IoT Product Design and Coding Bootcamp

Brian Rashap, Ph.D.

24-Feb-2020

Table of contents

IoT Fun


I THINK MY NEST SMOKE ALARM IS GOING OFF. GOOGLE ADWORDS JUST PITCHED ME A FIRE EXTINGUISHER AND AN OFFER FOR TEMPORARY HOUSING.
TOM FISH BURNE
© marketoonist.com

Brian Rashap, Ph.D.

- Proud husband of Krista and father of Shelby (21) and Ethan (18)
- Electrical Engineer with 25 years industrial experience
- High School track coach
- Hobbies: running, cycling, reading, spending time with family

Introductions

INTRODUCTIONS

Class Rules

- Respect Each Other, Help Each Other
- Ask Questions
- Be On Time (let's us know via Slack if you won't be here)
- Keep Your Workspace and the Classroom Neat and Tidy
- If you are struggling, let myself, Susan, or Esteban know. We are here to HELP!

Grading

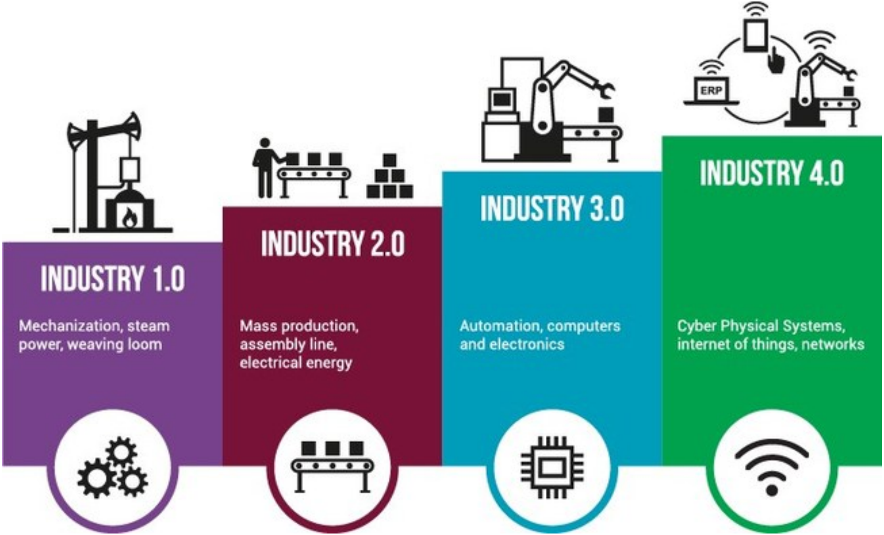
1. In class assignments - 30
2. Individual smart device 20
3. Capstone 40
4. Assessments 10

More information later today on how assignments are turned in

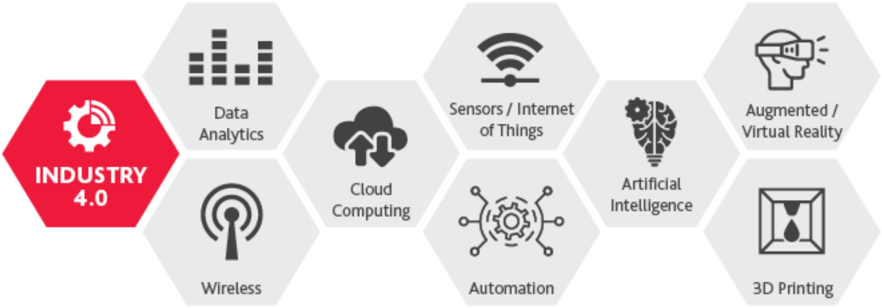
GITHUB Simplified

```
// In Powershell go to ./Documents/<yourname>
// Get a repository that already exists and pull
   it into your local machine
  git clone <URL of repository>

// From the repository directory, get updates
  git pull

// Send your changes up to the repository
  git add .
  git commit -m "<comment>"
  git push

// You may get asked to enter your GIT username
git config --global user.email "you@example.com"
```

