

introduction to
**Digital
Electronics**

MIT ILLUMINATIONS SEMINAR

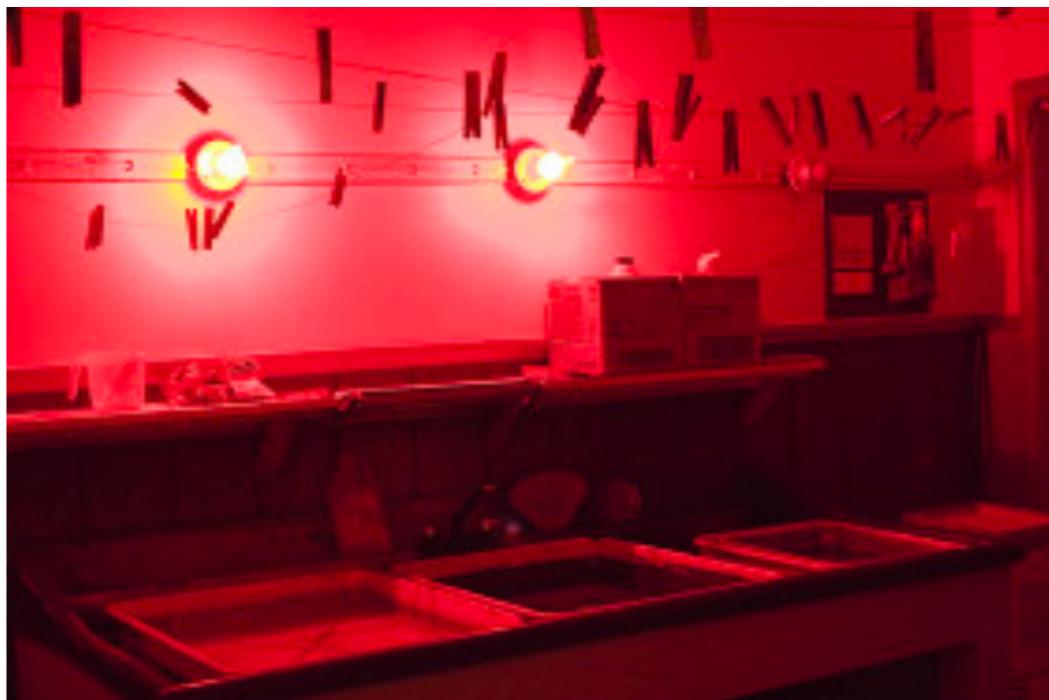
HELLO!

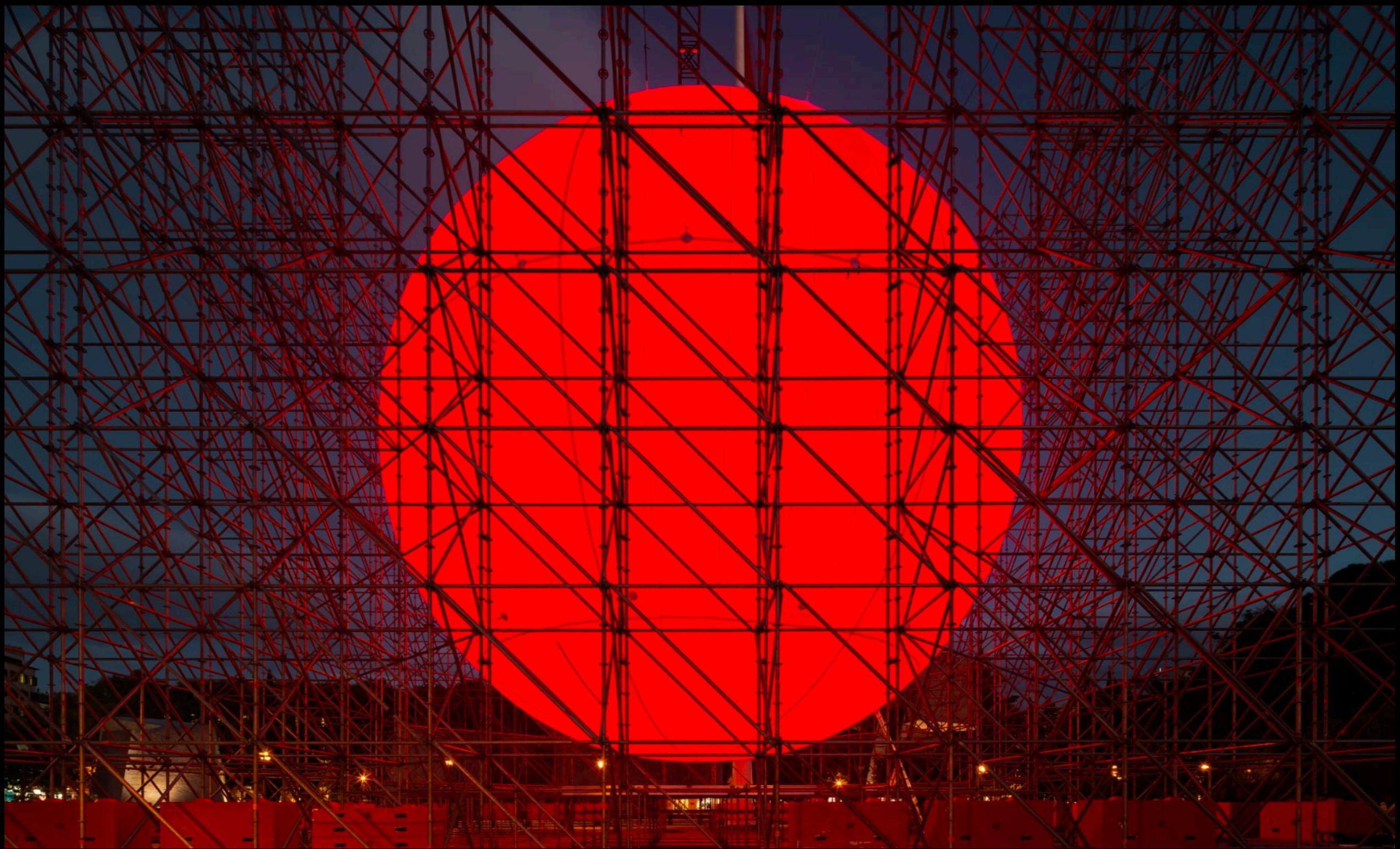
As Promised...
Our LAs!

WARM UP!

Come up with as many uses as possible for a red light bulb.



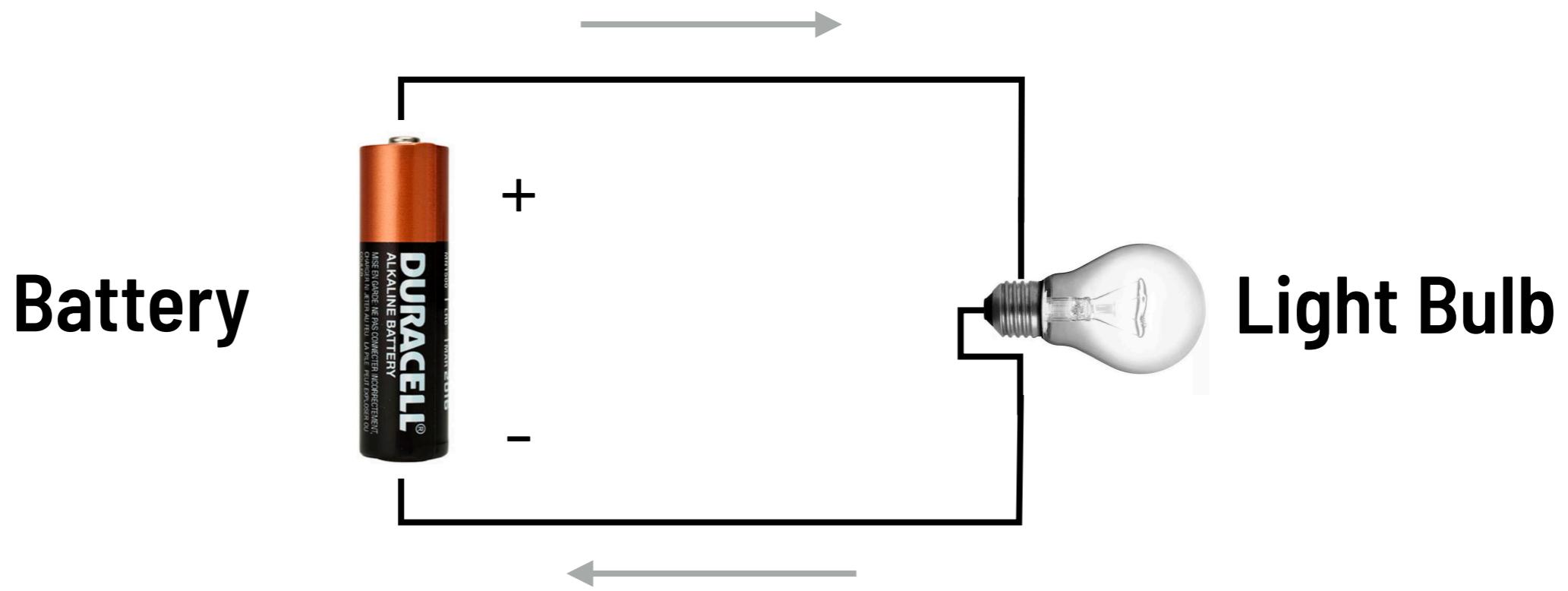




Research shows that
intelligence have
increased...

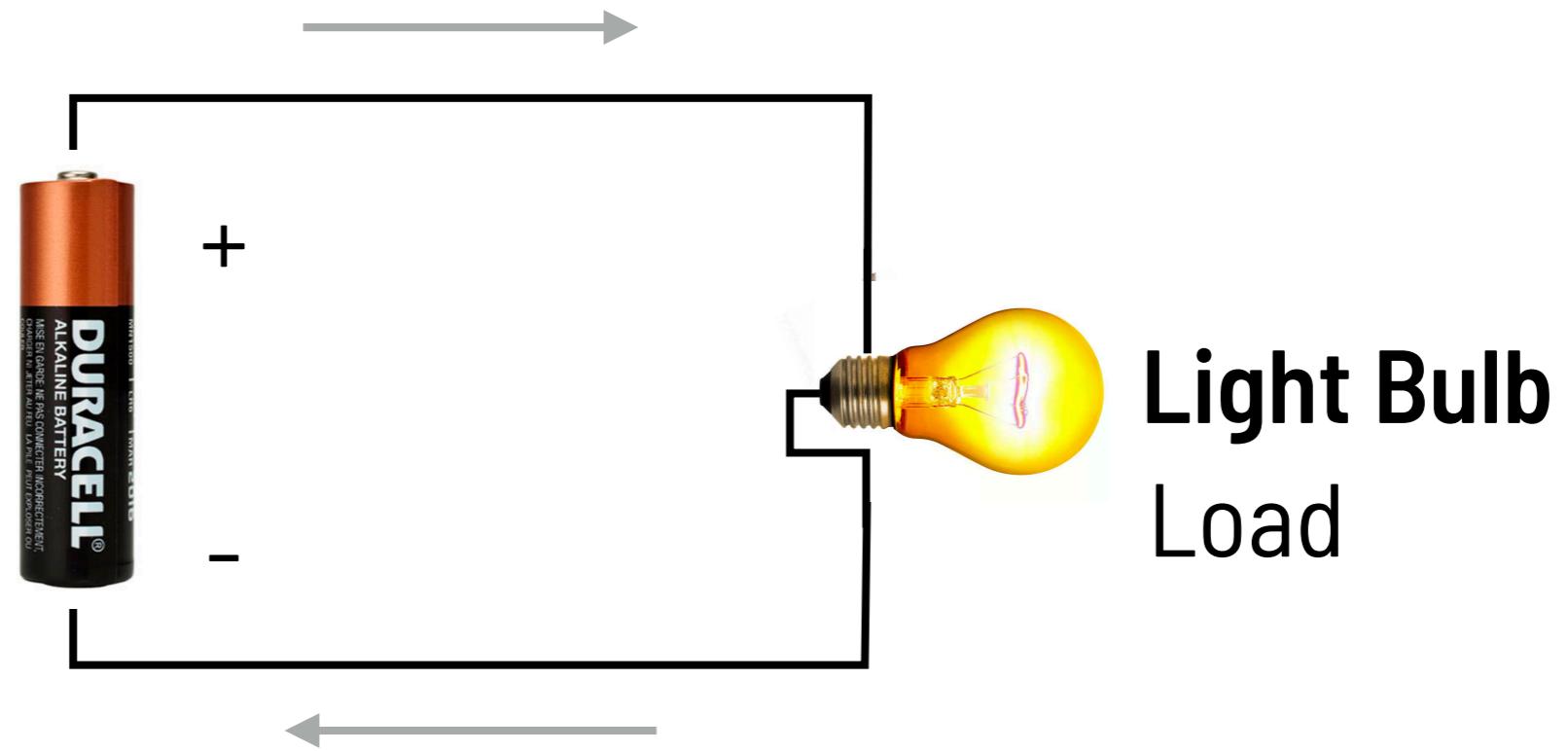
...while creative
thinking scores have
significantly decreased

Let's look at a circuit!



Let's look at a circuit!

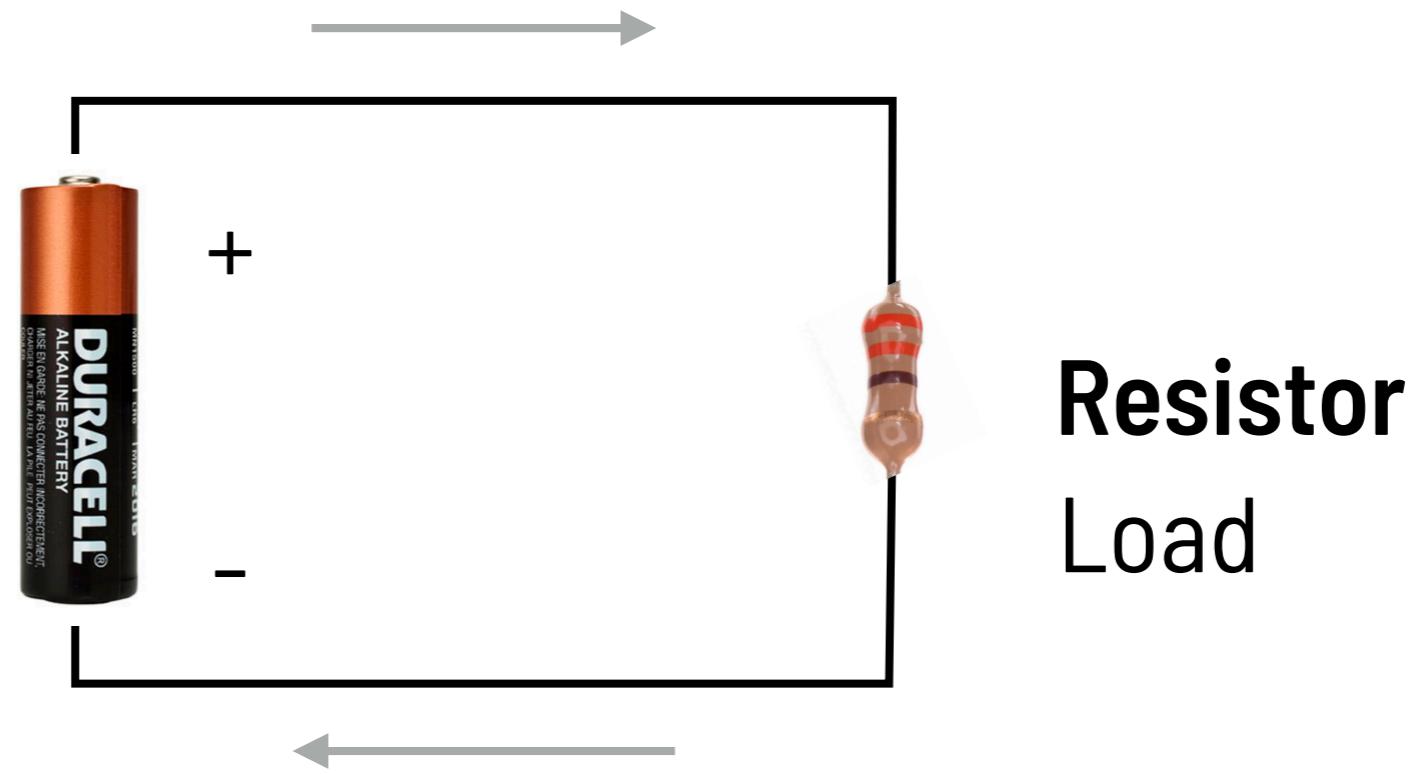
Battery
Power Source



Light Bulb
Load

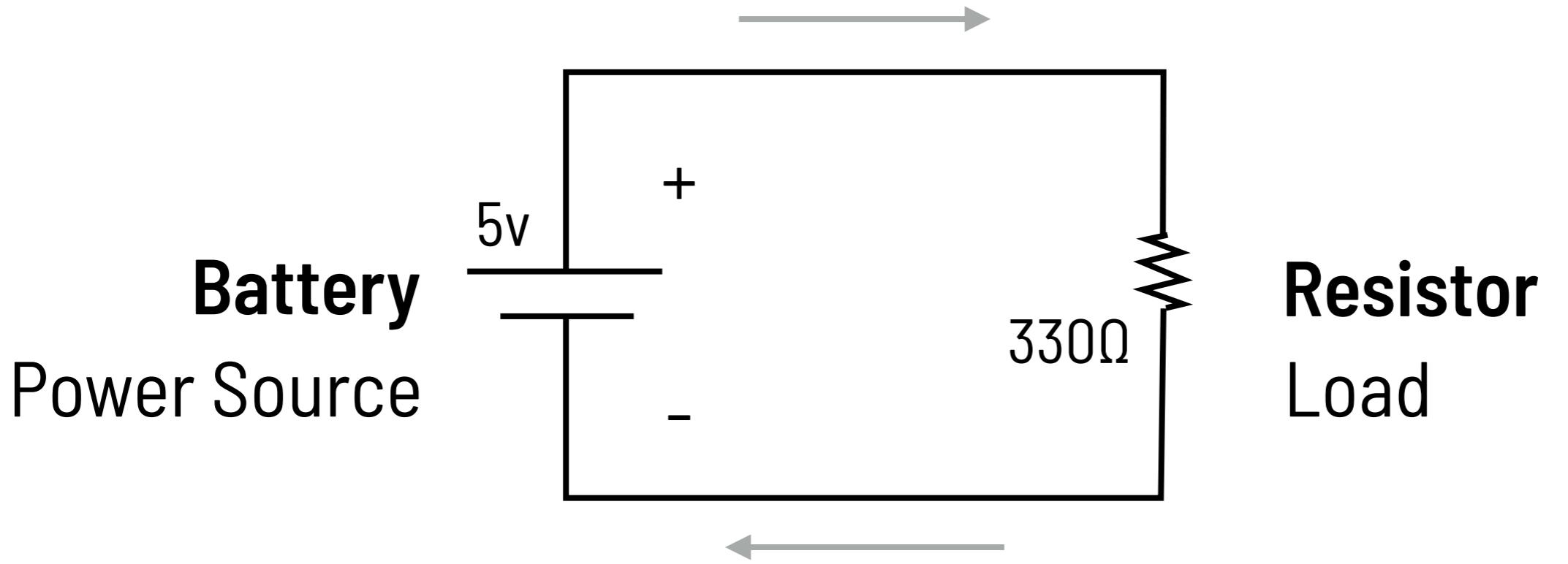
Let's look at a circuit!

