



# Instructor Materials

## Chapter 2

### Sensors, Actuators, and Microcontrollers



## IoT Fundamentals

### Connecting Things 2.01

Cisco | Networking Academy®  
Mind Wide Open™





## Chapter 2: Sensors, Actuators, and Microcontrollers



### IoT Fundamentals Connecting Things 2.01

Cisco | Networking Academy®  
Mind Wide Open™



## Chapter 2 - Sections & Objectives

- 2.1 Learn Electronics
  - Explain how components and devices are used to build and measure values in electronic circuits.
- 2.2 Microcontrollers: The SparkFun Inventor's Kit
  - Create circuits and microcontroller programs with the Arduino and a variety of components.
- 2.3 Packet Tracer 7.0 and the IoT
  - Explain how Packet Tracer models IoT systems.



## 2.1 Learn Electronics



Cisco | Networking Academy®  
Mind Wide Open™



## Learn Electronics

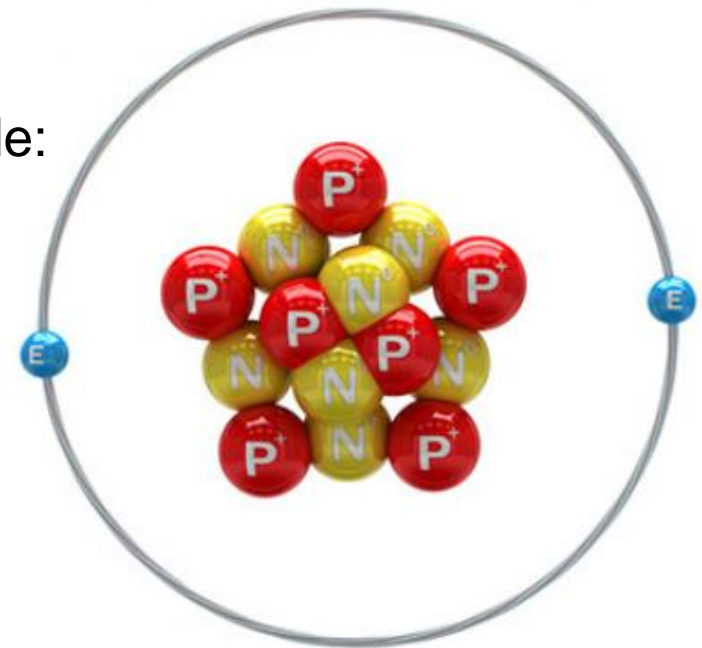
# 2.1.1 Basic Electronic Terminology & Concepts

### ■ What is Electronics?

- Electronics is the field of study focused on the control of electricity and the physical components and circuits that help direct electrical energy.

### ■ Definitions

- Terms commonly used in electronics include:
  - Electrons, atoms, and chemical elements
  - Electric current
  - Electrical conductors, insulators, and circuits
  - Voltage, Amperes (amps), and Power





## Learn Electronics

# Basic Electronic Terminology / Concepts (cont'd)

- Ohm's Law
  - Ohm's Law states that within a circuit, voltage (V) is directly proportional to the strength of current (I) multiplied by resistance (R).
  - Resistance is measured in ohms ( $\Omega$ )
- Basic Circuit
  - An electrical circuit is a closed conductive path that allows electrons to flow and create an electric current.
  - A circuit also needs an electrical energy source like a battery to start the flow of electricity.