Evolution of Industry

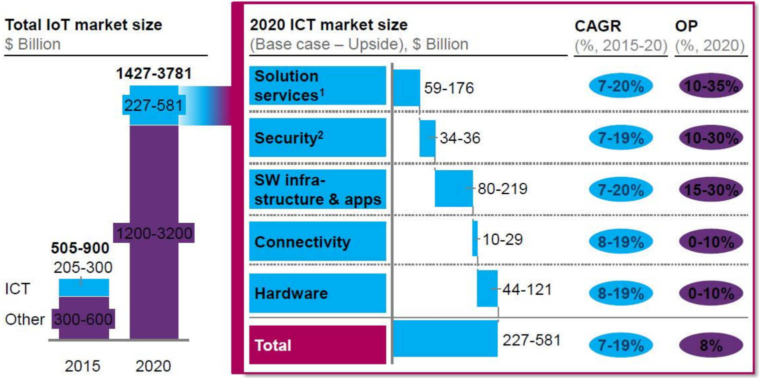


Components of Industry 4.0



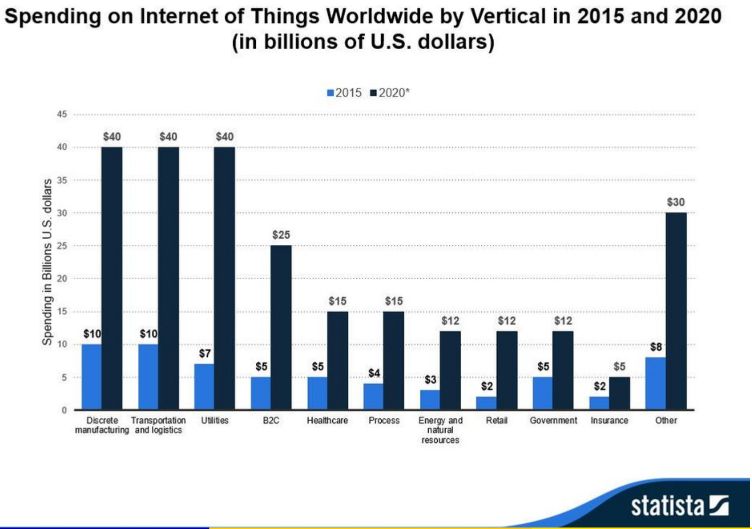
IoT Market Size

Resulting in a large IoT market size, of which a significant component is ICT

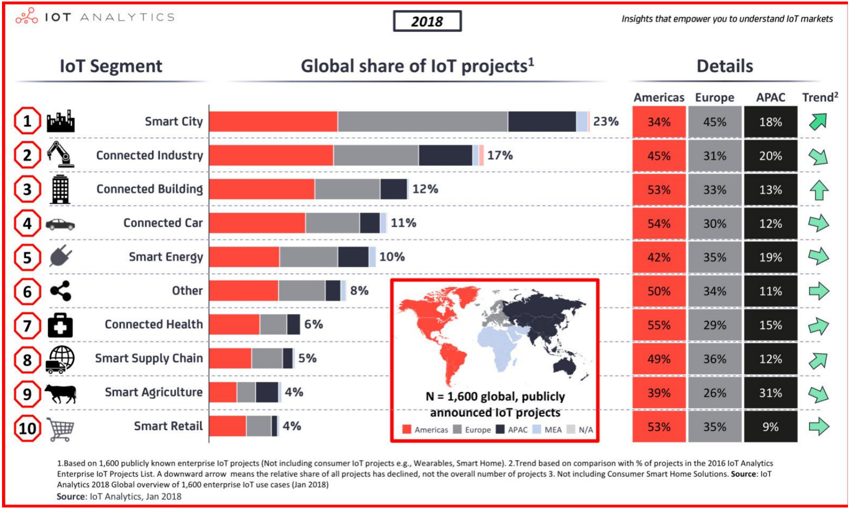


1 Solution services not considered technical products
2 $3-$6B is IoT security and $25-$35B is for mobile security

Spending by IoT Vertical



IoT Segments

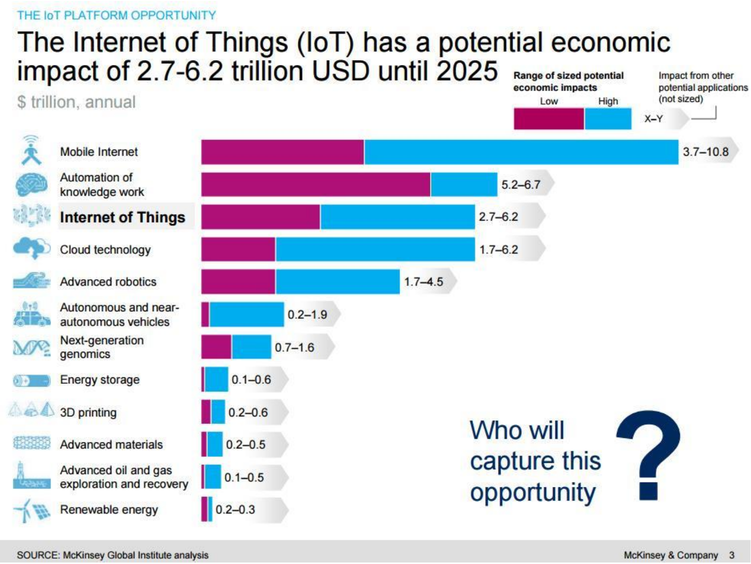


IoT Segment	Global share of IoT projects[1]	Americas	Europe	APAC	Trend[2]
1 Smart City	23%	34%	45%	18%	
2 Connected Industry	17%	45%	31%	20%	
3 Connected Building	12%	53%	33%	13%	
4 Connected Car	11%	54%	30%	12%	
5 Smart Energy	10%	42%	35%	19%	
6 Other	8%	50%	34%	11%	
7 Connected Health	6%	55%	29%	15%	
8 Smart Supply Chain	5%	49%	36%	12%	
9 Smart Agriculture	4%	39%	26%	31%	
10 Smart Retail	4%	53%	35%	9%	