Battery
Power Source



Resistor
Load

Let's look at a circuit!



$$V = IR$$

Voltage = Current × Resistance

Volts

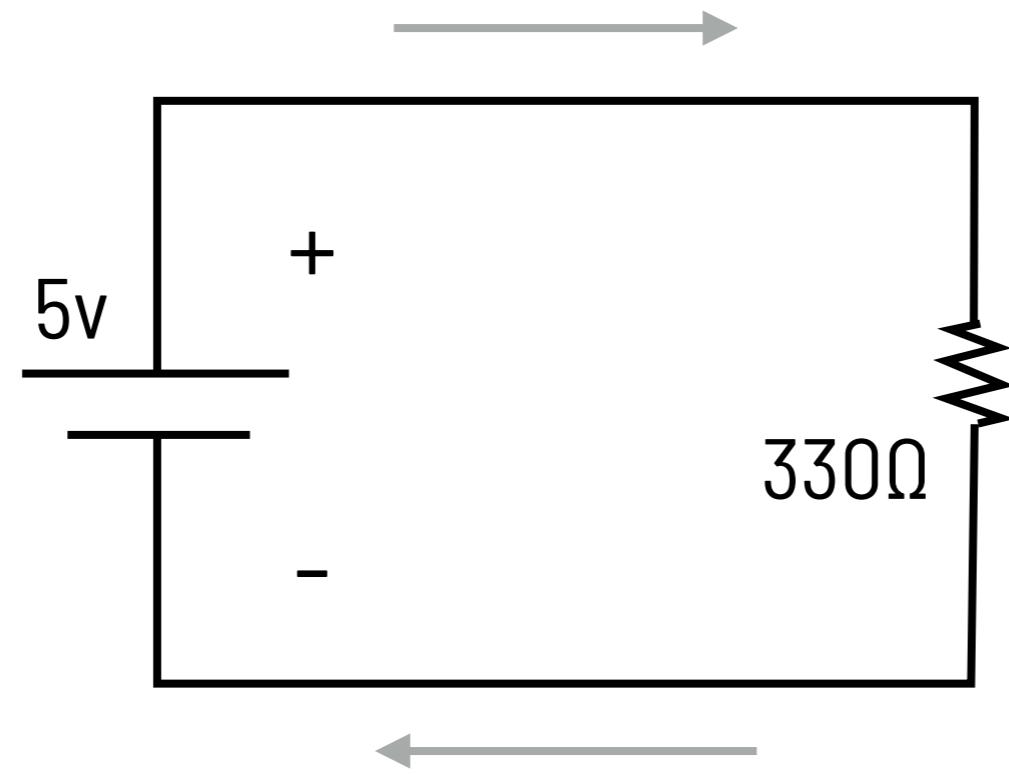
Amps

Ohms

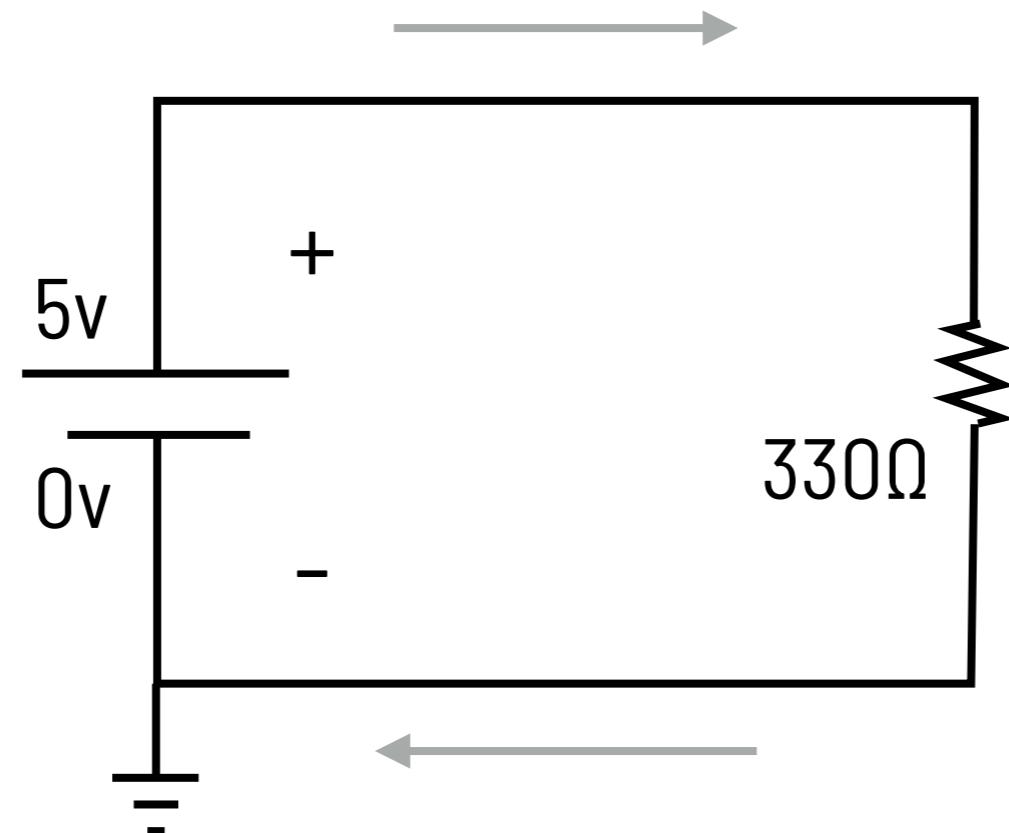
$$5 = I \cdot 330$$

Current $\approx 0.015A$

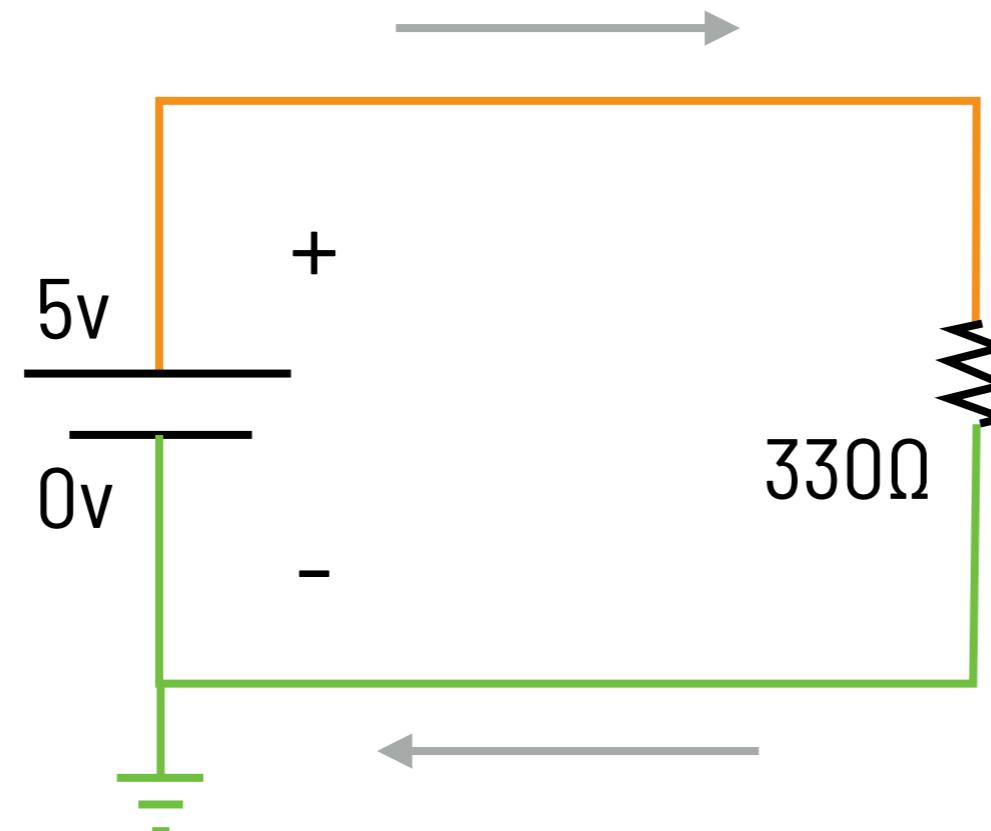
Let's look at a circuit!



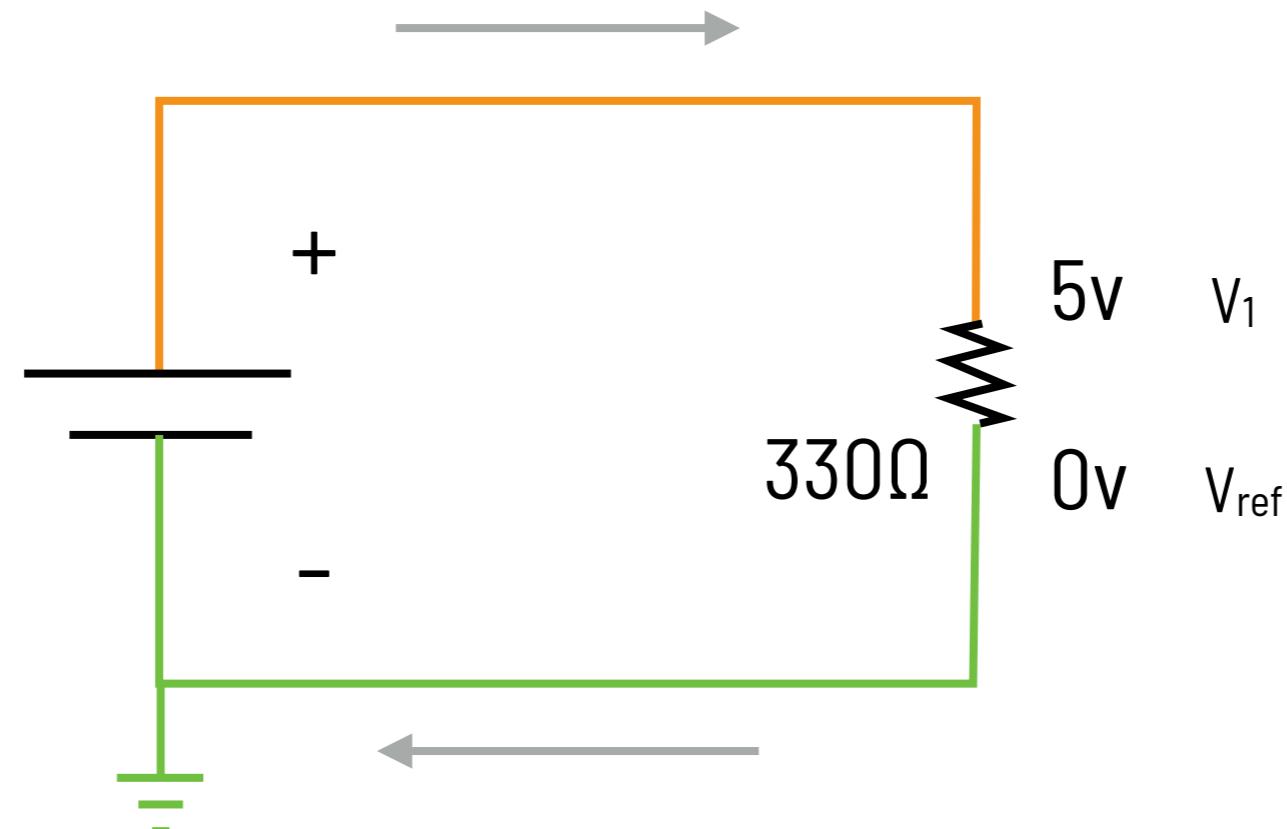
Let's look at a circuit!



Let's look at a circuit!

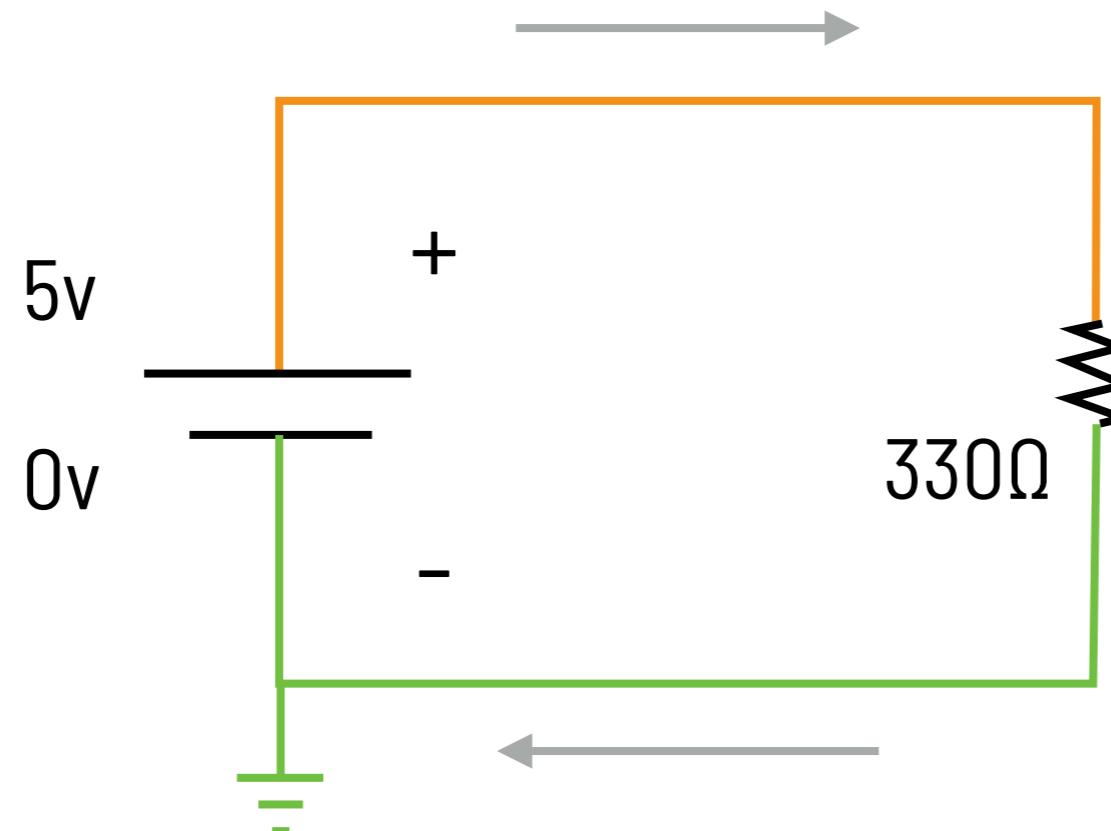


Let's look at a circuit!