$$V = I \times R$$

$$R = V / I$$

$$I = V / R$$



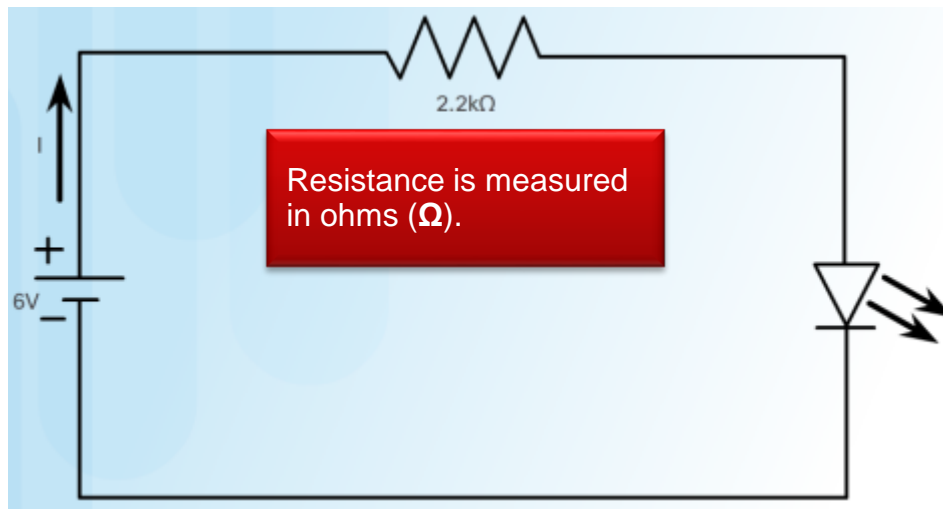
## Learn Electronics

# Basic Electronic Terminology / Concepts (cont'd)

### ■ Basic Circuit (Cont.)

- The following circuit diagram (schematic) consists of:
  - 6 volt (V) battery provides current
  - 2.2 k $\Omega$  resistor (protects the LED from receiving too much current and being destroyed)
  - A light-emitting diode (LED)

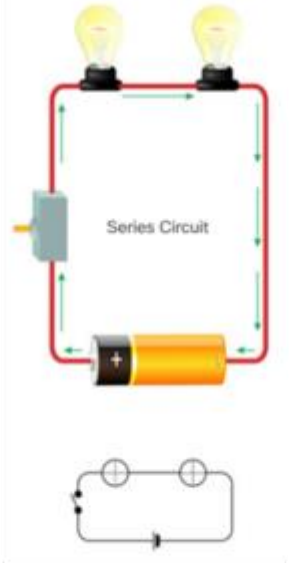
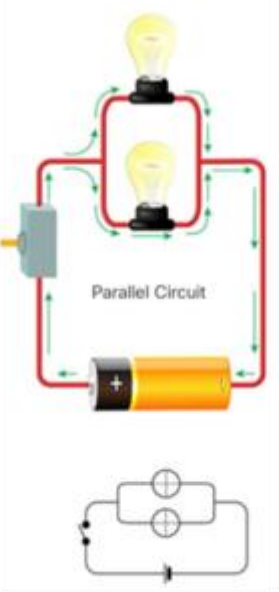
Current (I) flows from the positive terminal to the negative terminal



The triangular part represents a diode and the two arrows facing out represent the fact that this diode emits light.

# 2.1.2 Advanced Electronic Terminology /Concepts

## ■ Series and Parallel Circuits

<p><b>Series Circuit:</b></p> <ul style="list-style-type: none"> <li>Components are interconnected one after another in a path between the positive and negative terminals of the power source</li> </ul>	<p><b>Parallel Circuit:</b></p> <ul style="list-style-type: none"> <li>Current flows from the battery terminal but splits at a junction which leads to parallel pathways through the circuit.</li> <li>Components connected along each pathway each get their own share of current</li> </ul>
 <p>The diagram shows a series circuit with a battery at the bottom, a switch on the left, and two light bulbs at the top connected in a single loop. Green arrows indicate the current flows clockwise from the positive terminal of the battery, through the switch, then through each light bulb in sequence, and back to the negative terminal. Below the physical diagram is a simplified schematic showing a battery, a switch, and two circles representing light bulbs connected in a single rectangular loop.</p>	 <p>The diagram shows a parallel circuit with a battery at the bottom, a switch on the left, and two light bulbs at the top connected in parallel. Green arrows indicate the current flows clockwise from the positive terminal of the battery, through the switch, and then splits into two parallel paths, each passing through a light bulb before rejoining and returning to the negative terminal. Below the physical diagram is a simplified schematic showing a battery, a switch, and two circles representing light bulbs connected in parallel between two common vertical wires.</p>



# Advanced Electronic Terminology/Concepts (cont'd)

- Passive, Active, Linear, and Nonlinear Circuits
  - Active circuits contain active components; components that rely on external power source to control current flow.
  - Passive circuits contain passive components; components incapable of controlling current flow.
  - Analog circuits are circuits where the signal is contiguous.
  
