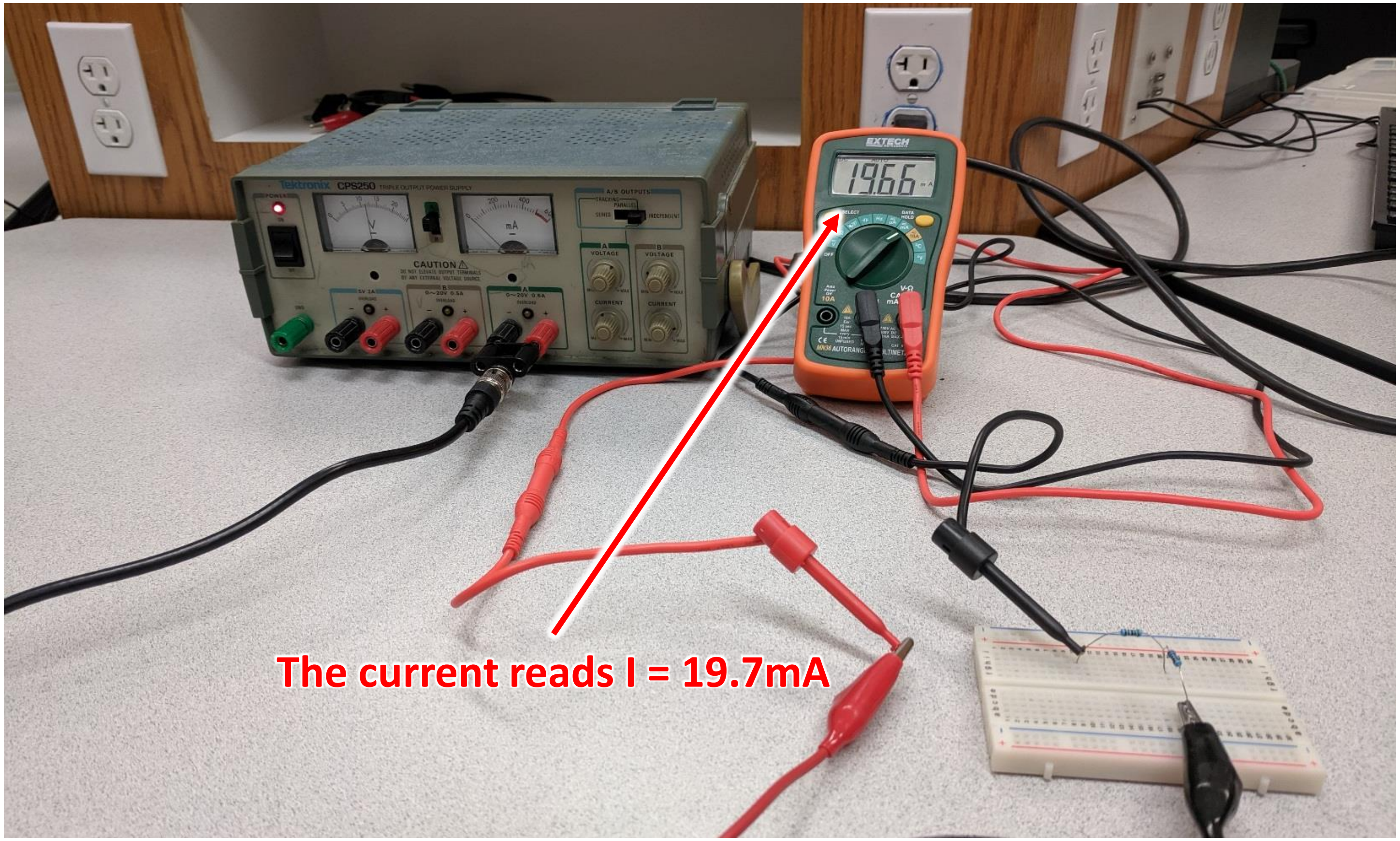
Just be sure to break the circuit to insert the current meter.

Otherwise: short circuit!

Iteration 1 – Testing the Prototype

Test

4. Connect the multimeter in series: ✓
5. Measure the current:



Iteration 1 – Test Analysis

Test

Think about the following questions:

- How did your circuit measurement today compare to your results from Multisim?
- What advantages do you see to simulation in Multisim over prototyping on a breadboard?
- What advantages do you see to prototyping over simulation?

You won’t always need to build both a model and a prototype of the same design. One may be more appropriate than the other, or perhaps each are more suited to different parts of the design.

Iteration 2 – Improve

Improve

There are still an enormous number of things we could do:

- If your prototype met the requirement, you could start planning how to build a final version of the circuit.
- If your prototype did not meet the requirement, you could start adjusting your component values and build a new prototype…
- …or we could choose a new design concept and start over.

We could also add a new feature:

- An LED light that turns on when the circuit is connected.

To add a new feature, we'll also have to specify how it should work by adding another requirement.

Iteration 2 – New Requirements

Ask

We now have two requirements:

Supply 20 mA of current into a 100 Ω resistor.

