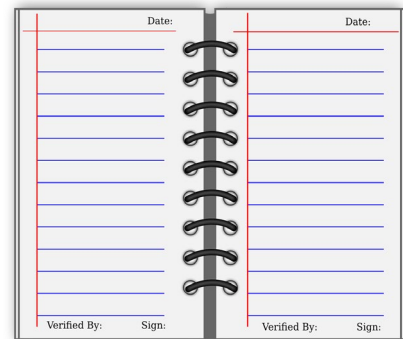


# Logbooks Should Be Comprehensive

## Document All Phases of Planning & Assembly

### What information about electrical projects should appear in logbooks?

1. Sketch or draw the circuit.
2. Create a circuit diagram.
3. Create a pictorial diagram.
  - You may choose to use 3D modeling software found online. Several sites have downloadable component files that let you compile your own pictorial model of a circuit or motherboard, etc.
  - FREE Resources for 3D Modeling
    - [TinkerCad.com](http://TinkerCad.com)
    - [FreeCad.org](http://FreeCad.org)
    - [SketchUp.com](http://SketchUp.com)
    - [TraceParts.com](http://TraceParts.com)
    - [All3DP.com](http://All3DP.com) review of free modeling systems
    - [All3DP.com](http://All3DP.com) overview of types of 3D modeling
  - PAID Resources for 3D Modeling Software
    - [Solidworks.com](http://Solidworks.com)
    - [AutoDesk.com](http://AutoDesk.com)
4. Include photo documentation of progress as each step is drafted, diagrammed, or assembled.
5. Use video to document your progress whenever possible.



### RULES OF DOCUMENTATION

1. Write only on one side to avoid text and sketches bleeding through.
2. Fill the page with sketches – draw big and record the scale. If the real object is 200 cm and your drawing is 20 mm, note the scale is 1:10.
3. Use engineering tools for engineering drawings.
4. Guessing is not enough once you begin working with electronics.
5. Provide detailed calculations with formulas.
6. Always include the date and initial the page.
7. Never tear out pages of an engineering notebook.
8. You can add diagrams, pictures and tables by taping or carefully adding them to a notebook.

# Basic Electrical Terms

## A - L

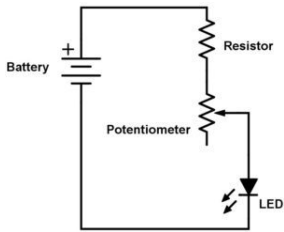
Keep this reference handy and add additional vocabulary as you learn about new components.

- **AC** - Abbreviation for alternating current, which is voltage that flips back and forth between positive and negative.
- **Ampere** - Unit of current (symbol: A).
- **Arduino** - Open-source electronic prototyping platform enabling users to create interactive electronic objects.
- **Breadboard** - A board used to make temporary circuits. The breadboard has metal-lined sockets for connecting electronic components in a test circuit.
- **Capacitor** - An electronic component consisting of two conducting surfaces, separated by an insulator. It is used to store and release energy and to control high-frequency signals. **You can think of a capacitor as a battery with very low capacity.** You can charge and discharge it just like a battery. The capacitor is often used to introduce a time-delay in a circuit.
- **Circuit** - A collection of electronic parts connected together, usually designed to perform some kind of function.
- **Circuit diagram** - A diagram that depicts a circuit, using symbols for electronic components. Used to design and communicate circuits with other people, like a blueprint or a plan.
- **Closed circuit** - A circuit in which current can flow through electronic components, from a point of high voltage to a point of low voltage.
- **Conductance** - The opposite of resistance. Materials with high conductance (e.g. metals) have low resistance. The unit of conductance is siemens (S).
- **Current** - The flow of electric charge. The unit for current is amperes (A).
- **DC** - Abbreviation for direct current voltage, which is voltage that does not alternate.
- **Diode** - An electronic component that allows current to flow freely in only one direction.
- **I** - Symbol for current. The unit for current is the ampere (A).
- **Inductor** – Inductors are just coils of wire, but they do some interesting things. Any wire with current flowing through it has a small magnetic field surrounding it. When you wind the wire into a coil, the field becomes stronger. Inductors also resist current so placing one between the battery and LED means the current increases gradually to activate the LED rather than current going from zero to maximum right away.
- **Integrated circuit (IC)** - An electronic component that contains several simpler electronic components. An IC is a miniaturized electronic circuit. An Integrated Circuit (IC) consists of many basic electronic components. It's just an electronic circuit that has been shrunk to fit inside a chip and could be an amplifier, or a microprocessor, or USB to serial converter... It could be anything!
- **Jumper** - A short length of wire used to temporarily complete a circuit or to bypass a break in a circuit.
- **Kilo** - A prefix meaning "thousand." A 10-k $\Omega$  resistor is 10,000 ohms.
- **Lead** - Length of wire used to make connections between components in a circuit.
- **Light-emitting diode (LED)** - A solid-state device that has two key features: it allows current to flow in only one direction (that is the "diode" part), and it emits light when current flows through it in the "allowed" direction. LEDs are described by several specifications, some of the more important of which are: Maximum current; Brightness; Color of light; Angle of light beam (for example, an LED with an angle of 15 degrees produces a more focused beam than one with a beam of 45 degrees); and Size, usually 5 mm.