- Direct Current vs. Alternating Current
  - In DC current, electron flow is only in one direction.
  - Batteries, power supplies, thermocouples, solar cells, or dynamos generate DC.
  - In AC current, electron flow periodically reverses direction.
  - Hydroelectric plants generate AC.





# Advanced Electronic Terminology/Concepts (cont'd)

## ■ Analog Circuits vs. Digital Circuits

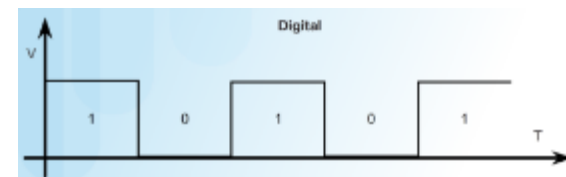
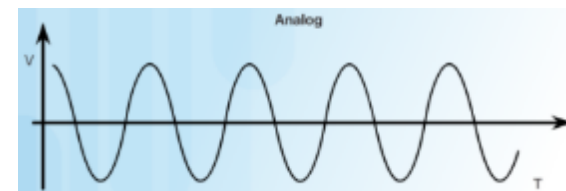
- Analog Circuits: Circuits in which signals vary continuously with time.
- Digital circuits: Circuits in which signals that take one of two discrete values.

## ■ Components

- Electronic components are specialized devices used in a circuit to control current.
- Components have two or more electrical terminals (leads) that enable them to connect to an electronic circuit.

## ■ Larger Electronic Building Blocks

- Solenoids can be used to electrically open door latches, open or shut valves, move robotic limbs, and even actuate electric switch mechanisms.
- Relays allow for controlling a large amount of current and/or voltage with a small electrical signal.





## Learn Electronics

# 2.1.3 From Schematic Diagram to Breadboard to Soldered PCB

### ■ Design Phase:

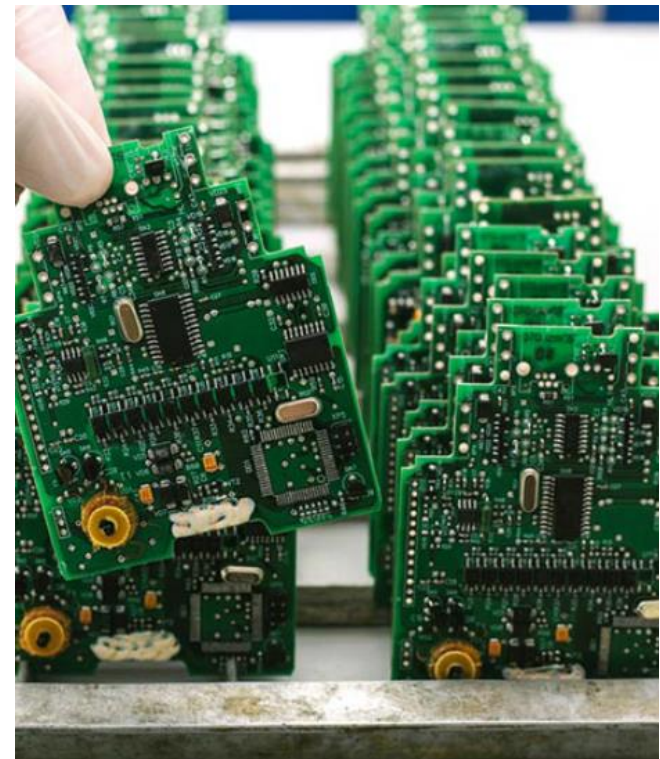
- Consists of three steps: Concept, Research, Circuit Design.
- A circuit diagram shows the components and interconnections of the circuit using standardized symbolic representations.

### ■ Prototype Phase:

- Consists of four steps: Hardware, Mechanical, and Software Development, PCB layout, Build prototypes, Product Testing
- A solderless breadboard is a tool commonly used in electronic prototyping.

