



Sensors, Actuators, and Microcontrollers



IoT Fundamentals Connecting Things 2.01

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Sections & Objectives

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



Learn Electronics



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Learn Electronics

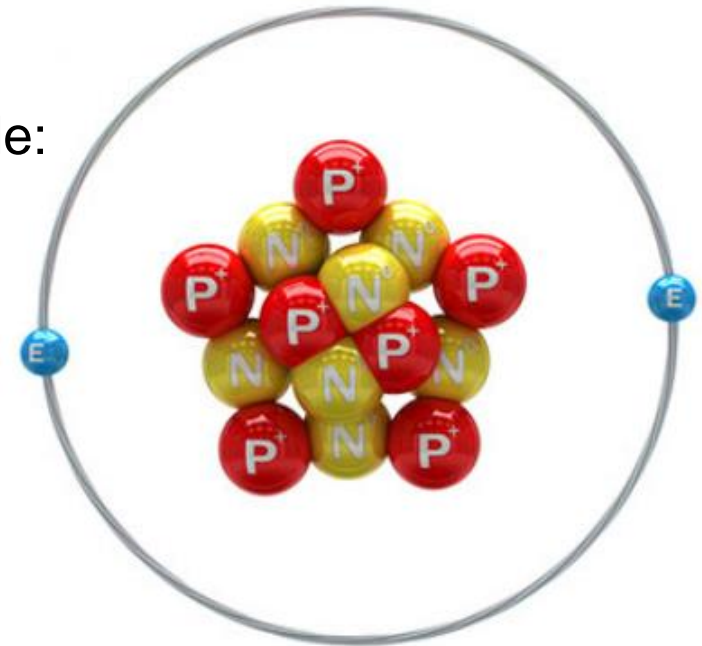
Basic Electronic Terminology & Concepts

■ 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 (Ω)
- 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.

$$V = I \times R$$

$$R = V / I$$

$$I = V / R$$



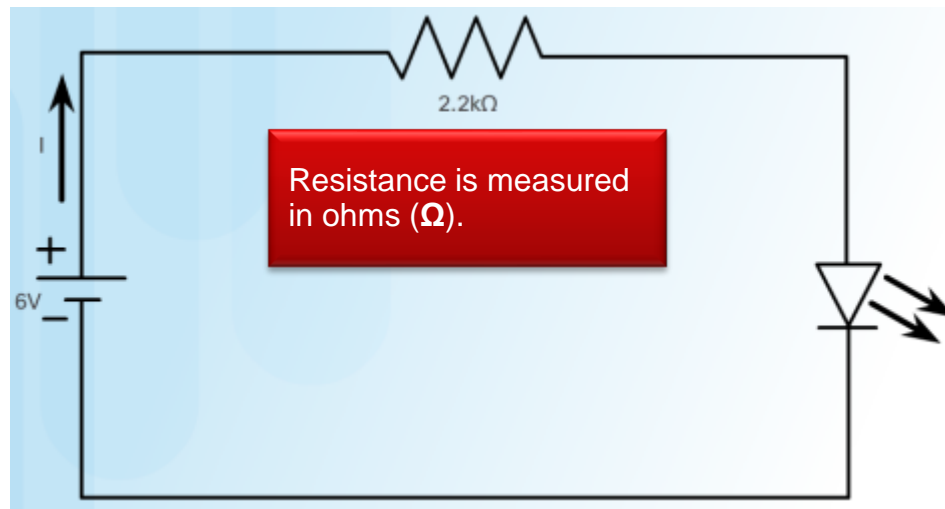
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Basic Electronic Terminology / Concepts (cont'd)

■ Basic Circuit (Cont.)

- The following circuit diagram (schematic) consists of:
 - 6 volt (V) battery provides current
 - 2.2 k Ω 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



Resistance is measured in ohms (Ω).