# Basic Electrical Terms

## M - Z

- **Mega** - A prefix meaning "million" (symbol: M). A 1-M $\Omega$  (megaohm) resistor has a resistance of 1 million ohms.
- **Multimeter** - An instrument with several different kinds of meters. Multimeters are used to measure voltage, current, and resistance, among other things.
- **Ohm** - Unit of resistance. The symbol for the ohm is  $\Omega$ . You can make this symbol in Microsoft Word by changing the font of a capital "W" into the font called "Symbol," using the "Format" menu.
- **Ohm's law** -  $V = IR$ , or "Voltage equals current times resistance." Example: Say a 1,000- $\Omega$  resistor has a voltage drop of 9 V. What is the amount of current that is flowing through the resistor? Plugging the numbers in yields  $9\text{ V} = I\text{ amps} \times 1,000\ \Omega$ , so  $I = 9/1,000$  amps (A), or 9 milliamps (mA).
- **Open circuit** - A circuit with a gap in it that prevents current from flowing. When you turn of a light with a light switch, you open up the circuit connecting the lightbulb to the source of electricity.
- **Parallel connection** - Current flows through two or more components at the same time. As an analogy, imagine a river splitting into two or more parallel streams, which then merge together again. The amount of current flowing through the various "streams" depends on their resistance.
- **R - Symbol for resistance.** The electrical resistance of an object is a measure of its opposition to the passage of a steady electrical current. Metals have very low resistance, whereas substances such as rubber and plastic have high resistance. The unit of resistance is the ohm, with the symbol  $\Omega$ .
- **Resistor** - An electronic component used to "resist" the flow of current. Resistors are used to control current in an electric circuit. The unit of resistance is the ohm ( $\Omega$ ). The value for the resistance of a resistor is coded by colored lines on the resistor. When they are in a circuit with a voltage supply, a "voltage drop" occurs across the resistor. Resistors have three key features: their level of resistance, their power rating, and their tolerance. Say a resistor has a resistance of 220 ohms ( $\Omega$ ), a power rating of 1/4 watt (W), and a tolerance of 5 percent. The power rating tells you the limit of the power (power = current x voltage through the resistor) that the resistor can withstand without overheating. Tolerance is a measure of the resistance range. A 220-ohm resistor with a 5 percent tolerance will have a resistance in the range of 220 ohms  $\pm$  11 ohms. An electrical specification might call for a resistor with a value of 100  $\Omega$  (ohms), but will also state a tolerance, such as " $\pm$ 1%". This means that any resistor with a value in the range 99  $\Omega$ –101  $\Omega$  is acceptable.
- **Short circuit** - A low-resistance connection established between two points in an electric circuit that are designed to be at different voltages. For example, connecting the positive and negative poles of a battery with a wire causes a short circuit. Because of the low resistance of the connection, the level of current can be very high, leading to excessive heat and damage to the circuit. Short circuits can cause fires and explosions if the current is large enough.
- **Serial connections** - In a serial connection, the current flows through each component one at a time, like a river passing through several dams. The amount of current flowing through the components is equal, since they are connected "end-to-end." Compare to parallel connection.
- **Tolerance** - The range of variation permitted in an electrical component.
- **Transistors** - The transistor is like an electronic switch. It can turn a current on and off. A simple way you can think of it is to look at the transistor as a relay without any moving parts.
- **V** - Symbol for voltage. The unit for voltage is the volt.
- **Voltage** - A measure of the difference in electric potential between two points. A voltage difference causes electrons to flow, much like a difference in height can make water flow. The unit for voltage is the volt (V).
- **Wingscope** - A free program that lets you use your computer as an oscilloscope. It is very useful for measuring voltage vs. time data for beginner electronics projects.