### ■ Production Phase:

- Consists of three steps: Production Readiness Review, Production, On-going Maintenance.
- Often employ on printed circuit boards (PCBs).





## 2.2 Microcontrollers: The SparkFun Inventors Kit



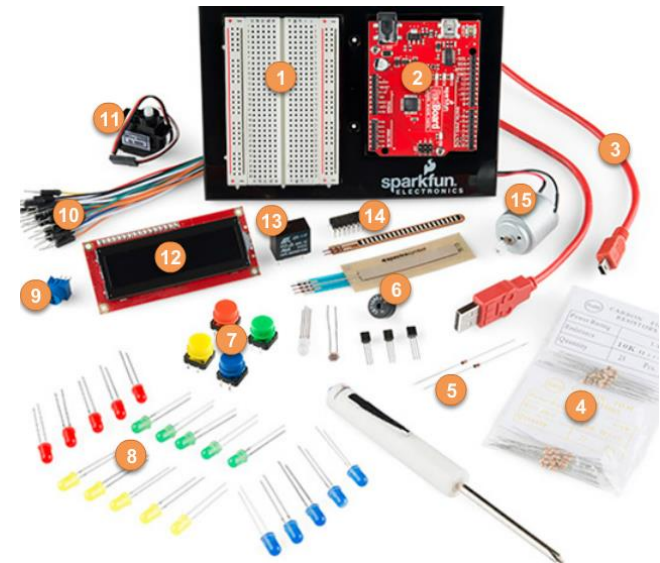
Cisco | Networking Academy®  
Mind Wide Open™



# Microcontrollers: The SparkFun Inventors Kit

## 2.2.1 Introducing the Kit

- Introduction to the SparkFun Inventor's Kit (SIK)
  - This is a starter kit for building circuits and includes:
    - Solderless breadboard
    - SparkFun RedBoard (Arduino-like board)
    - Various resistors, diodes, LEDs, sensors and actuators
    - Connecting wires (jumper wires, mini-B cable, ...)
- Arduino Microcontroller
  - The Arduino is a popular microcontroller for prototyping.
  - Instructions for the Arduino are programmed using the Arduino integrated development environment (IDE).
  - The SparkFun RedBoard is an Arduino-like board that can be programmed using Arduino IDE.





# Microcontrollers: The SparkFun Inventors Kit

## 2.2.2 Simple Circuits

### ■ Building a Circuit

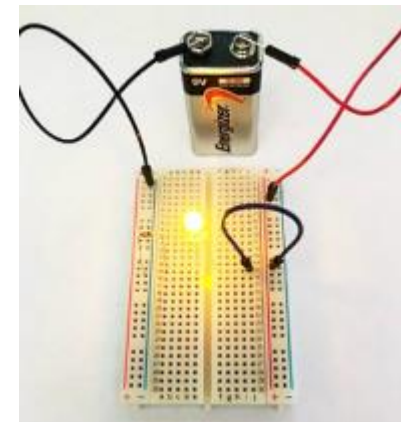
- A simple circuit can be created by:
  - Connecting electronic components (LED, resistor, and jumper wires) in series along a row on the breadboard.
  - Connecting the power source to the lower red and black jumper wires.
  - This should complete the circuit and light the LED.

### ■ The Arduino IDE

- Free, downloadable software used to interact with the Arduino board.

### ■ Writing code

- Programs written using the Arduino IDE are called sketches and are saved with the file extension of .ino.
- Arduino sketch keywords can be divided in three main category types: structures, values (variables and constants), and functions.
- Keywords used include void, setup(), loop() function, and more.







# Microcontrollers: The SparkFun Inventors Kit

## Simple Circuits (cont'd)

### ■ Testing

- To test and verify the sketch code, click on the checkmark toolbar icon.
- The IDE compiles the code and checks for syntax errors.
- To upload the sketch to the Arduino and test the code, click on the second toolbar icon (⇒)