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



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Advanced Electronic Terminology /Concepts

- Series and Parallel Circuits

<p>Series Circuit:</p> <ul style="list-style-type: none"> Components are interconnected one after another in a path between the positive and negative terminals of the power source 	<p>Parallel Circuit:</p> <ul style="list-style-type: none"> Current flows from the battery terminal but splits at a junction which leads to parallel pathways through the circuit. Components connected along each pathway each get their own share of current
<p style="text-align: center;">Series Circuit</p>	<p style="text-align: center;">Parallel Circuit</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

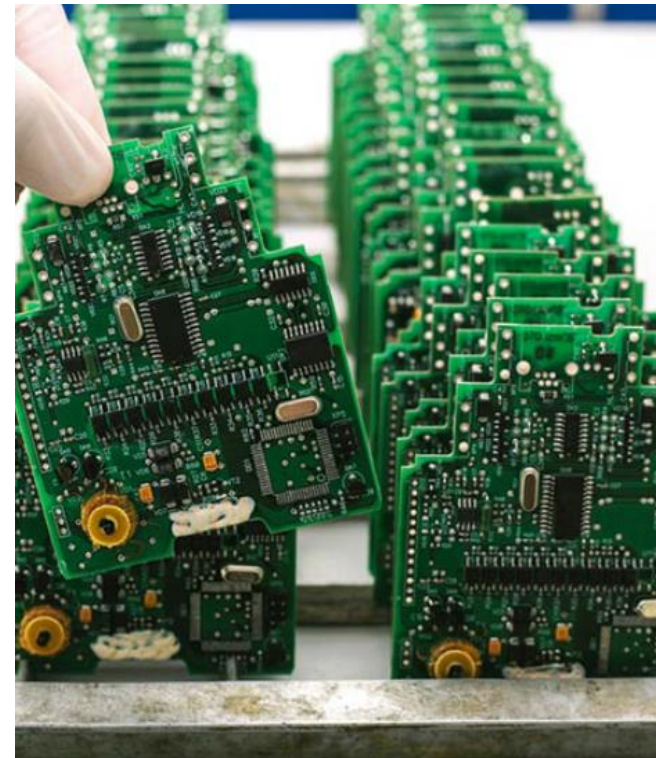
- Solenoids can be used to electrically open door latches, open or shut valves, move robotic limbs, and even actuate electric switch mechanisms.
- Relays allow for controlling a large amount of current and/or voltage with a small electrical signal.





Learn Electronics 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).





Microcontrollers: The SparkFun Inventors Kit



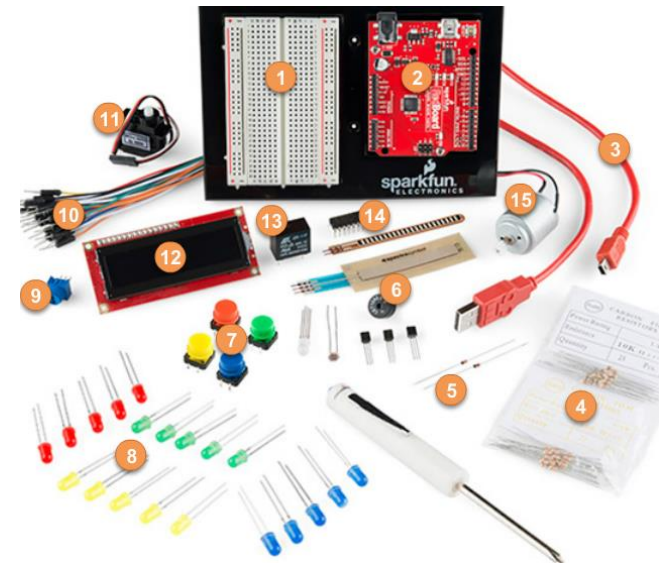
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Microcontrollers: The SparkFun Inventors Kit