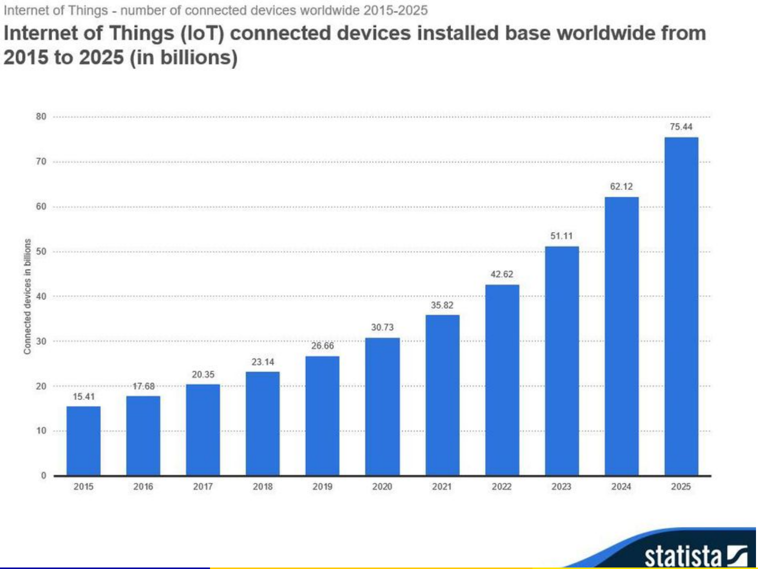
1.Based on 1,600 publicly known enterprise IoT projects (Not including consumer IoT projects e.g., Wearables, Smart Home). 2.Trend based on comparison with % of projects in the 2016 IoT Analytics Enterprise IoT Projects List. A downward arrow means the relative share of all projects has declined, not the overall number of projects 3. Not including Consumer Smart Home Solutions. **Source**: IoT Analytics 2018 Global overview of 1,600 enterprise IoT use cases (Jan 2018)

Source: IoT Analytics, Jan 2018

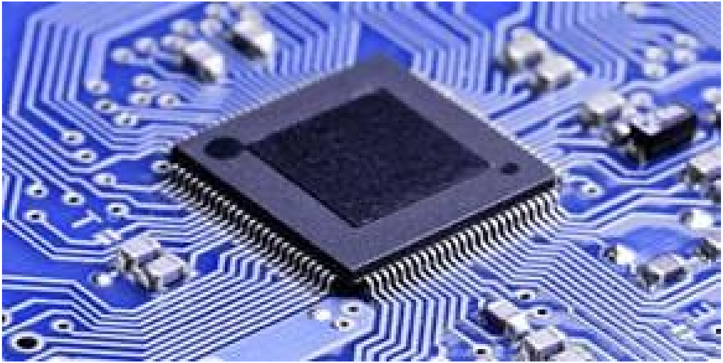
IoT Potential Economic Impact



IoT Growth

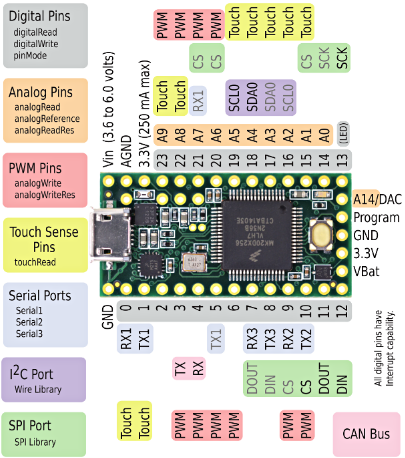

Internet of Things - number of connected devices worldwide 2015-2025
Internet of Things (IoT) connected devices installed base worldwide from 2015 to 2025 (in billions)
Connected devices in billions
80
70
60
50
40
30
20
10
0
15.41
17.68
20.35
23.14
26.66
30.73
35.82
42.62
51.11
62.12
75.44
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
statista

Our First Microcontroller



Teensy 3.2

- Cortex-M4 72MHz (overclocked to 96 MHz)
- 34 GPIO pins
- 3.3V and 5.0V operating voltages
- 500mA of available power with USB



Arduino IDE for Teensy

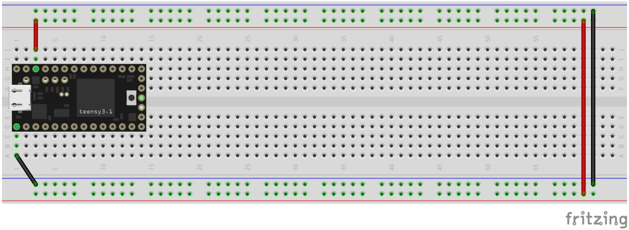
We are going to start off using the Arduino IDE[1]. The Arduino IDE is programmed essentailly using C++ code, but make the compiling and loading onto the microcontroller simplier.