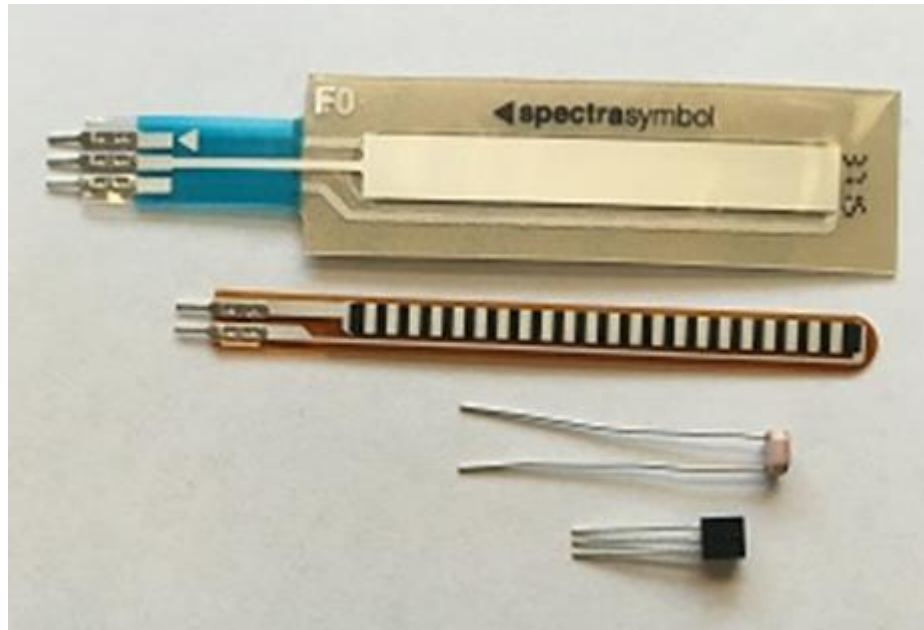


## Microcontrollers: The SparkFun Inventors Kit

### 2.2.3 Sensing the Environment

#### ■ Sensors

- Devices that detect an event from the physical environment and respond with electrical or optical signals as output.
- The SIK contains various sensors including Soft potentiometer, Flex sensor, Photo resistor and Temperature sensor.





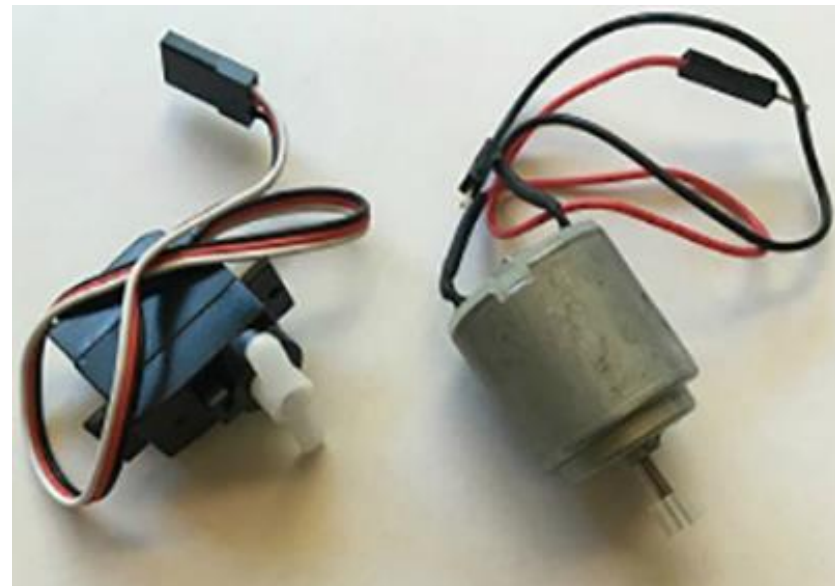
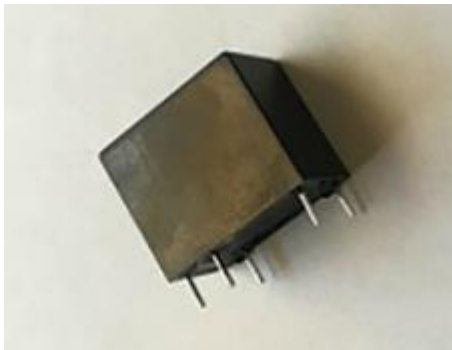


## Microcontrollers: The SparkFun Inventors Kit

### 2.2.4 Making it Happen

#### ■ Actuators and Relays

- An actuator is a type of motor that is responsible for creating movement.
- The SIK includes two types of electric actuators that convert electrical energy into mechanical torque.
- A relay is an electrically controlled mechanical switch.
- The SIK includes a plastic box that contains an electromagnet that causes a switch to trip when it receives a current.