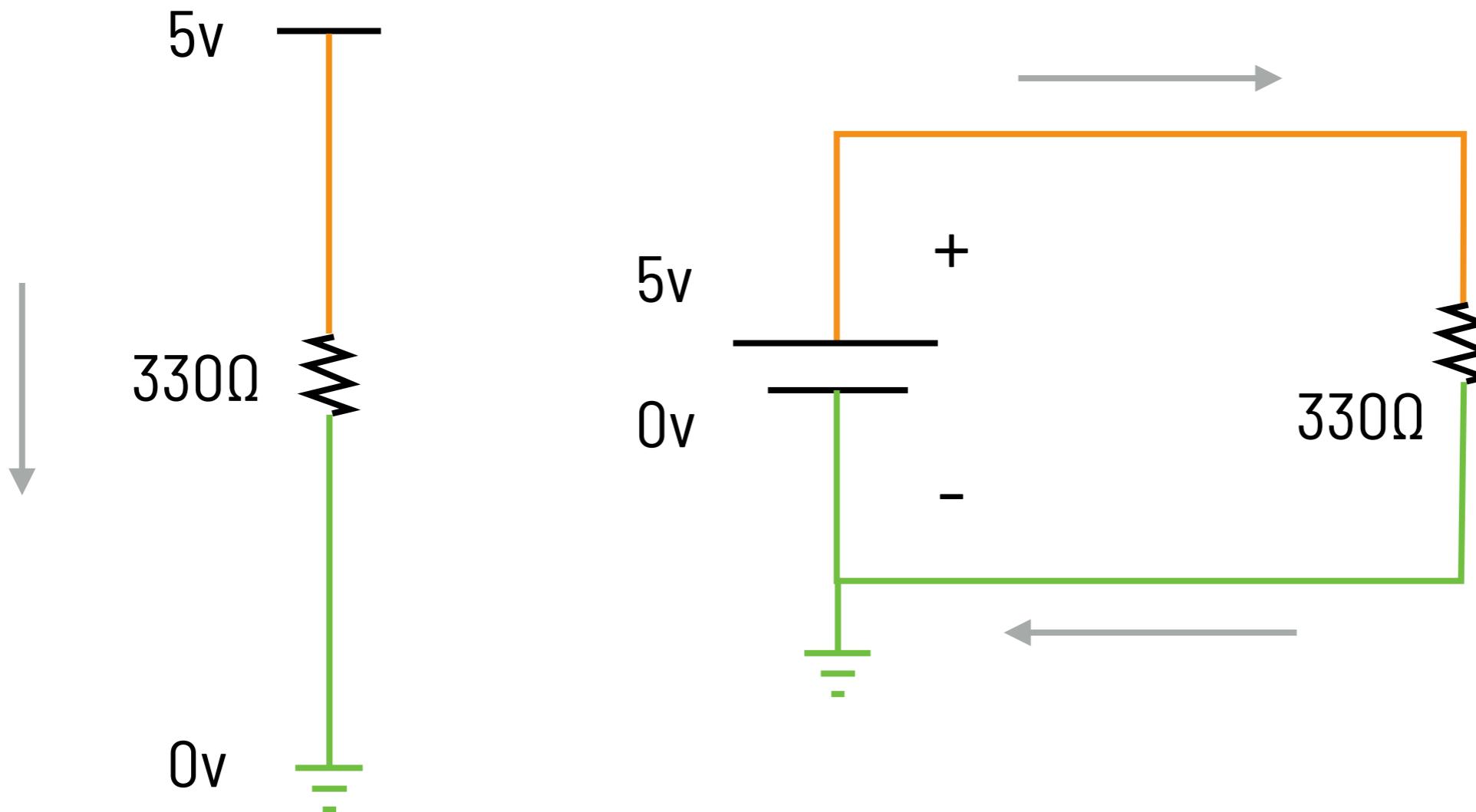


$$V_1 - V_{\text{ref}} = IR$$

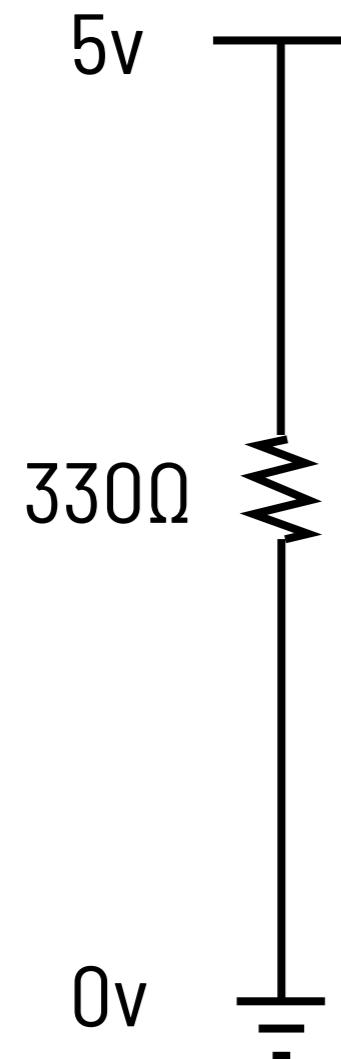
Let's look at a circuit!



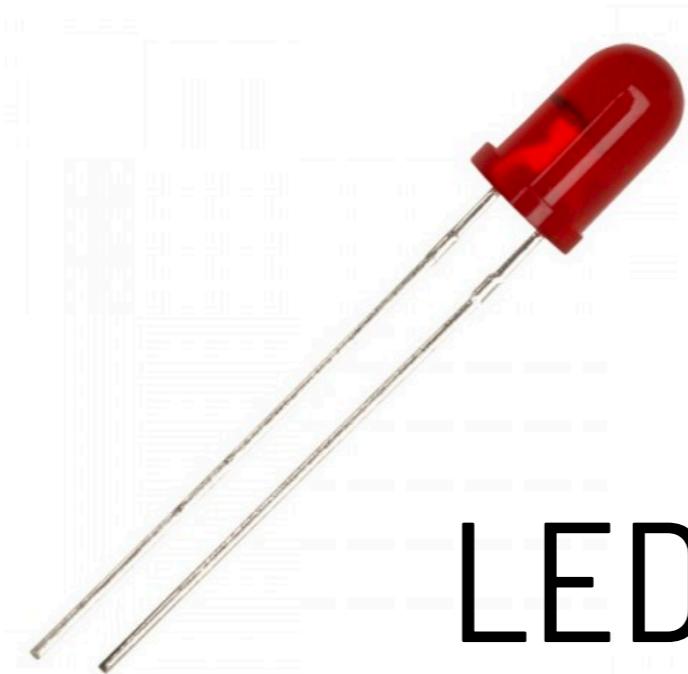
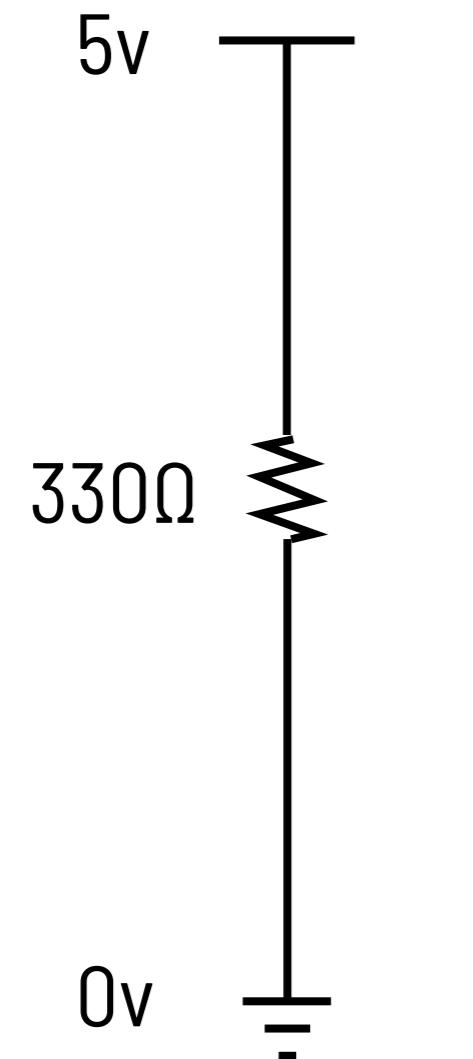
Let's look at a circuit!



Let's look at a circuit!

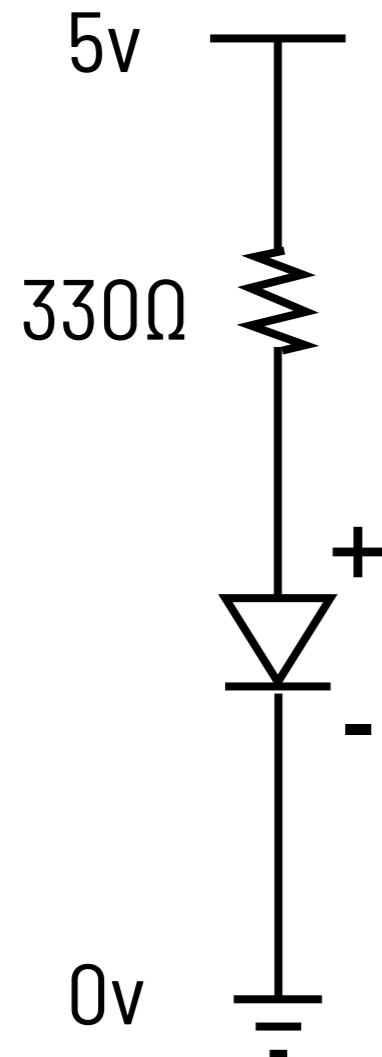


Time for some LIGHT!



LED
Light Emitting Diode

Time for some LIGHT!

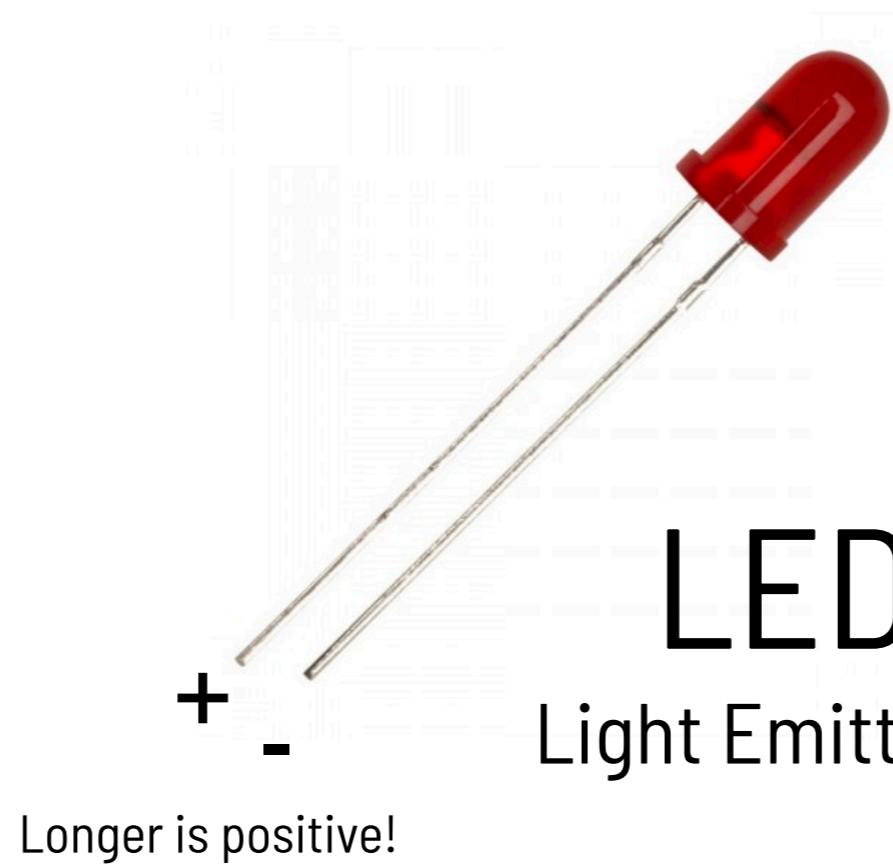
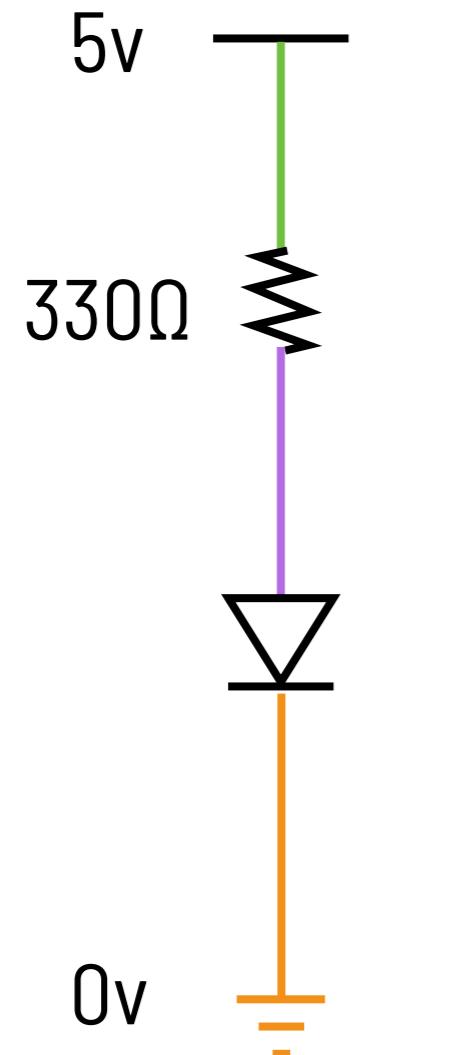


LED
Light Emitting Diode

Longer is positive!

Diodes conducts current primarily in one direction
Needs resistor!

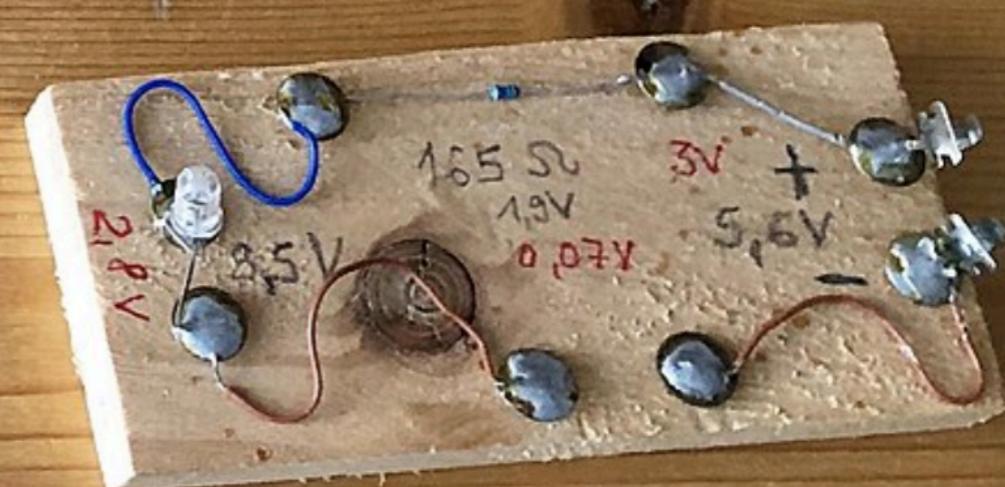
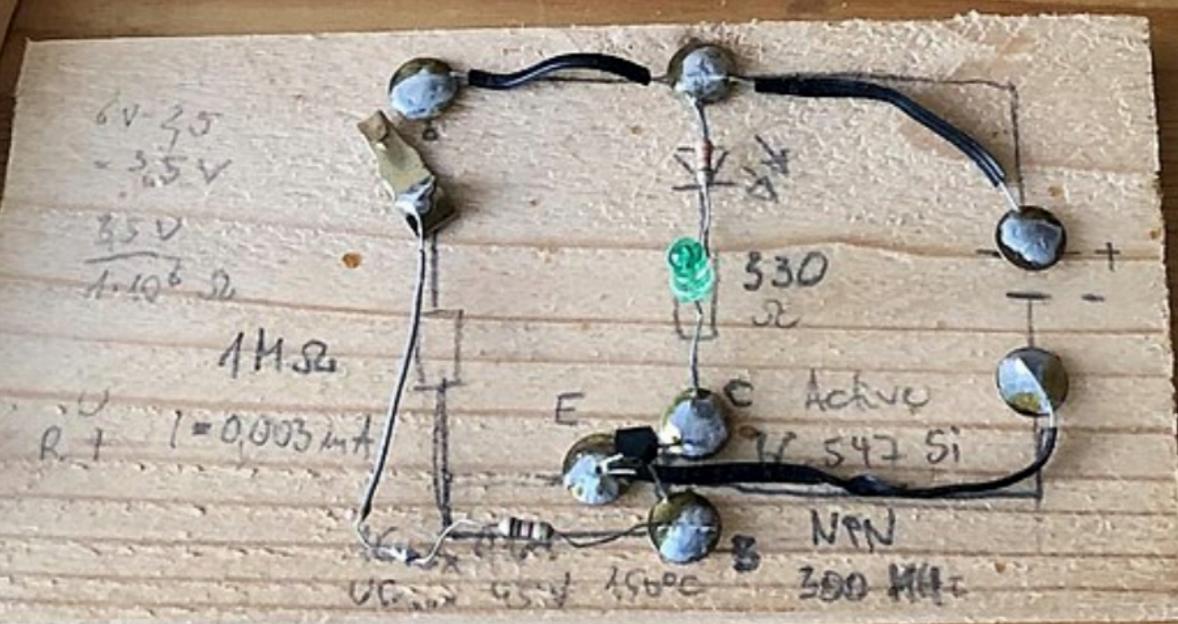
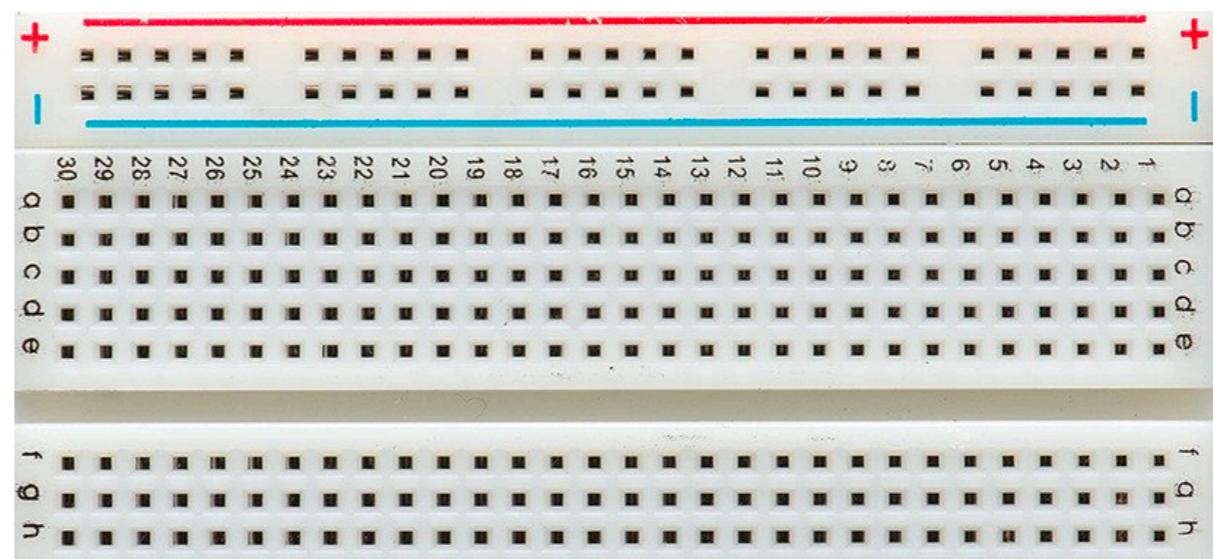
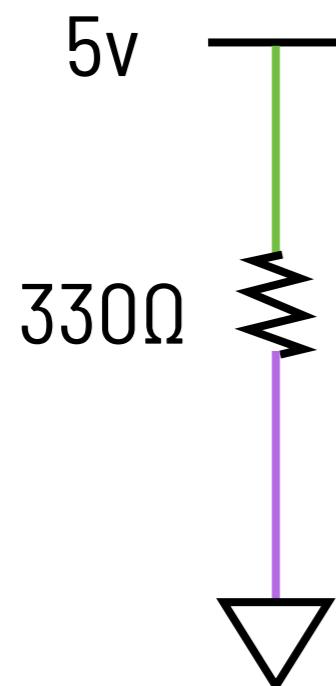
Time for some LIGHT!