We begin by installing the Arduino IDE:
https://www.arduino.cc/en/main/software

Then, we install the Teensyduino add-on:
https://www.pjrc.com/teensy/td_download.html

[1] An IDE, or Integrated Development Environment, enables programmers to consolidate the different aspects of writing a computer program.

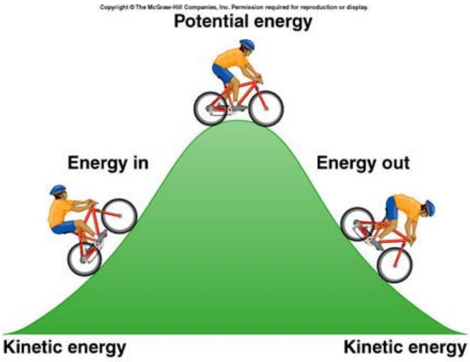
Teensy on Breadboard



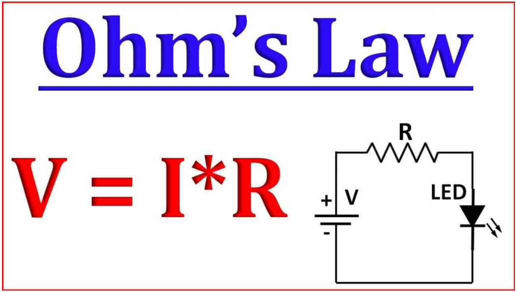
Basic Structure of Arduino Sketch

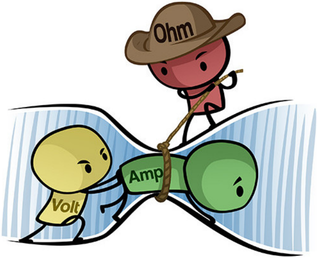
```

// heading is used to document and include packages. It is also used to configure the coding environment.

void setup() {
  // put your setup code here, to run once:

}

void loop() {
  // put your main code here, to run repeatedly:

}
```

Energy

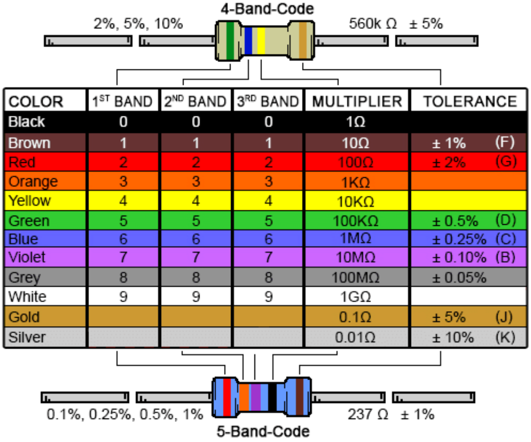

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.
Potential energy
Energy in
Energy out
Kinetic energy
Kinetic energy