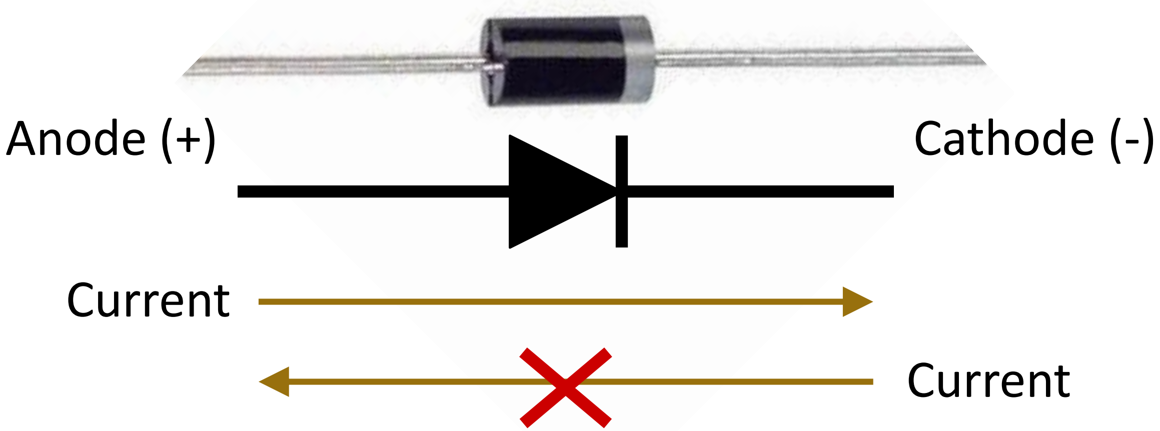
Turn on an LED when the 100 Ω resistor is connected.

Our old design doesn't even have an LED in the circuit, so our design has to change!

Our first step to imagining a new design is understanding how LEDs work. Perhaps we can then adapt our current circuit design instead of brainstorming an entire new list of circuit designs.

Concept Review – Diodes and LEDs

A diode is a simple semiconductor device that allows current to flow in one direction.



A light emitting diode (LED) emits light when current is flowing through it. An LED anode is longer than the cathode by convention.

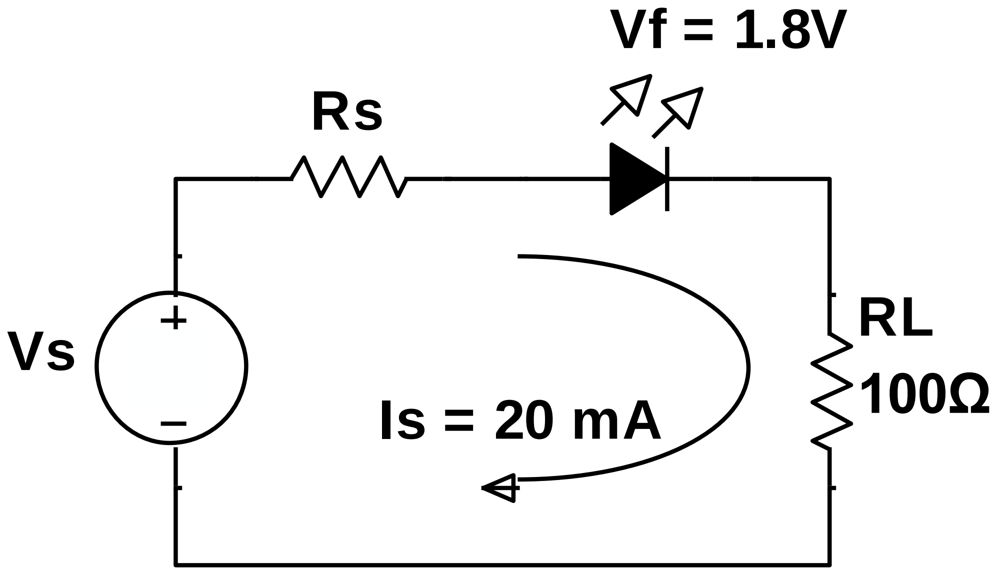
Every diode has a specified **forward voltage**, or the positive voltage between the anode and cathode that is required for current to flow.

For LEDs, this voltage can is typically in the range of 1.5V to 3V.

Iteration 2 – Design Changes

Plan

We have a red LED with a forward voltage of 1.8V available for both Multisim and breadboarding. Let's use it:



To simplify the redesign, keep the same series resistor (Rs) value.

Calculate the new source voltage (Vs) needed for a 20 mA current.

Iteration 2 – Testing the New Prototype

Test

Your instructor will provide you with a red LED.

Modify your breadboard prototype to include the LED and don’t forget to adjust the power supply voltage to your new value.

Measure the circuit performance:

- What is the current going into the 100 Ω resistor?
- Does the LED turn on?

Be sure to take a picture of your circuit before you break it down.

Put all of the equipment back as you found it and return the series resistor and LED to your instructor.