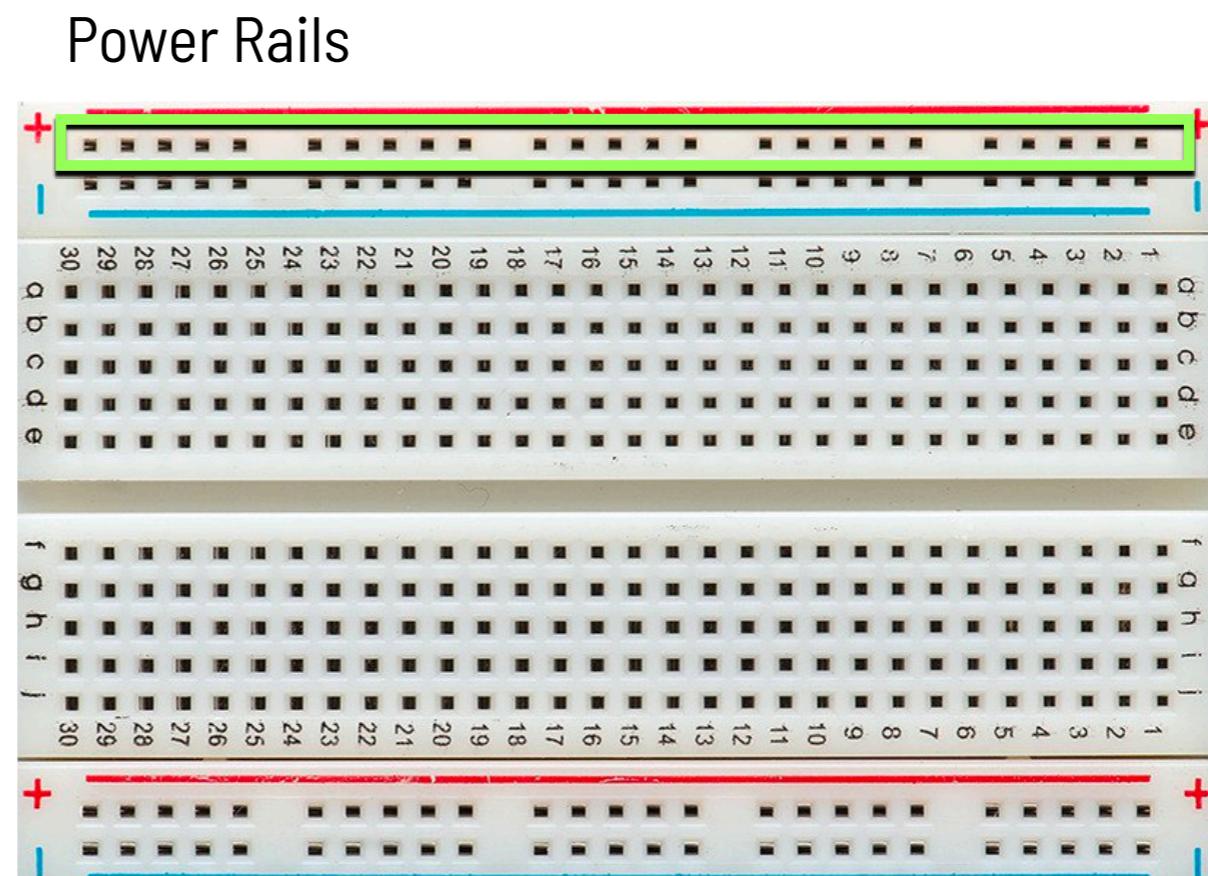
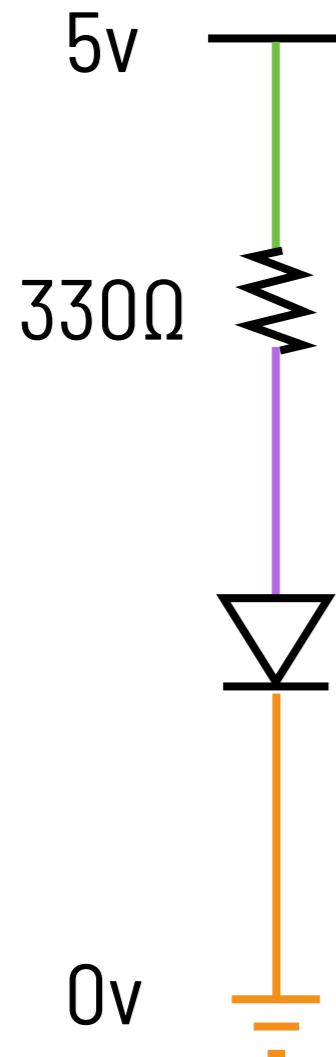
LED
Light Emitting Diode

Longer is positive!

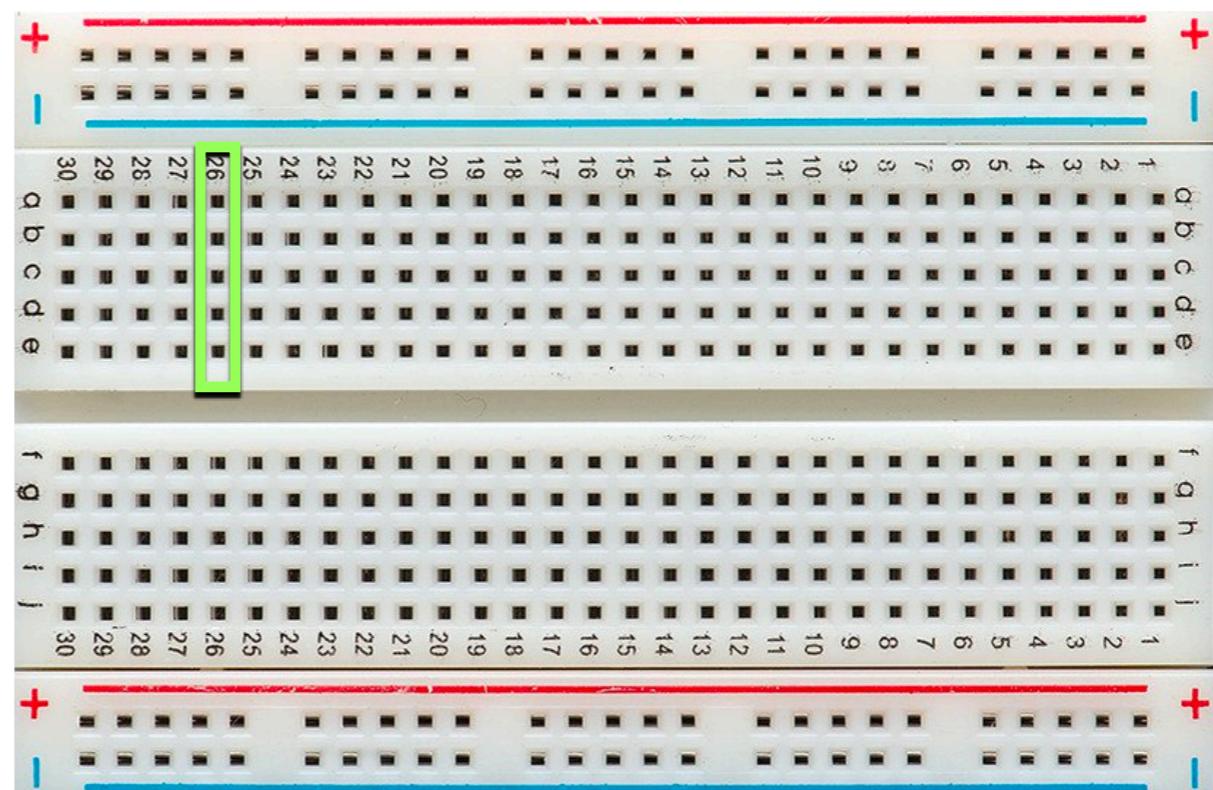
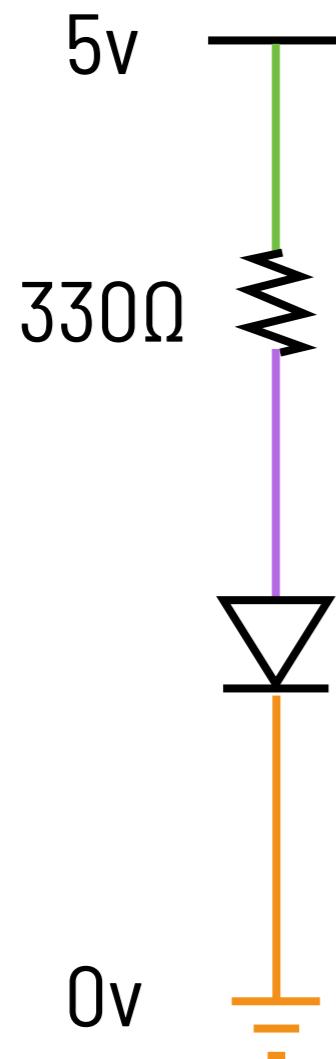
Breadboard



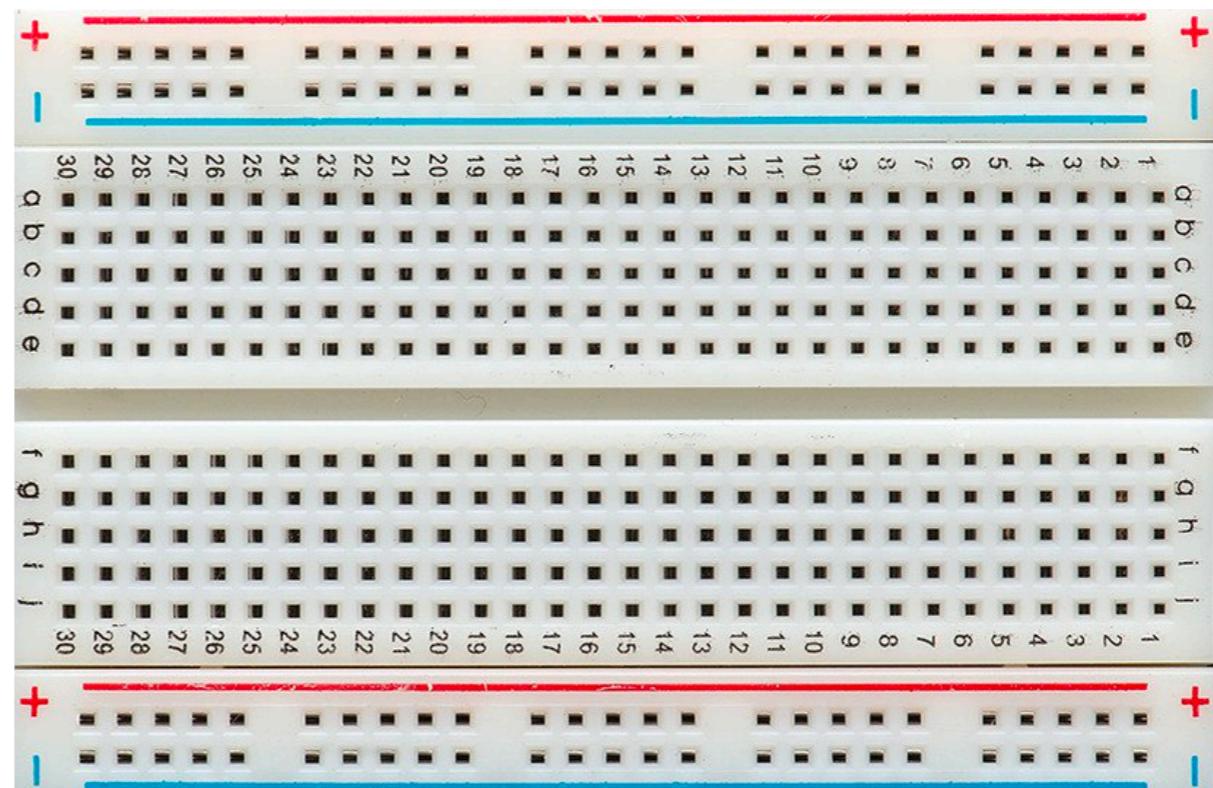
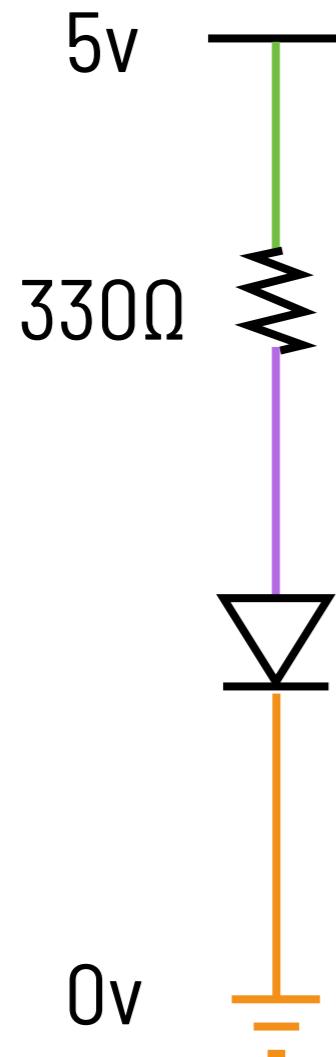
In Real Life!