Ohm's Law



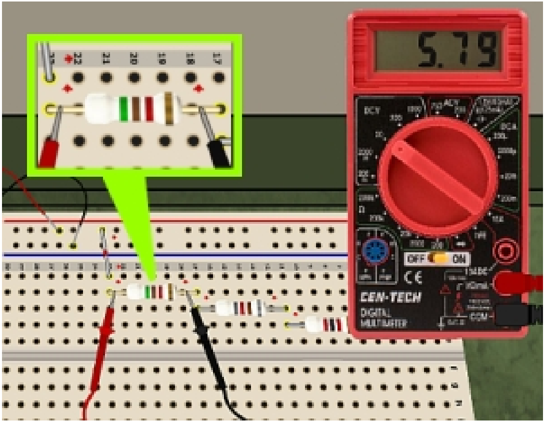


Resistor Color Bands

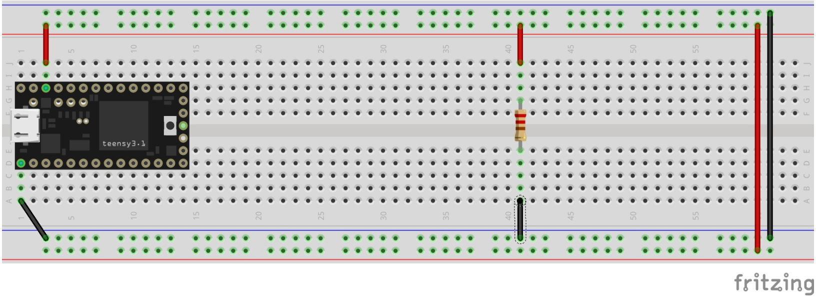


COLOR	1ST BAND	2ND BAND	3RD BAND	MULTIPLIER	TOLERANCE
Black	0	0	0	1Ω	
Brown	1	1	1	10Ω	± 1% (F)
Red	2	2	2	100Ω	± 2% (G)
Orange	3	3	3	1KΩ	
Yellow	4	4	4	10KΩ	
Green	5	5	5	100KΩ	± 0.5% (D)
Blue	6	6	6	1MΩ	± 0.25% (C)
Violet	7	7	7	10MΩ	± 0.10% (B)
Grey	8	8	8	100MΩ	± 0.05%
White	9	9	9	1GΩ	
Gold				0.1Ω	± 5%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

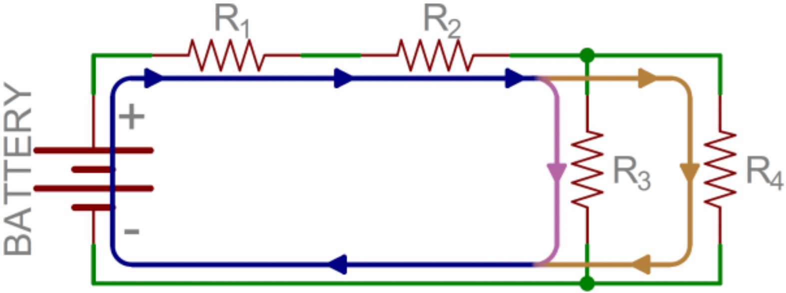
Measuring Voltage, Current, and Resistance



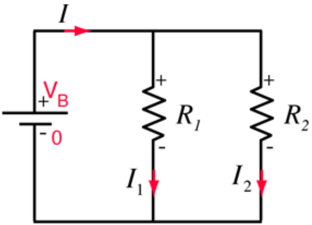
One Resistor



Resistors in Series and Parallel

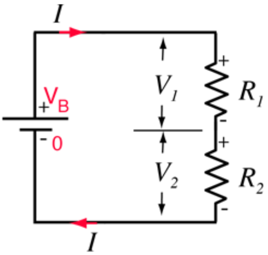


Resistors in Series and Parallel



Parallel resistors

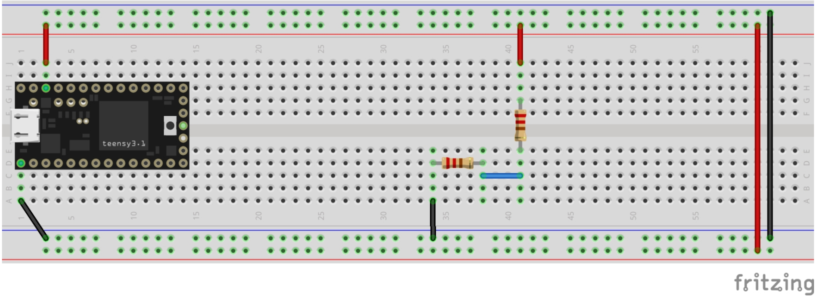
$$\frac{1}{R_{equivalent}} = \frac{1}{R_1} + \frac{1}{R_2}$$



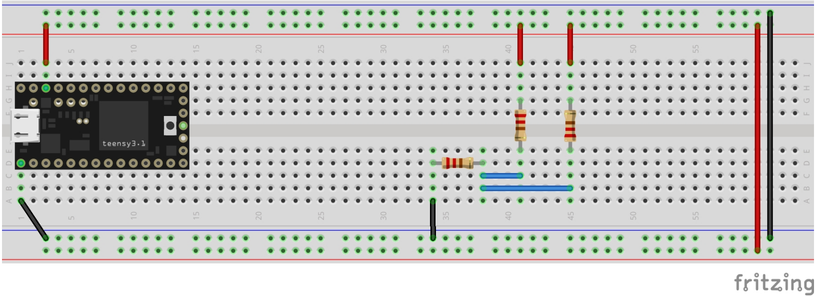
Series resistors

$$R_{equivalent} = R_1 + R_2$$

Resistors in Series

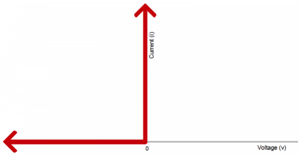


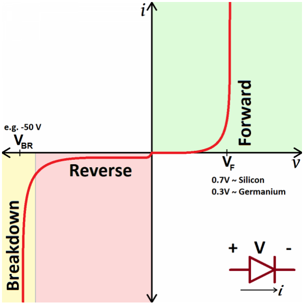
Resistors in Series and Parallel



Diodes

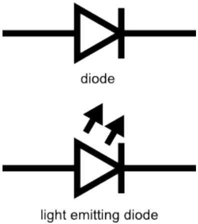
The key function of an diode is to control the direction of current-flow. Current passing through a diode can only go in one direction, called the forward direction. Current trying to flow the reverse direction is blocked.