## 2.3 Packet Tracer 7.x and the IoT



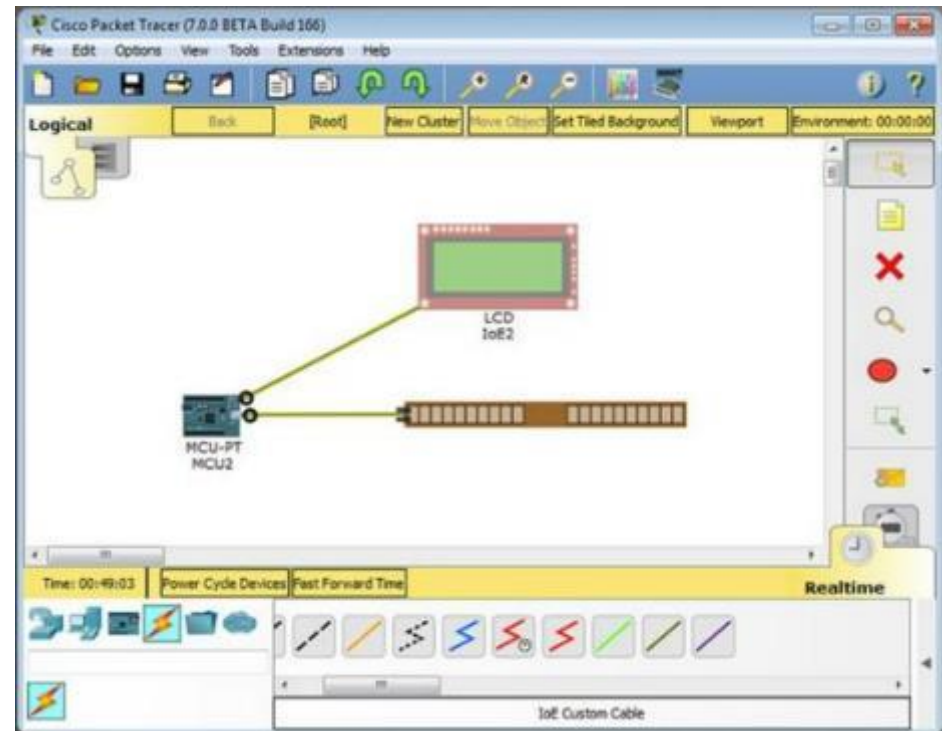
Cisco | Networking Academy®  
Mind Wide Open™



## Packet Tracer 7.x and the IoT

# PT 7.x – End-to-End IoT System Model

- How Everything Connects in PT
  - Packet Tracer 7.x can be used as a prototyping tool.
  - There is a new group icon contained in Packet Tracer version 7.1 that is labeled Components.
  - The PT IoT boards contains an MCU and a SBC.
  - The MCU and SBC are similar to an Arduino and a Raspberry Pi, respectively.
  - There are also actuators and sensors that can be used in prototypes.
  - The IoE Custom Cable found in the Connections group can be used to connect IoT things to an MCU board.





## 2.4 Chapter Summary



Cisco | Networking Academy®  
Mind Wide Open™



## Chapter Summary

# Summary

- Electronics is an important part of the IoT.
- IoT devices are often built from scratch; therefore, understanding electronics concepts, components and terminology is critical. It is also important for an IoT professional to be able to read and create electronics schematics.
- The SparkFun kit contains a number of devices and parts to help a beginner to get started with electronics and microcontrollers. It also introduces important concepts such as electronic circuits and how to program Arduino microcontrollers. Working with the kit, a beginner can also learn how to program sensors to monitor the environment. Actuators and relays are often used to influence the environment or create action.
- Students can use Cisco Packet Tracer 7.x as a tool for modeling and prototyping IoT systems.