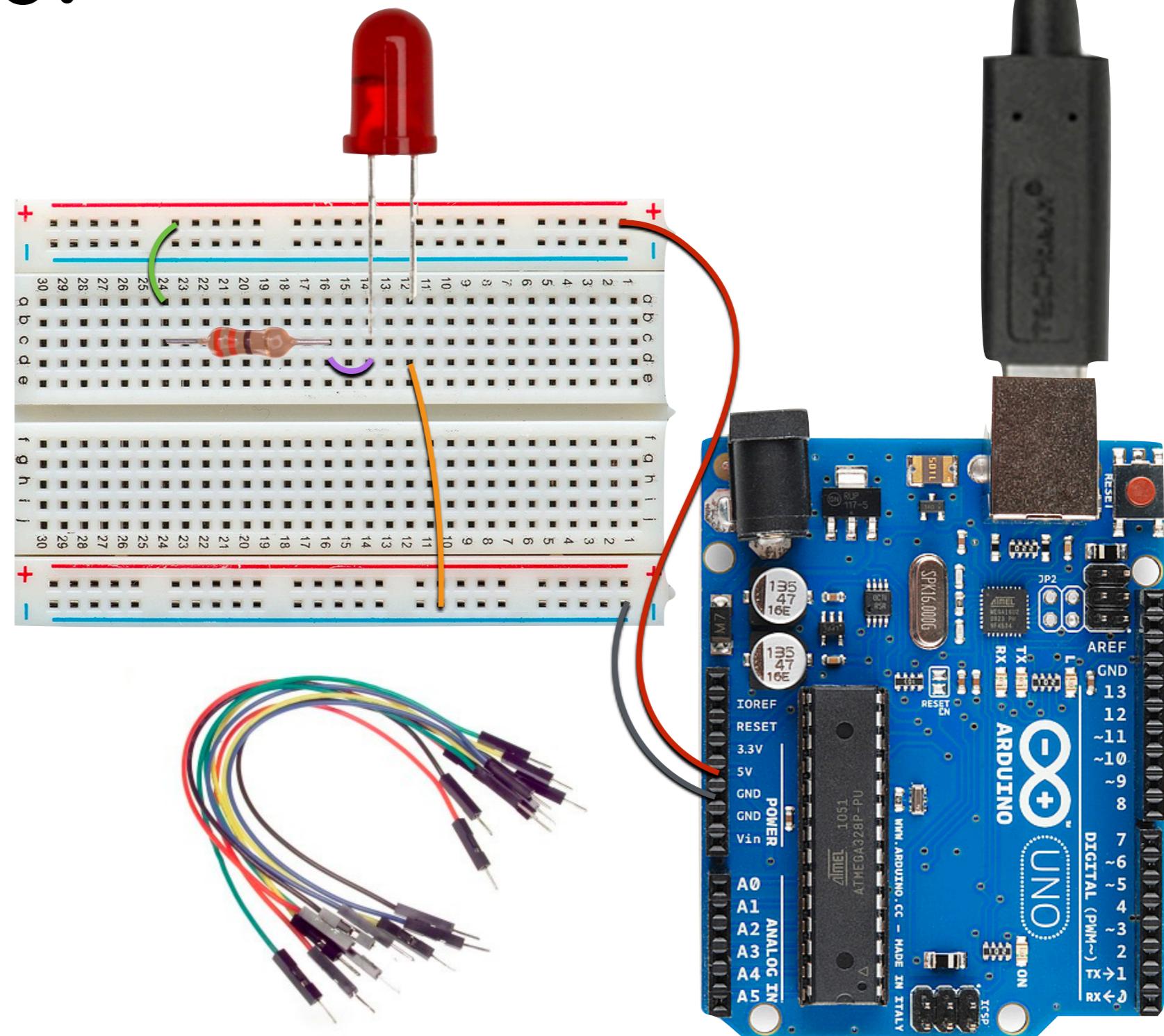
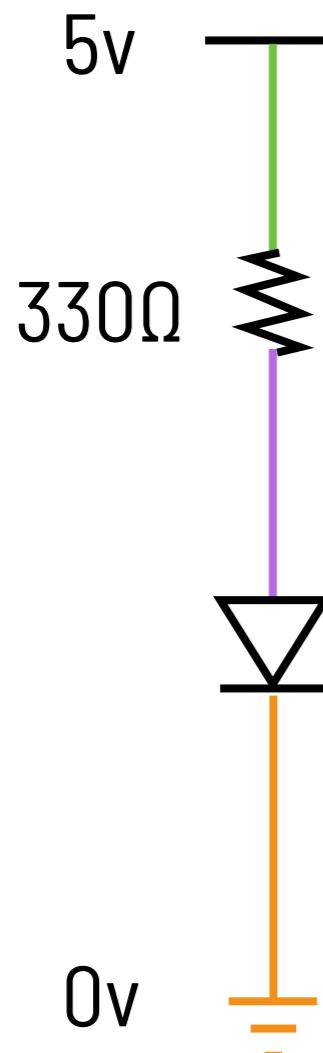
In Real Life!



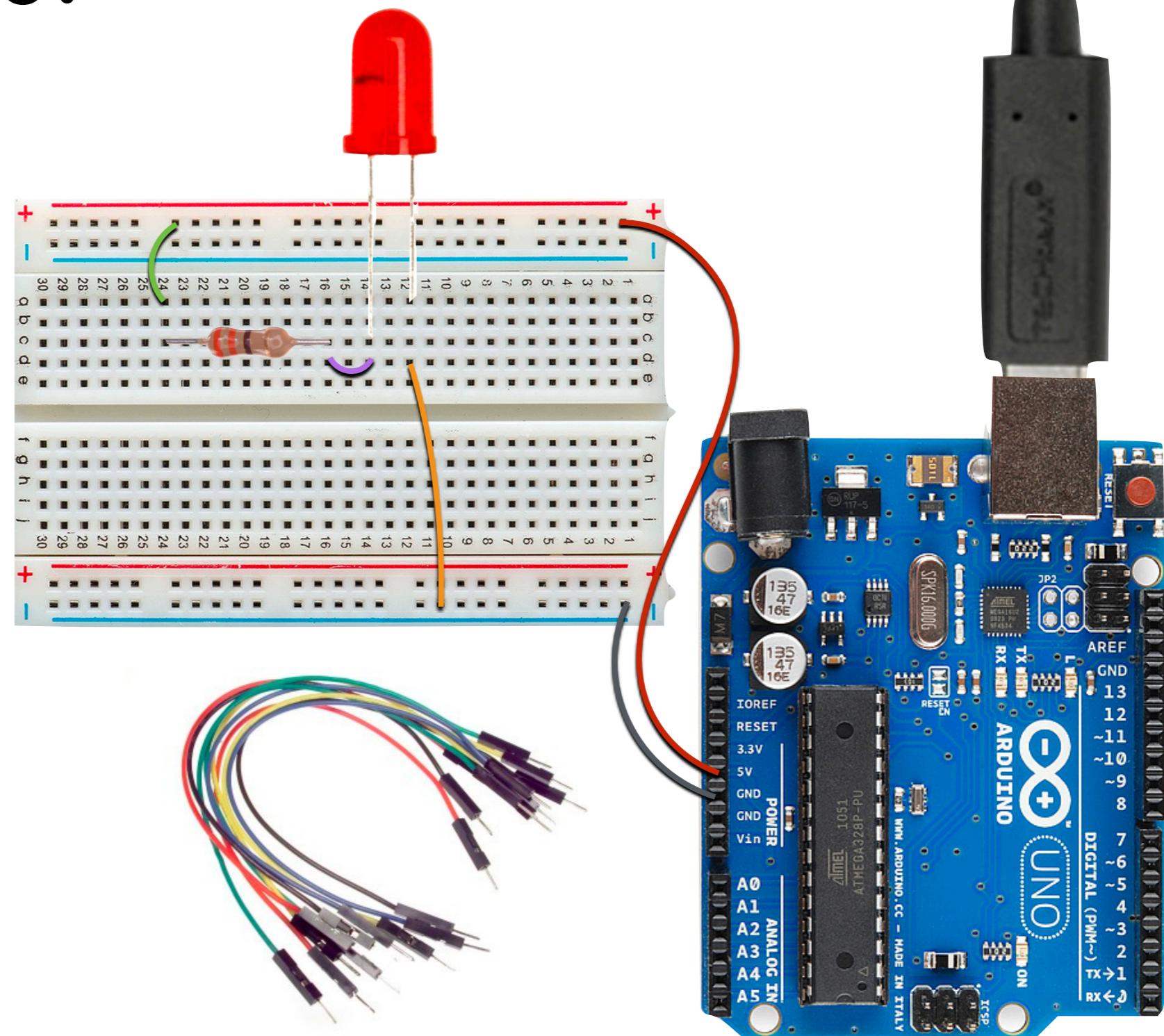
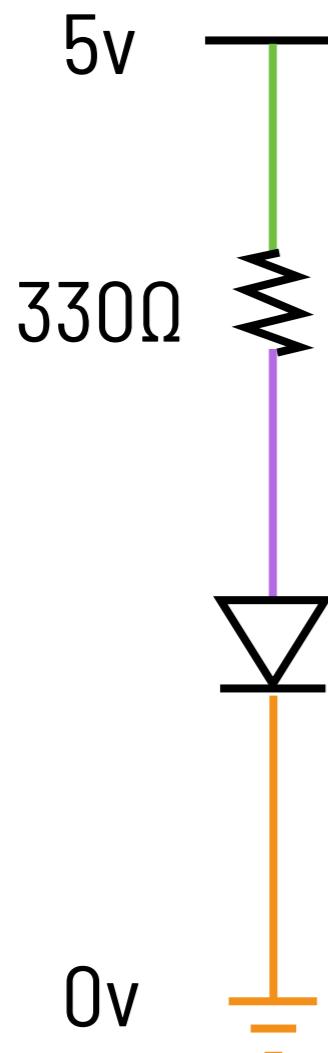
In Real Life!



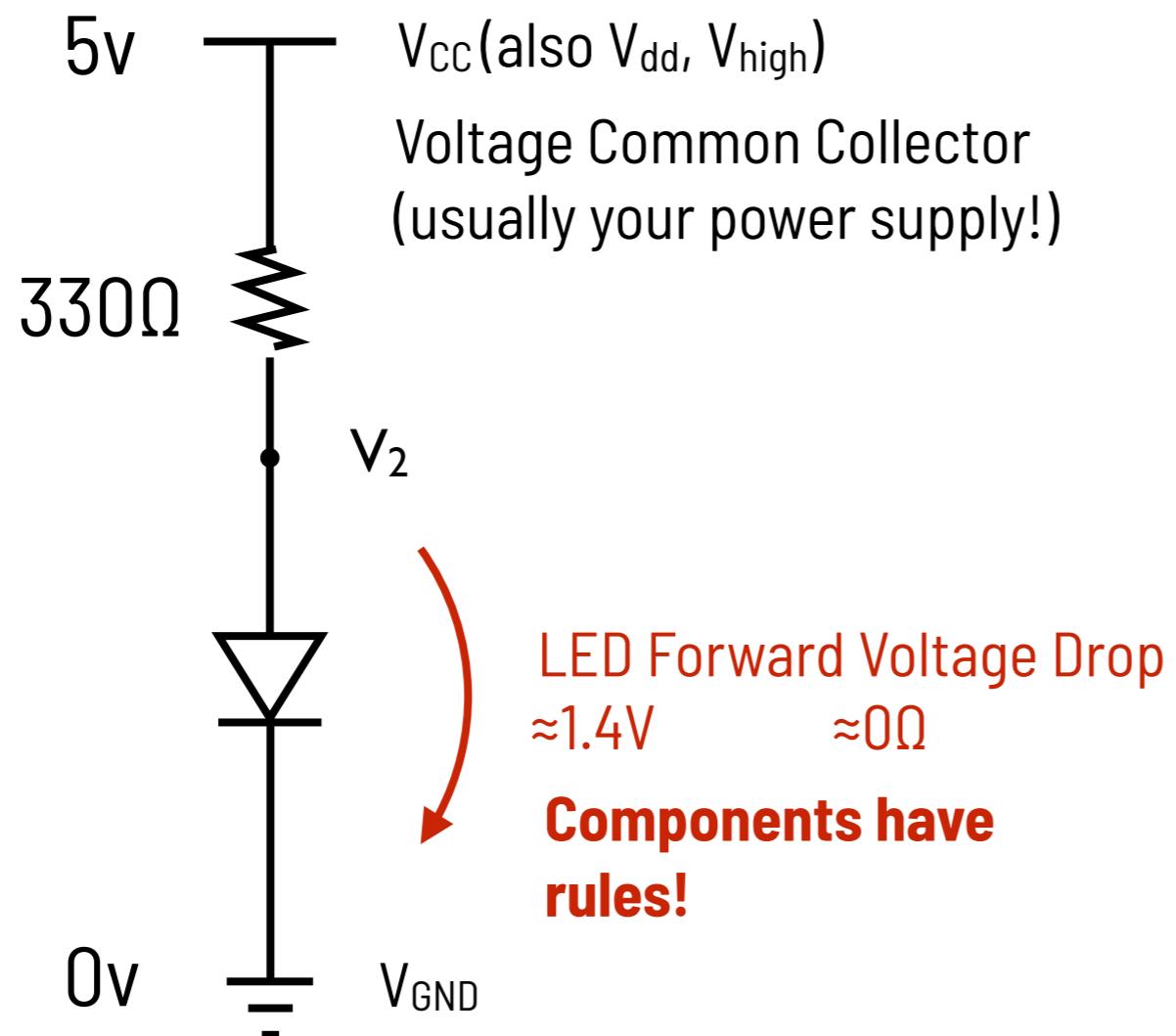
In Real Life!



In Real Life!

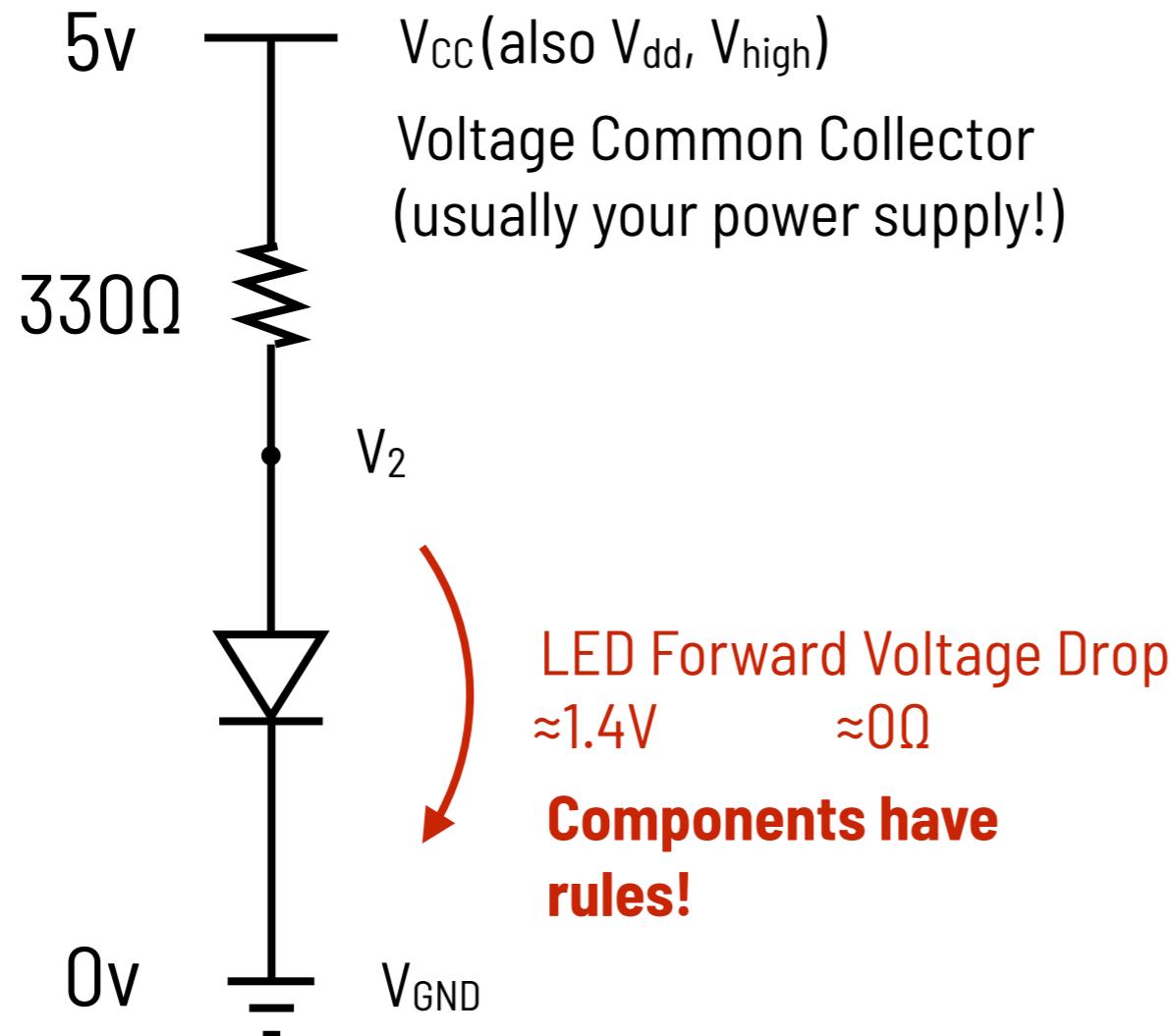


A closer look...