Light Emitting Diodes

LEDs (that's "ell-ee-dees") are a particular type of diode that convert electrical energy into light.

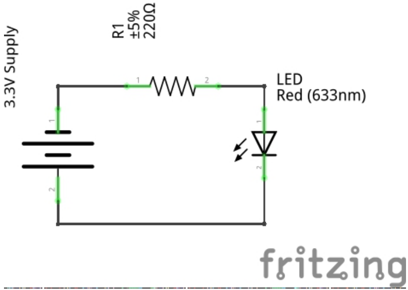


Current Limiting Resistors

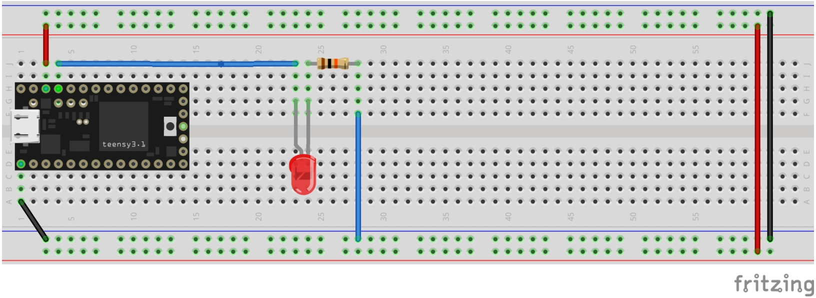
As a LED has very little resistance, when it is connected directly to a power supply, the current draw will exceed its specs and it will burn out.

$$V_{pp} - V_{LED} = IR \Longrightarrow R >= \frac{V_{pp} - V_{LED}}{I_{max}}$$

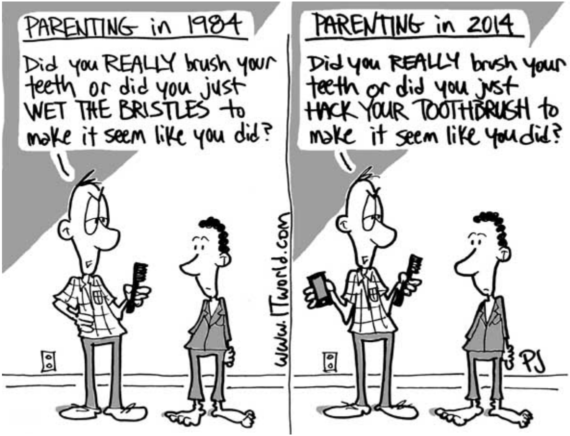
For a 3.3V power supply, a 0.43V across the LED, and a max current of 100mA, the resistor needs to be greater than 29Ω.



Hello LED



IoT Fun


PARENTING in 1984
Did you REALLY brush your teeth or did you just WET THE BRISTLES to make it seem like you did?
www.ITworld.com
PARENTING in 2014
Did you REALLY brush your teeth or did you just HACK YOUR TOOTHBRUSH to make it seem like you did?
PJ

REVIEW: For Loops

```
// FOR loop syntax
for (initialization; condition; increment) {
  // statement(s);
}

// EXAMPLE
for (j=0; j <= 255, j++) {
  analogWrite(ledPin, j);
  }
```

While loops

```
// WHILE loop syntax
while (condition) {
  // statement(s)
}


// EXAMPLE
while (button == HIGH) {
  digitalWrite(ledPin, HIGH);
} //continue this loop until button is released
```

For vs While Loops

For vs While Loop

Comparison Chart

For Loop	While Loop
The for loop is used for definite loops when the number of iterations is known.	The while loop is used when the number of iterations is not known.
For loops can have their counter variables declared in the declaration itself.	There is no built-in loop control variable with a while loop.
This is preferable when we know exactly how many times the loop will be repeated.	The while loop will continue to run infinite number of times until the condition is met.
The loop iterates infinite number of times if the condition is not specified.	If the condition is not specified, it shows a compilation error.