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

Simple Circuits

■ Building a Circuit

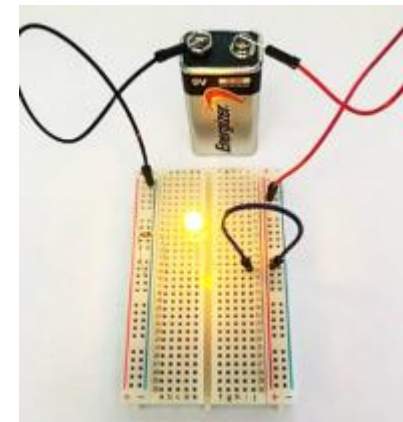
- A simple circuit can be created by:
 - Connecting electronic components (LED, resistor, and jumper wires) in series along a row on the breadboard.
 - Connecting the power source to the lower red and black jumper wires.
 - This should complete the circuit and light the LED.

■ 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 (⇒)

```
sketch_may12a | Arduino 1.6.8  
sketch_may12a  
void setup() {  
  // put your setup code here, to run once:  
}  
  
void loop() {  
  // put your main code here, to run repeatedly:  
}
```

Done uploading.

Sketch uses 450 bytes (1%) of program storage space. Maximum is 32,256 bytes.
Global variables use 9 bytes (0%) of dynamic memory, leaving 2,039 bytes for local variables. Maximum is 2,048 bytes.

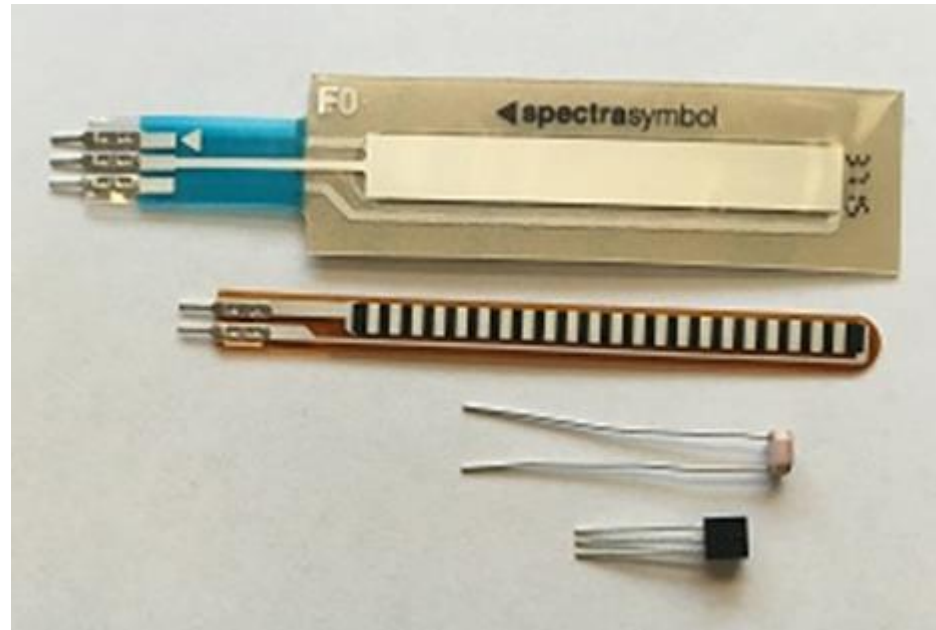
9 Arduino/Genuino Uno on /dev/cu.usbserial-DN00N00D



Microcontrollers: The SparkFun Inventors Kit

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.