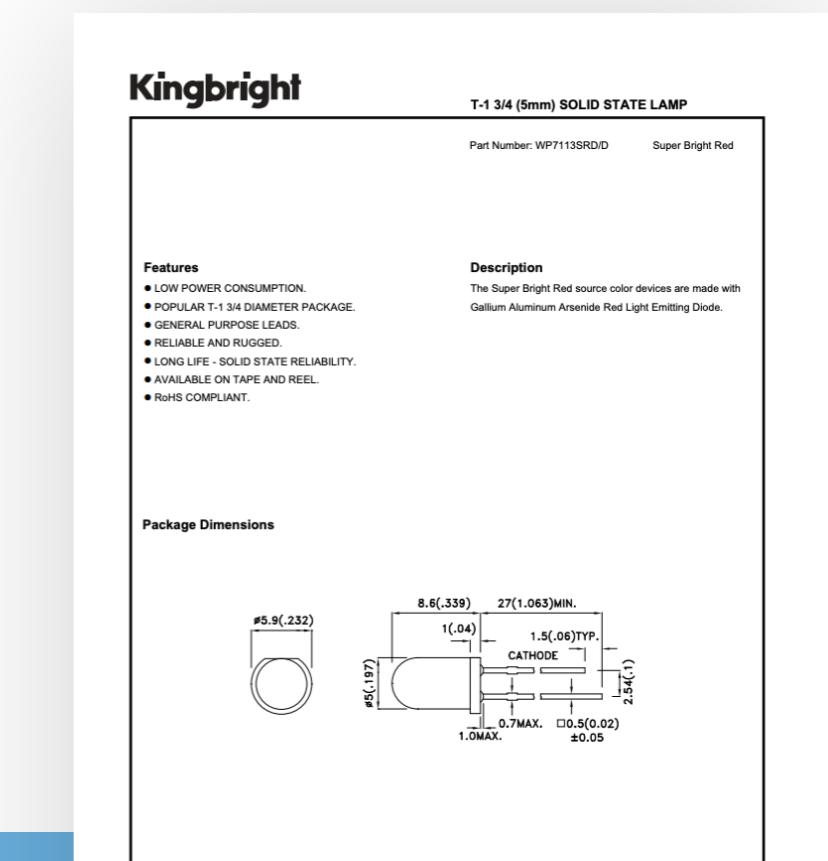


$$V_2 - V_{GND} = 1.4\text{V}$$

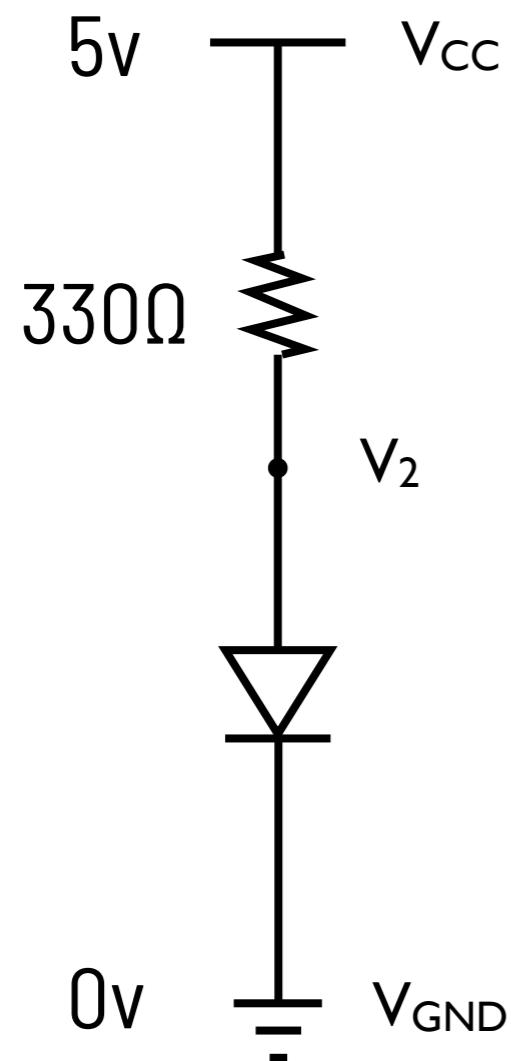
A closer look...



$$V_2 = 1.4V$$
$$V_{CC} - V_2 = I \cdot R$$
$$5 - 1.4 = I \cdot 330$$
$$I \approx 10 \text{ mA}$$

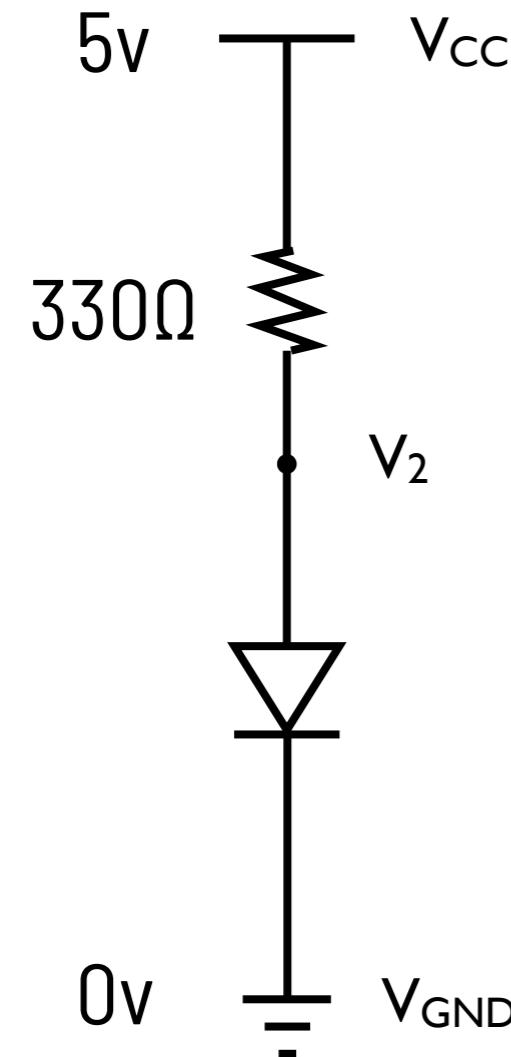


A closer look...

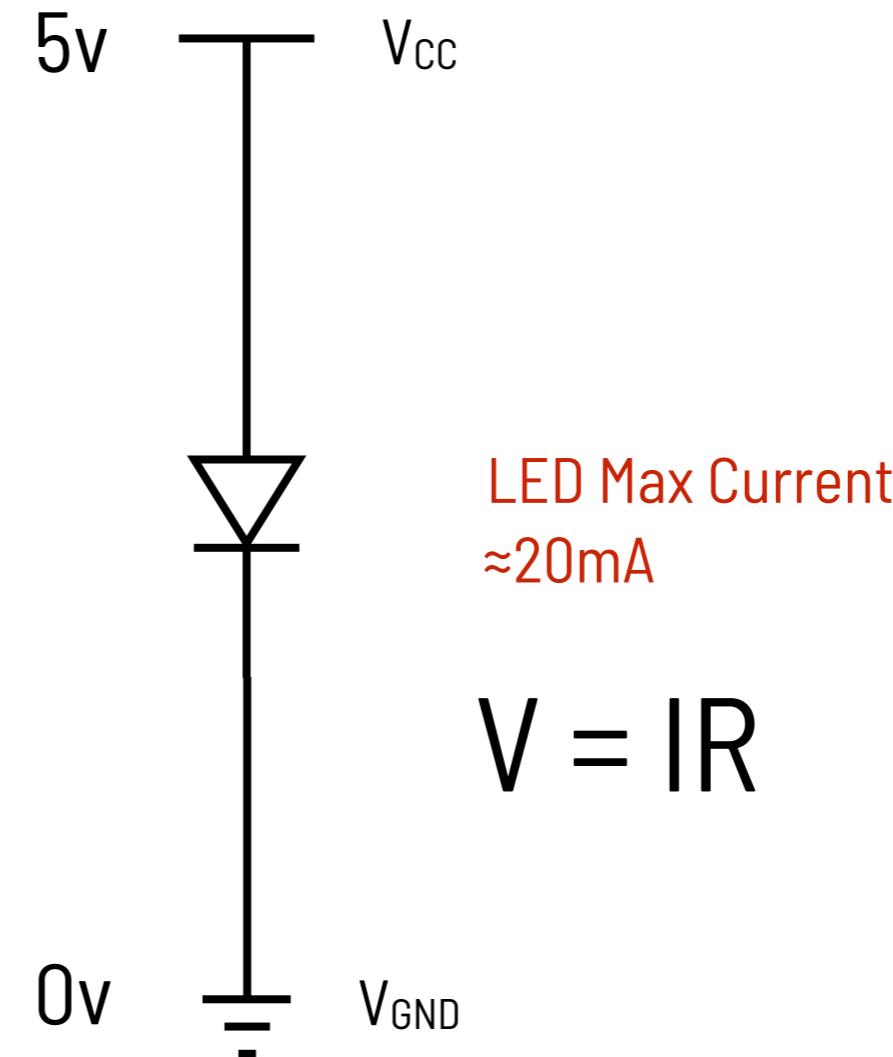


$$I \approx 10 \text{ mA}$$

A closer look...



$$I \approx 10 \text{ mA}$$



$$V = IR$$

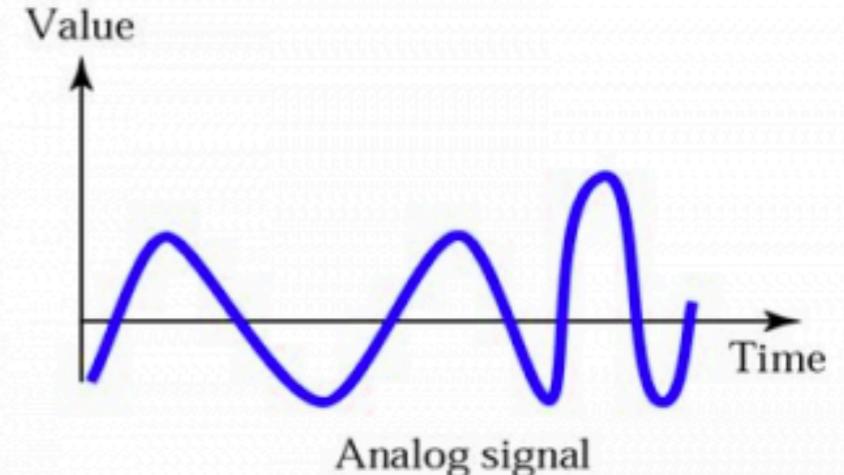
$$I \approx \text{BIG NUMBER}$$

Digital vs Analog Circuits

Analog Circuits

Range of voltages

Usually requires math!

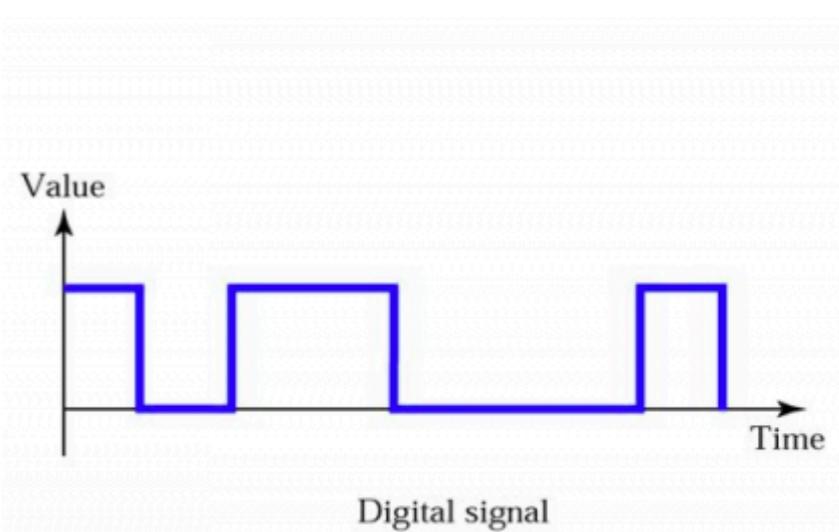


Digital Circuits

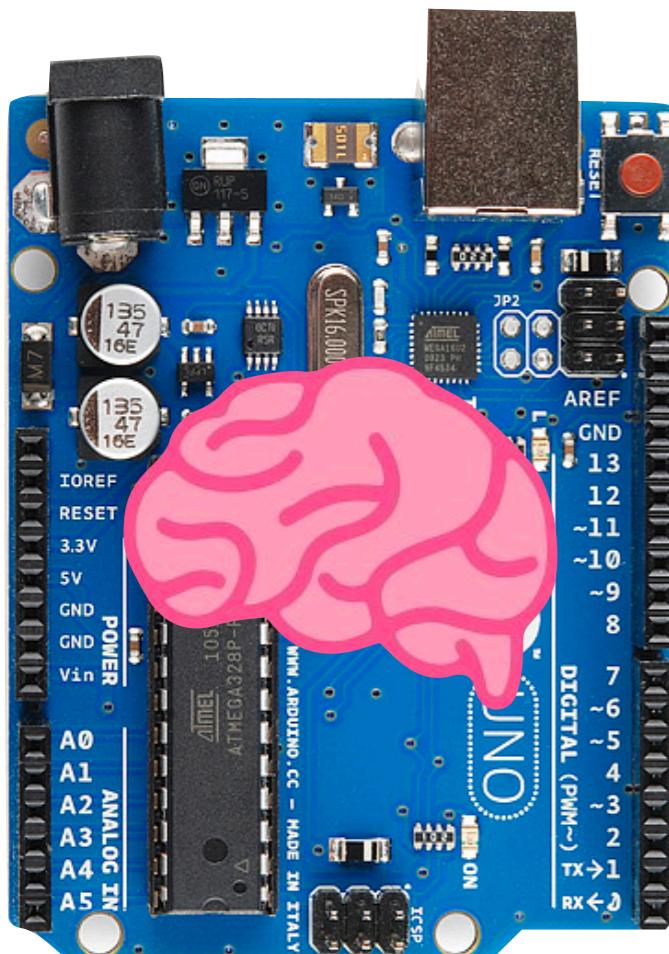
Usually 2 distinct voltages ([high](#) & [low](#))

5v and 0v (roughly)

```
0110010101101011000010110100101101100  
01110101011100110110001001101001011101000  
111001100100001
```

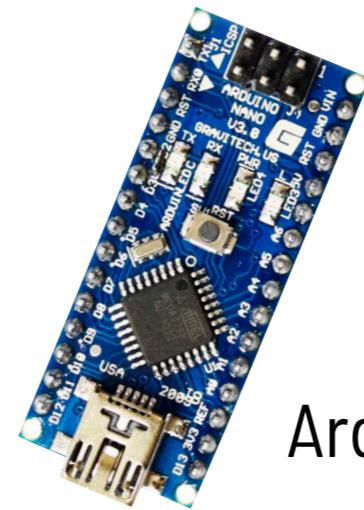


Using your Arduino!

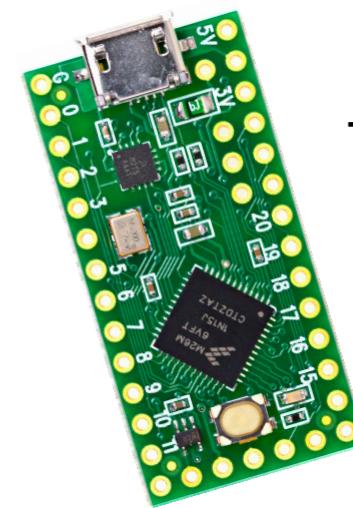


Arduino Uno

A Microcontroller
.. or a small computer!
Has inputs and outputs you can control



Arduino Nano

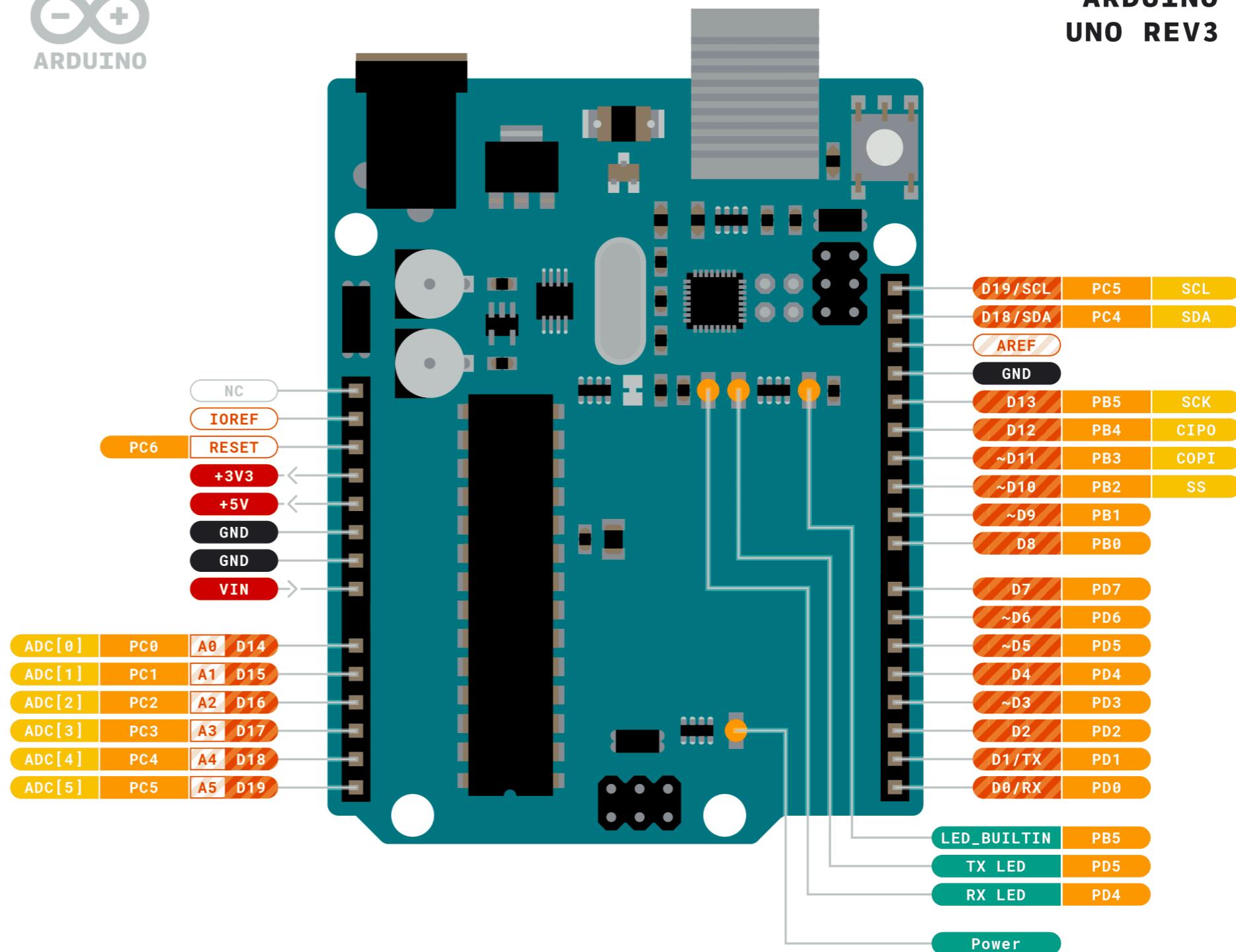


Teensy



ARDUINO
UNO REV3

Quick Look



■ Ground ■ Internal Pin ■ Digital Pin ■ Microcontroller's Port
■ Power ■ SWD Pin ■ Analog Pin
■ LED ■ Other Pin ■ Default