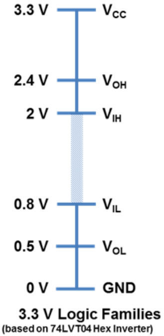
DifferenceBetween.net

Serial Monitor

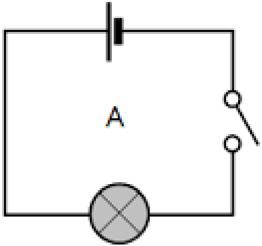
```
void setup() {

// Enable Serial Monitor
  Serial.begin (9600);
  while (!Serial);  // wait for Serial monitor
  Serial.println ("Ready to Go");
}

void loop() {
  for (i=0; i <=13; i++)
  Serial.print(i);
  delay(ledDelay);
}
```

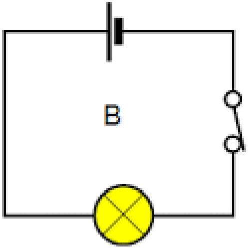
Digital Output

Digital electronics rely on binary logic to store, process, and transmit data or information. Binary Logic refers to one of two states – ON or OFF. This is commonly translated as a binary 1 or binary 0. A binary 1 is also referred to as a HIGH signal and a binary 0 is referred to as a LOW signal.

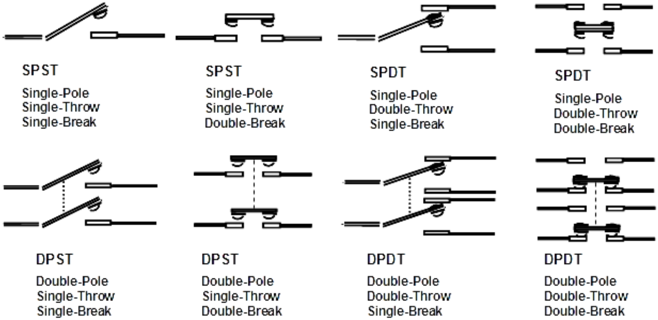


Switches

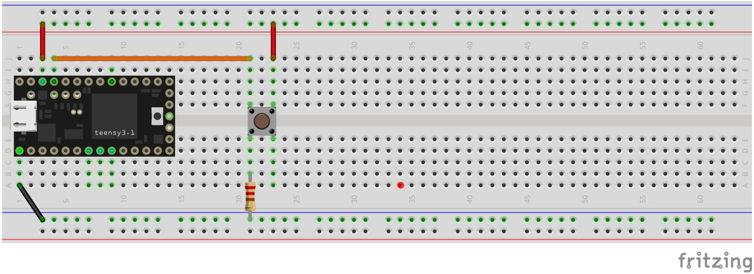




Types of Switches



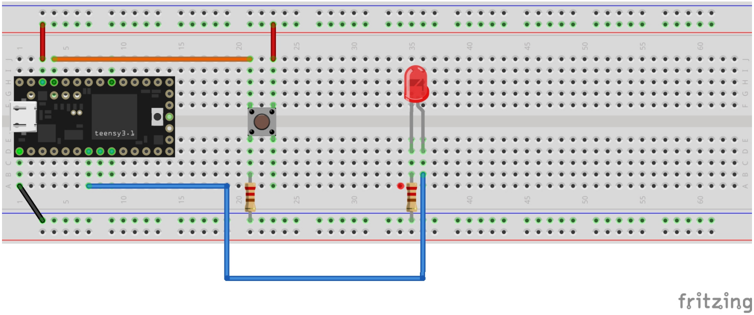
Our First Button



If Statements

```
// IF statement SYNTAX
if (condition) {
  //statement(s)
}

// EXAMPLE
if (button == HIGH) {
  digitalWrite(ledPin, HIGH);
  }
```

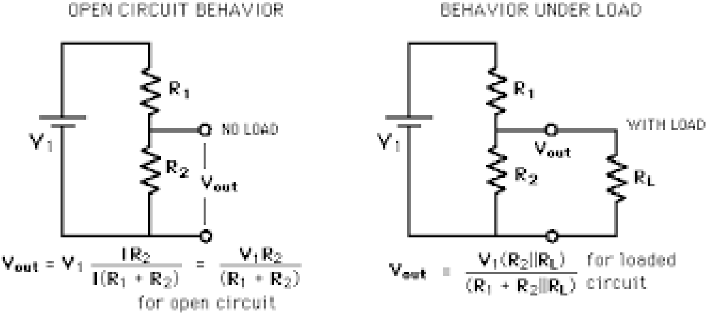
Button and LED



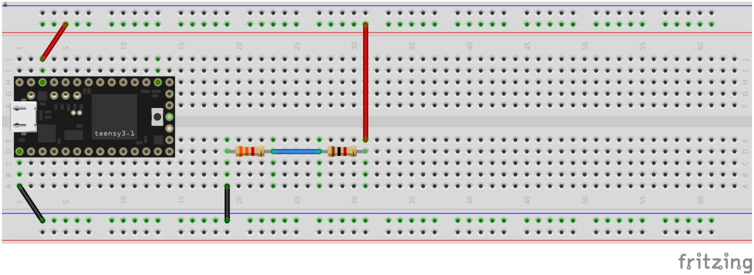
IoT Humor

"I remember when you could only lose a chess game to a supercomputer."