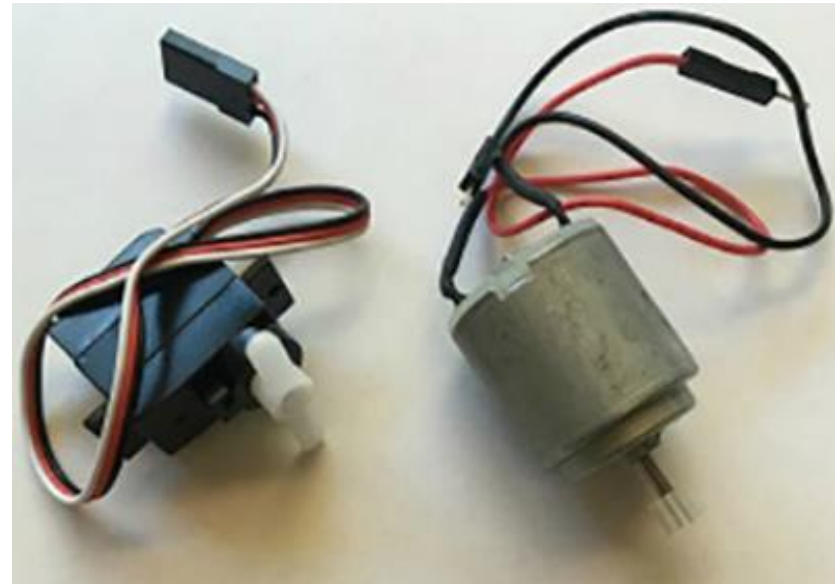
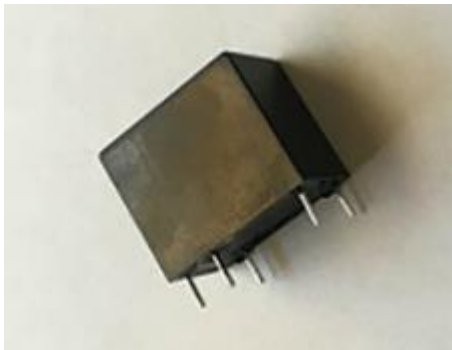


Microcontrollers: The SparkFun Inventors Kit

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.





Packet Tracer 7.x and the IoT



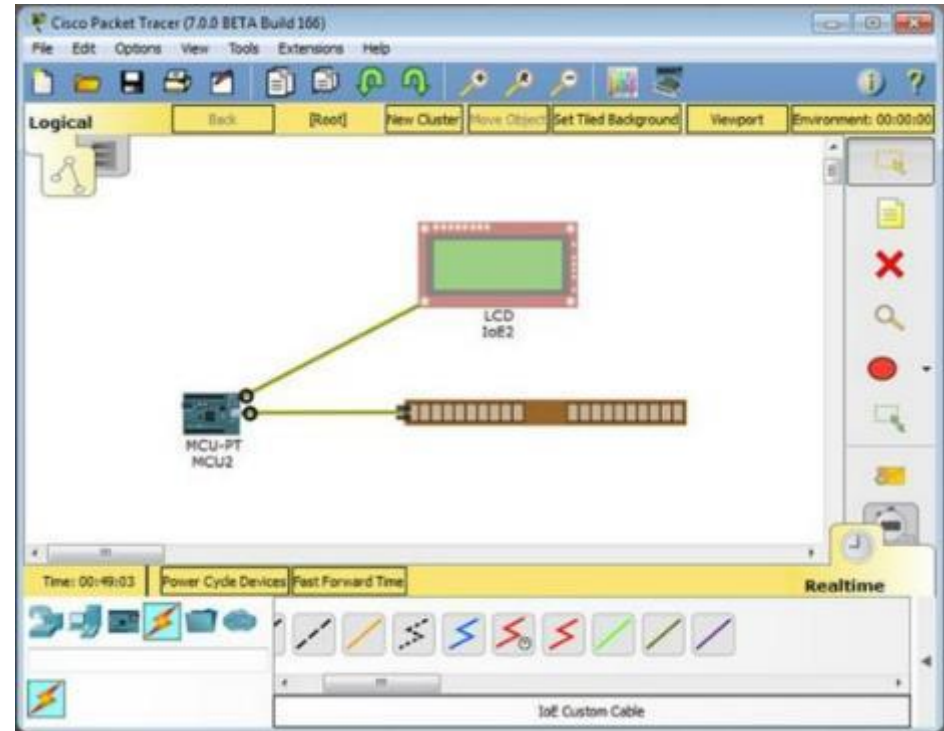
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Packet Tracer 7.x and the IoT

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.





Chapter Summary



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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.

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