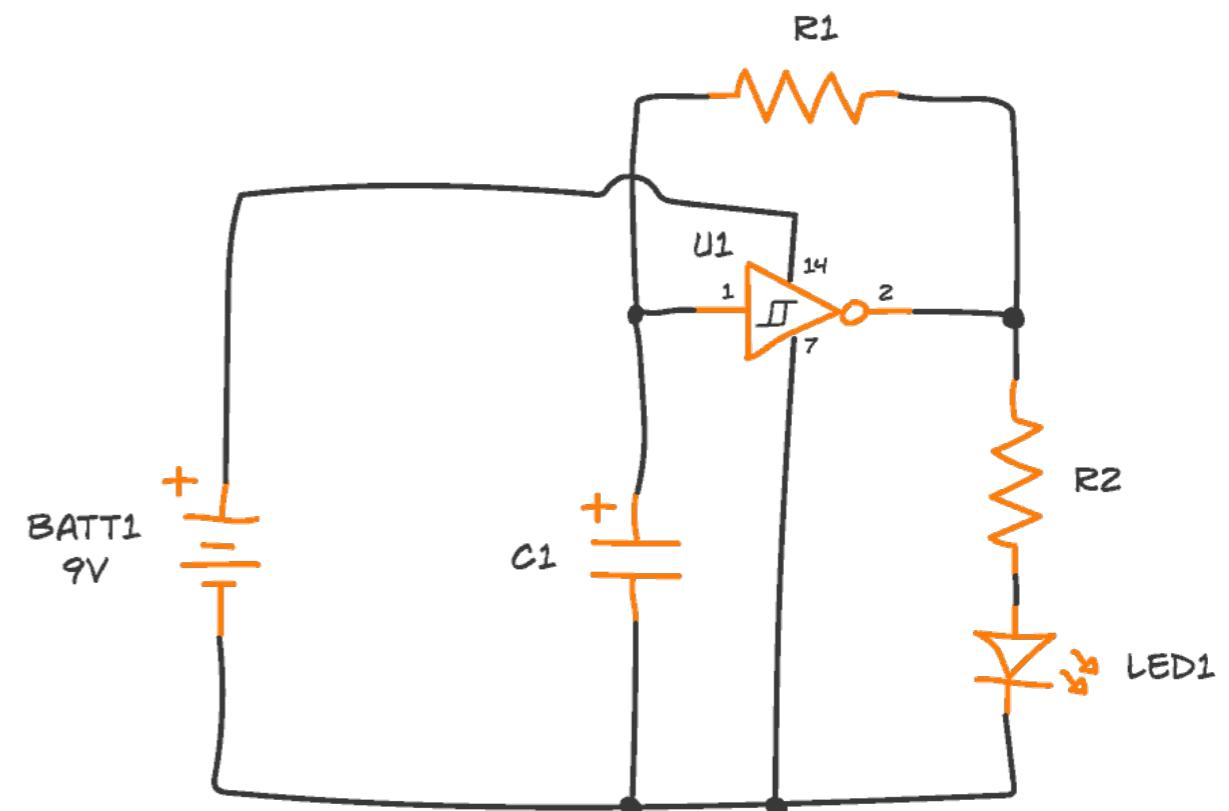
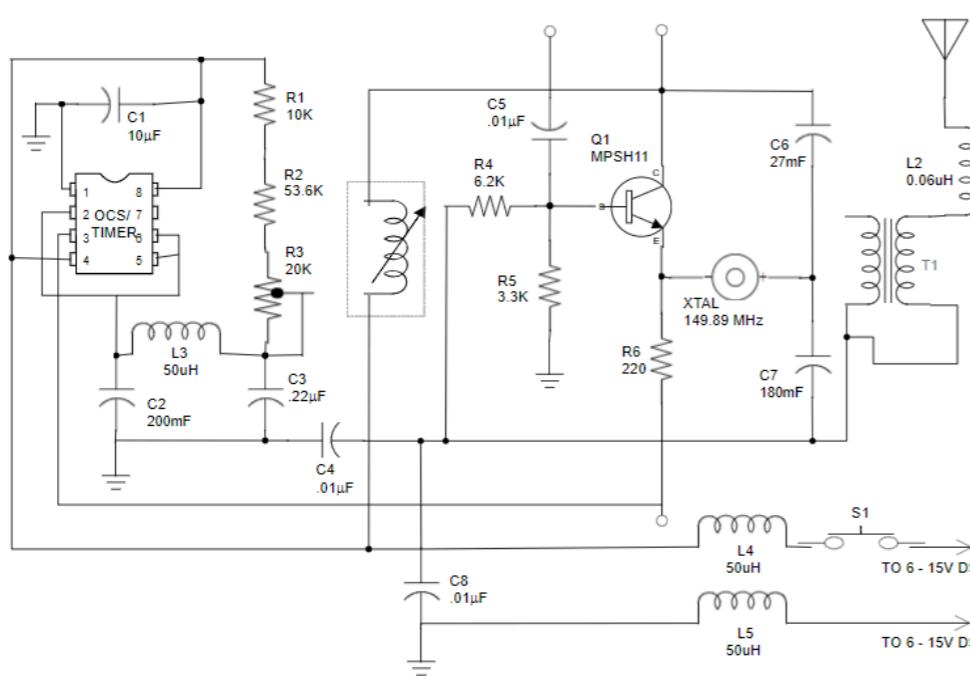
ARDUINO.CC



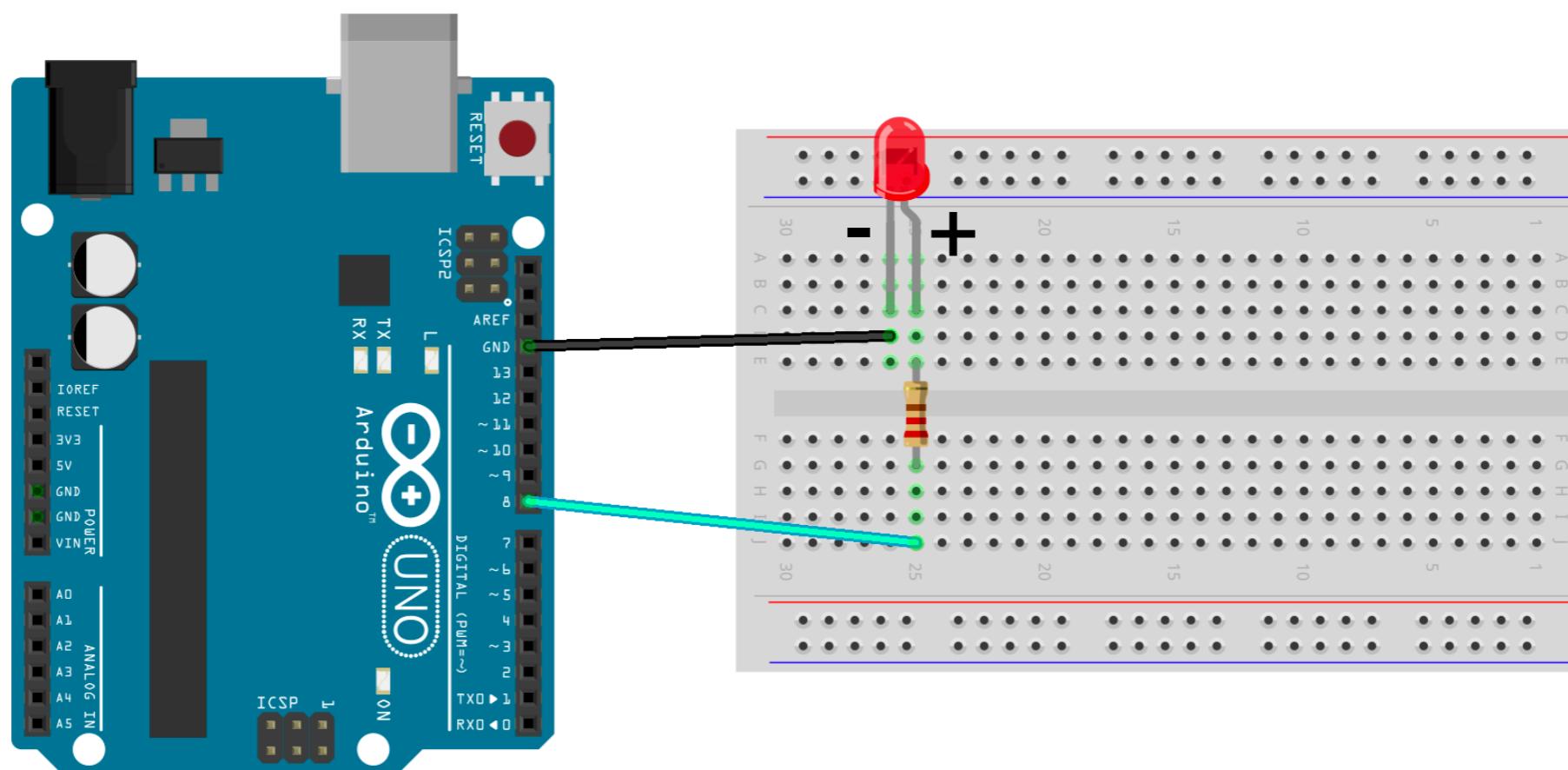
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Schematic Diagram

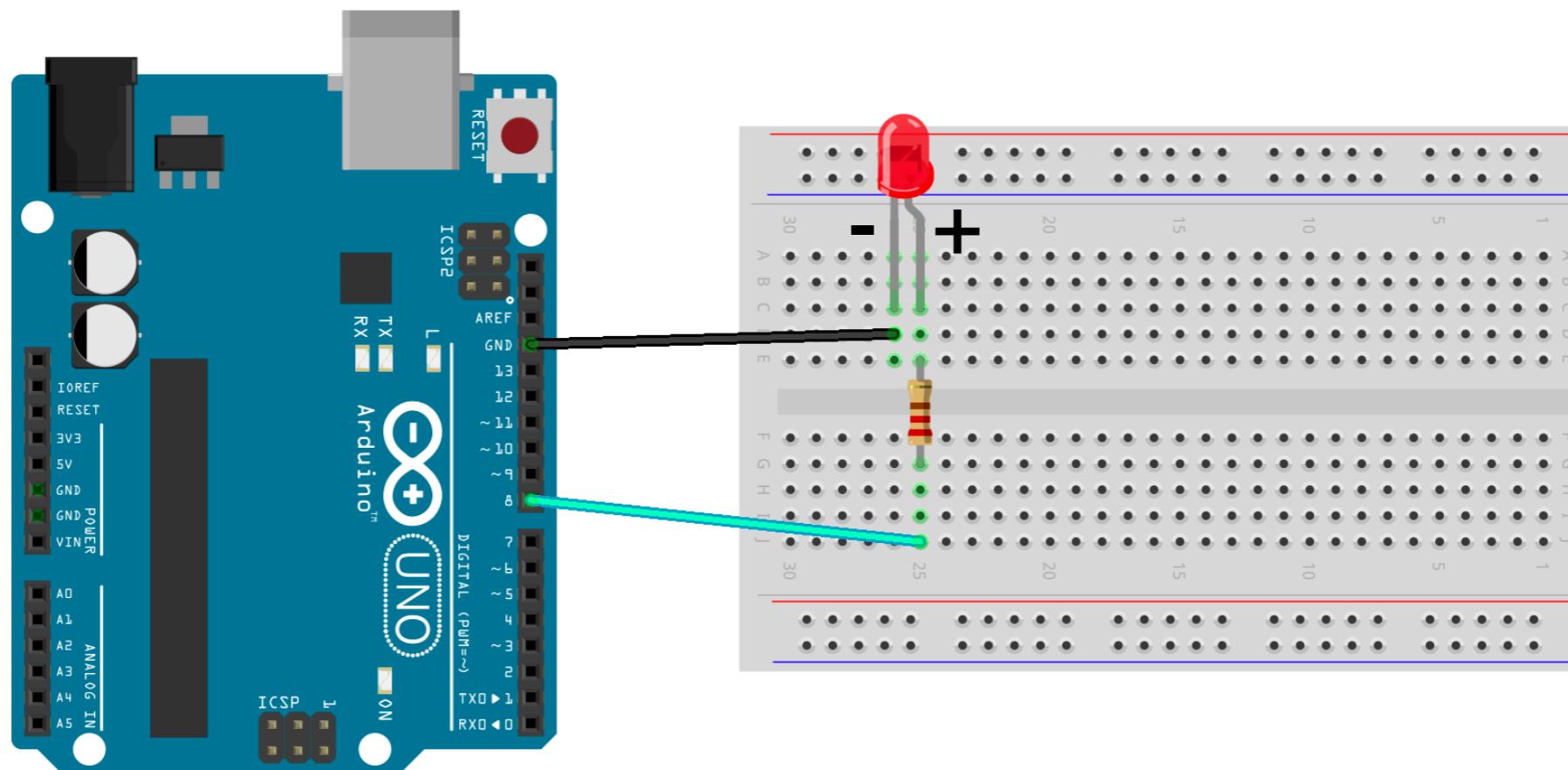
circuit representation showing the functionality and connectivity between different components



Using your Arduino!

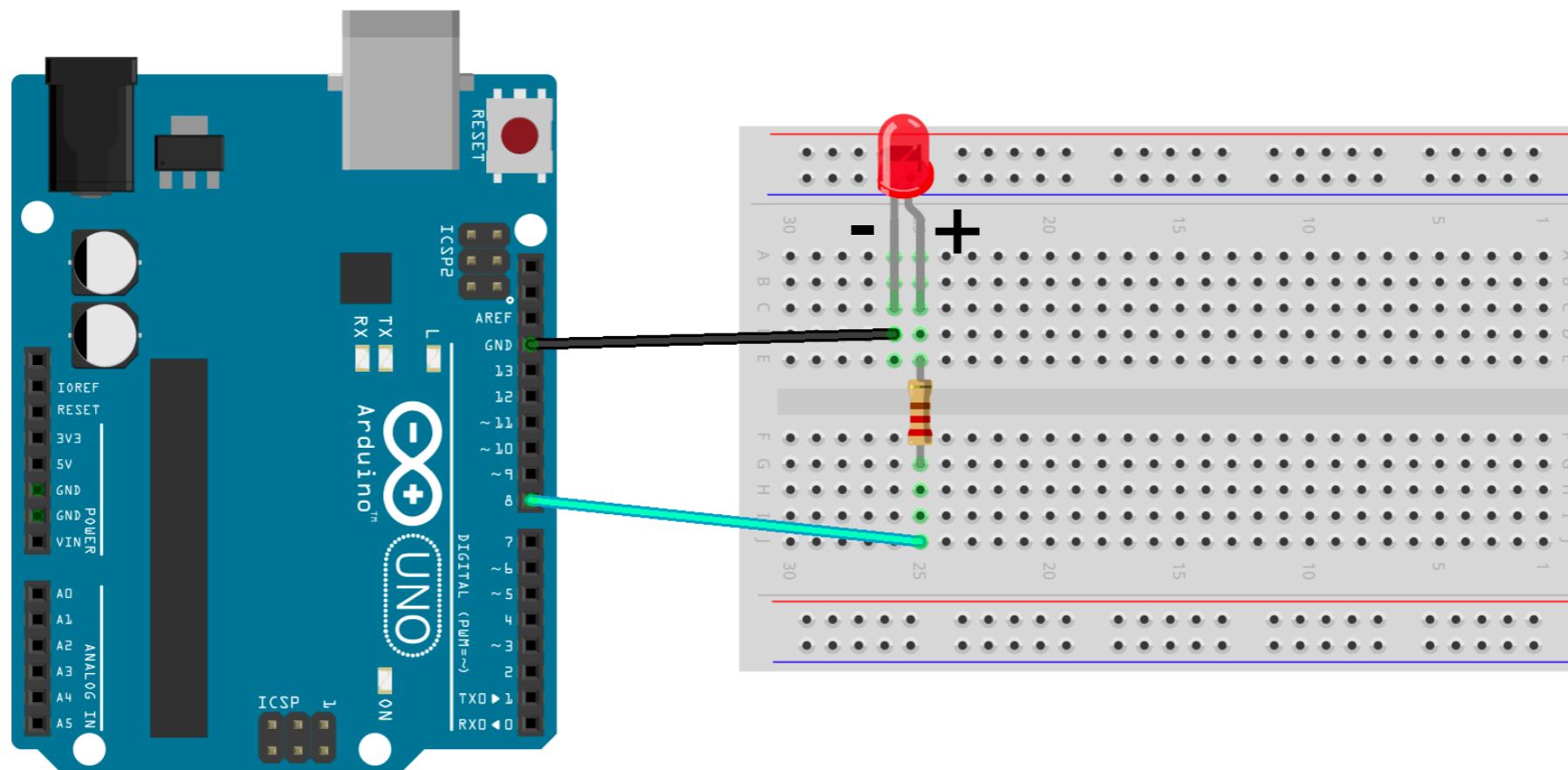


Blink!