Voltage Divider

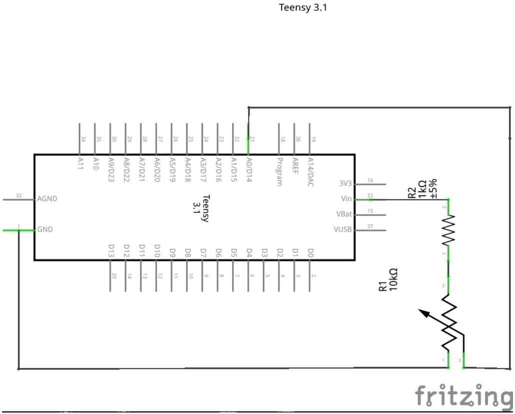


Voltage Dividing



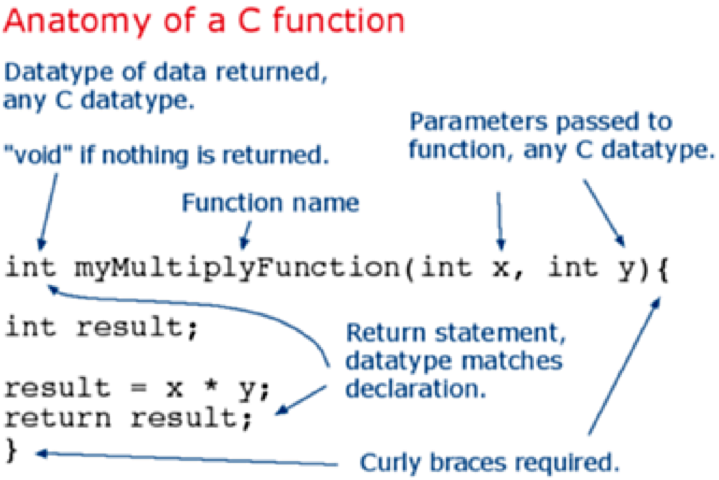
We are just using the Teensy to provide Power and GND.
The right resistor should be 1kΩ
The left resistor between 2.2kΩ and 6.8kΩ

Analog Input Schematic

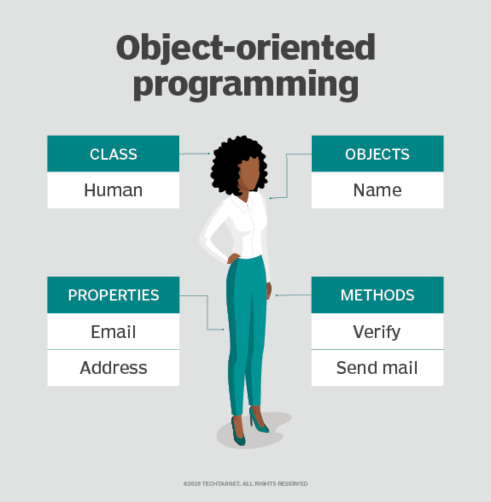


Feel free to use any PIN you would like to measure the voltage.

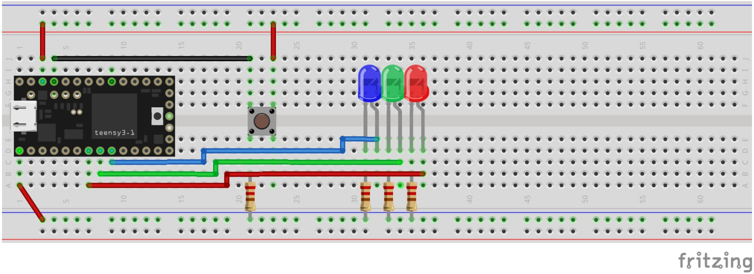
Anatomy of a Function



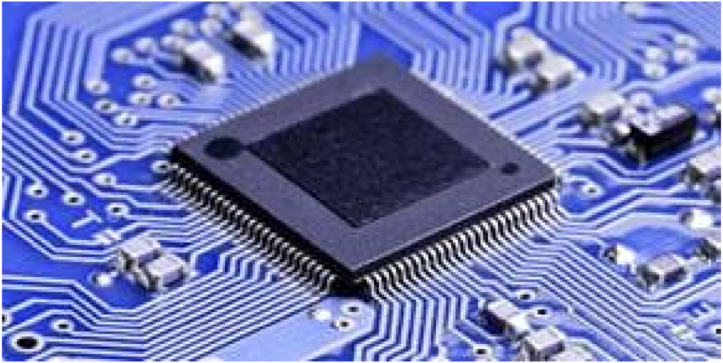
Objects


Object-oriented programming
CLASS
Human
OBJECTS
Name
PROPERTIES
Email
Address
METHODS
Verify
Send mail
©2019 TECHTARGET. ALL RIGHTS RESERVED

oneButton LED



Our Second Microcontroller



Particle Argon Pin Layout