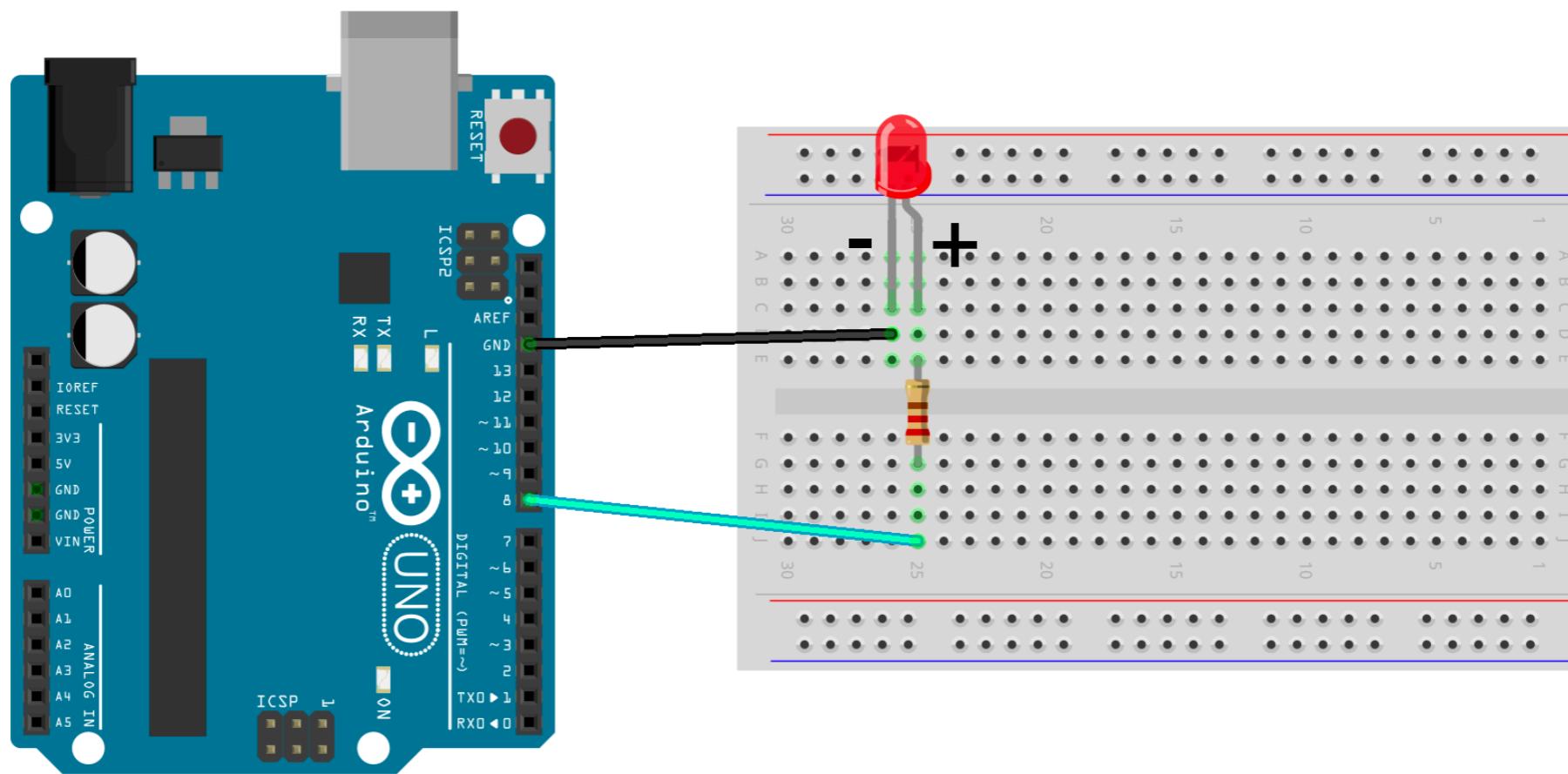


Blink!

A bit of software now...



Blink!



It's your turn!

Turn the LED on for 1 seconds,
and off for 2 seconds

Button Inputs

Arduino

Digital Pin 8

5v

Big resistor!
 $> 1k\Omega$

-



What does the Arduino
sense when it's not
connected to GND?

Value is *floating*!
Pull up resistor!

Button Inputs

Arduino

Digital Pin 8

5v



A physical photograph of a small, rectangular pushbutton switch with two metal pins extending from the bottom.

```
int inPin = 8;      // pushbutton connected to digital pin 8
int val = 0;        // variable to store the read value

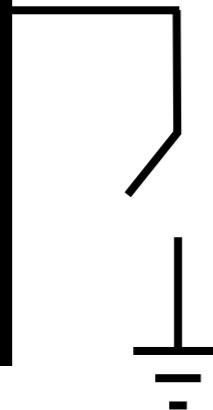
void setup()
{
    pinMode(inPin, INPUT); // sets the digital pin 8 as input
}

void loop()
{
    val = digitalRead(inPin); // read the input pin
}
```

Button Inputs

Arduino

Digital Pin 8



```
int inPin = 8;      // pushbutton connected to digital pin 8
int val = 0;        // variable to store the read value

void setup()
{
    pinMode(inPin, INPUT_PULLUP); // sets the digital pin 8 as input
}

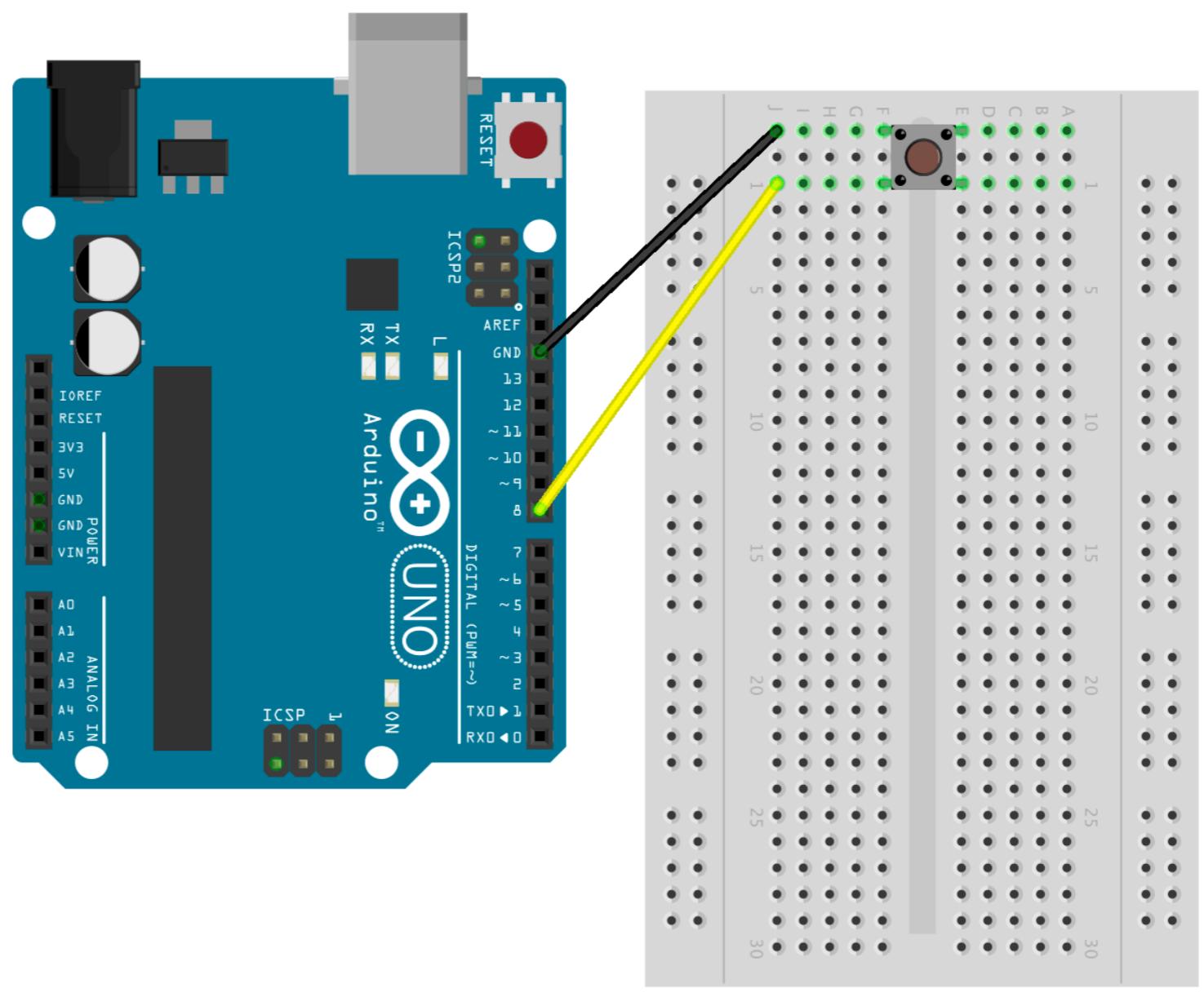
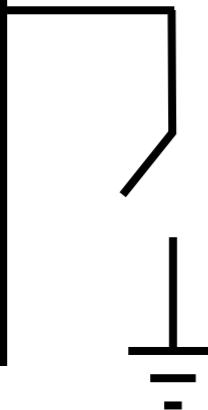
void loop()
{
    val = digitalRead(inPin); // read the input pin
}
```



Button Inputs

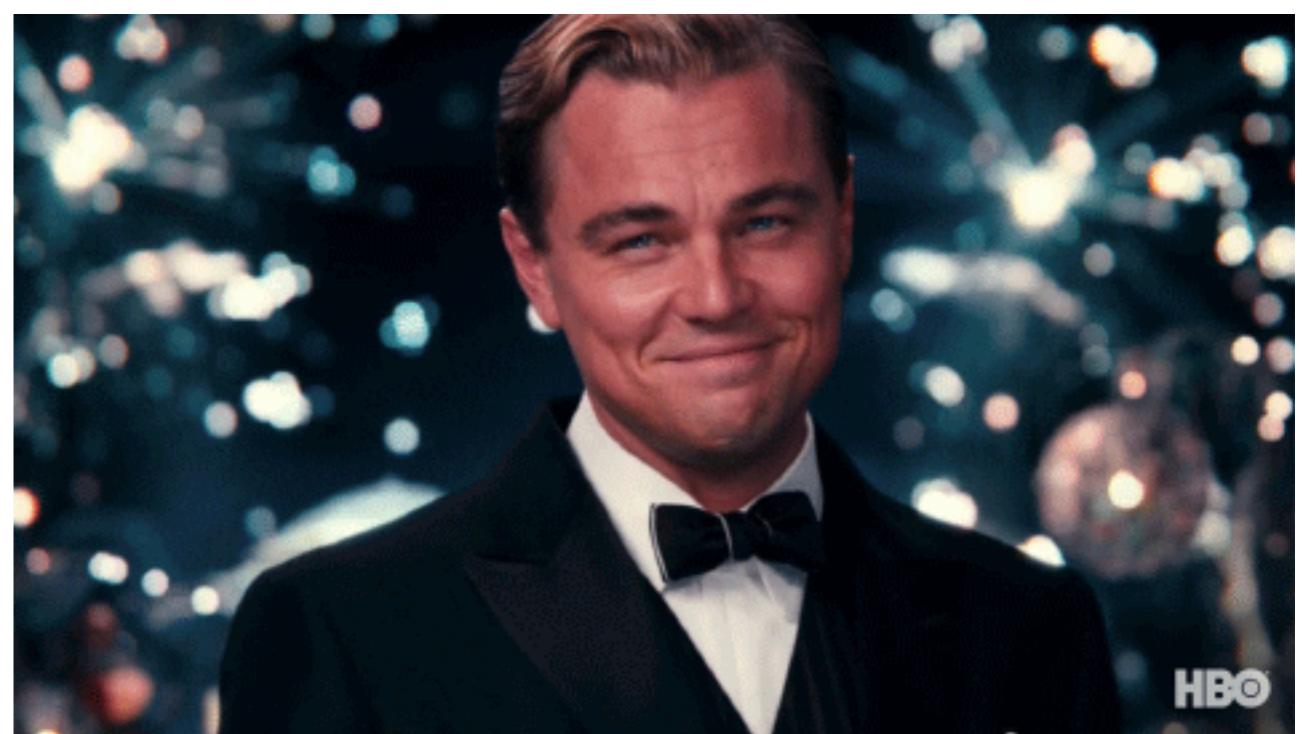
Arduino

Digital Pin 8



Congratulations!

You can now control Input/Output!



Curiosities

1. Using the Arduino, program a simple LED to **blink 3 times when you press a button.**
2. In your kit, you received a nifty little RGB LED as shown to the right. This LED is actually 3 LEDs in 1, all sharing a common cathode.

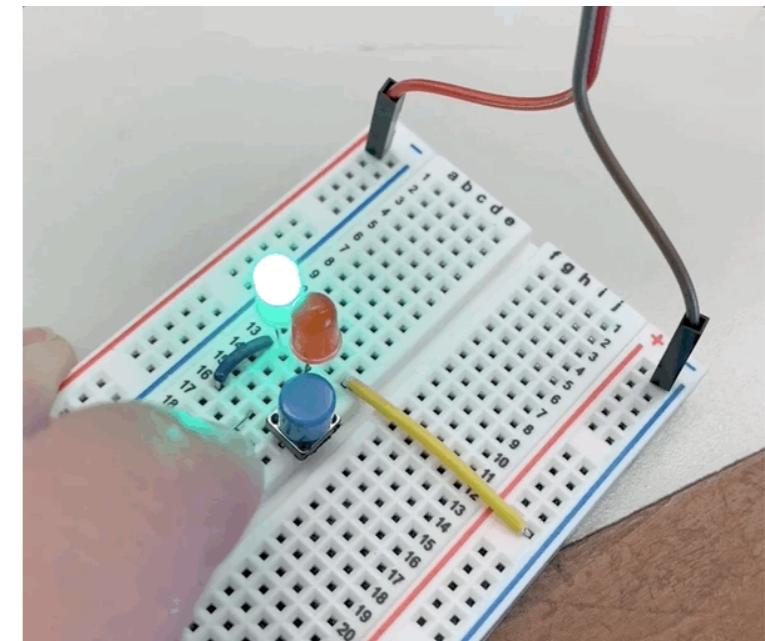
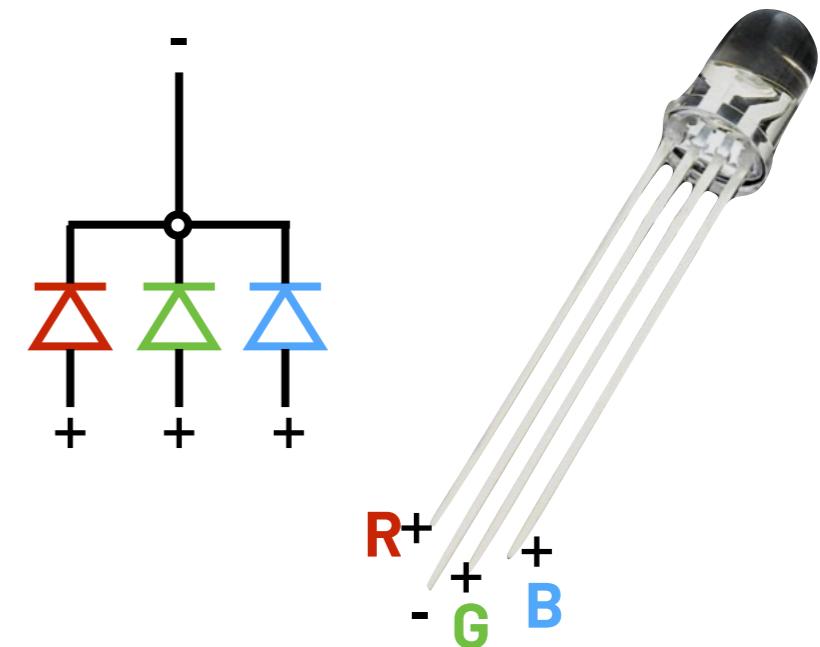
Using the Arduino, **control this light** such that when you hit a button, it cycles through the following colors: Red, Green, Yellow, Blue, Purple, Cyan, White.

3. **Make a simple reaction game.** When the Arduino starts up, the RGB LED stays off. When the LED turns to bright white, hit the button as fast as you can.

- If you hit the button within 0.1s, show a green LED.
- If you hit the button between 0.1s and 0.6s, show a blue LED.
- If you hit the button after 0.6s, show a red LED.

4. **BONUS** Trick Circuit! Produce the effect on the right, **only using the 5v and GND on the Arduino.**

The effect is: when you don't have the button pressed, the green button is on. When you have the button pressed, the red button is on. Draw a circuit diagram, then explain why it works.



See you next week!

Try the curiosities - Try to complete at least 2 of them before the next seminar.

We'll be on Slack if you have any questions or need any help!