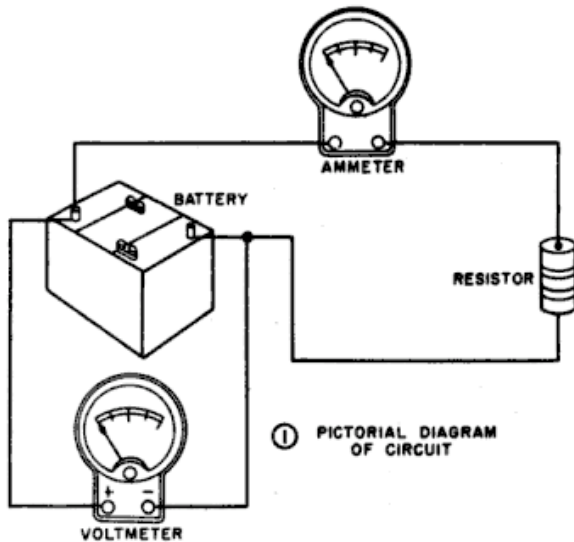
# Basic Electrical Circuit Diagrams

Some Basic electronic symbols

CAPACITOR (NP)	TRANSISTOR PNP	INDUCTORS	DPDT
CAP. polarized	TRANSISTOR NPN	MICROPHONE	SPDT
RESISTOR	JFET - N	NOR Gate	Push NO
POTENTIOMETER	JFET - P	NAND Gate	Push NC
RHEOSTAT	OpAmp	INVERTER	SPST
DIODE	Photo Transistor	Signal Gen.	SP4Pos
LED	Relay - SPST	Battery	Relay SPDT
ZENER	Speaker	Common / Ground	Signal
Rectifier Bridge	Antenna	Buzzer	
SCR		Lamp	
Triac			
Varistor			
Crystal			

## Electrical Symbols

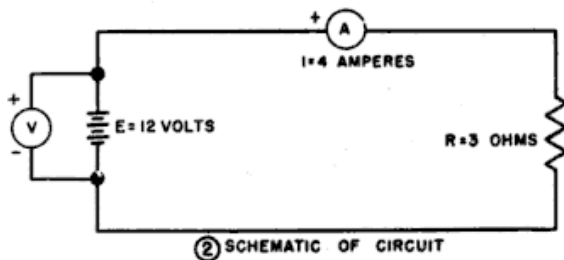
An electronic symbol is a pictogram used to represent various electrical and electronic devices or functions, such as wires, batteries, resistors, and transistors, in a schematic diagram of an electrical or electronic circuit. These symbols are largely standardized internationally today but may vary among countries or professions.



## Pictorial Diagram

A pictorial diagram depicts a circuit, using icons or images to represent electronic components.

These diagrams are used in education and training.

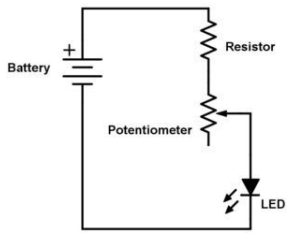


## Circuit diagram

A circuit diagram depicts a circuit, using symbols to represent electronic components.

These diagrams are used to design and communicate circuits with other people, like a blueprint or a plan.

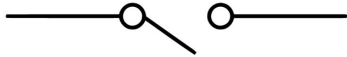
Figure 48. Diagram of a basic circuit.



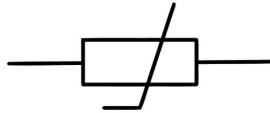
# Basic Electrical Knowledge

## Most Common Circuit Symbols

# ELECTRICAL CIRCUIT SYMBOLS



SWITCH (open)



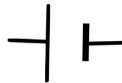
THERMISTOR



LAMP



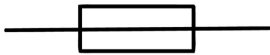
SWITCH (closed)



CELL



AMMETER



FUSE



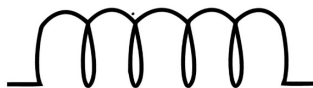
GROUND



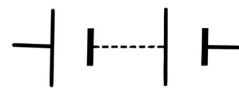
VOLTMETER



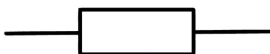
DIODE



INDUCTOR



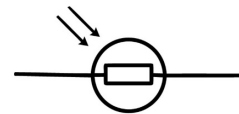
BATTERY



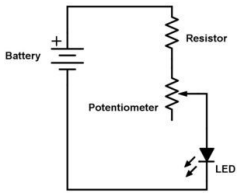
RESISTOR



BUZZER



LDR



# Basic Electrical Knowledge

## Extended List of Circuit Symbols

### ELECTRONIC CIRCUIT SYMBOLS

WIRE	JOINED WIRE	WIRE NOT JOINED	CELL	BATTERY	DC SUPPLY	AC SUPPLY	EARTH/ GROUND	FUSE
<b>POWER SUPPLY</b>								
NPN BJT	PNP BJT	PNP JFET	NPN JFET	N CHANNEL MOSFET enh	P CHANNEL MOSFET enh	N CHANNEL MOSFET enh	P CHANNEL MOSFET enh	N CHANNEL MOSFET dep
<b>TRANSISTORS</b>								
<b>METERS</b>								
DIODE	LED	ZENER DIODE	PHOTO DIODE	SCR	VARICAP	TUNNEL DIODE	SCHOTTKY DIODE	CAPACITOR
<b>DIODES</b>								
<b>CAPACITORS</b>								
<b>RESISTORS</b>								
<b>OUTPUT DEVICES</b>								
PUSH TO BREAK	PUSH TO MAKE	SPST	SPDT	SPTT	DPST	DPDT	BELL	BUZZER
<b>SWITCHES</b>								
<b>OUTPUT DEVICES</b>								
<b>INPUT DEVICES</b>								
<b>MISCELLANEOUS</b>								
<b>LOGIC GATES</b>								
NOT	AND	NAND	OR	NOR	EX-OR	EX-NOR		

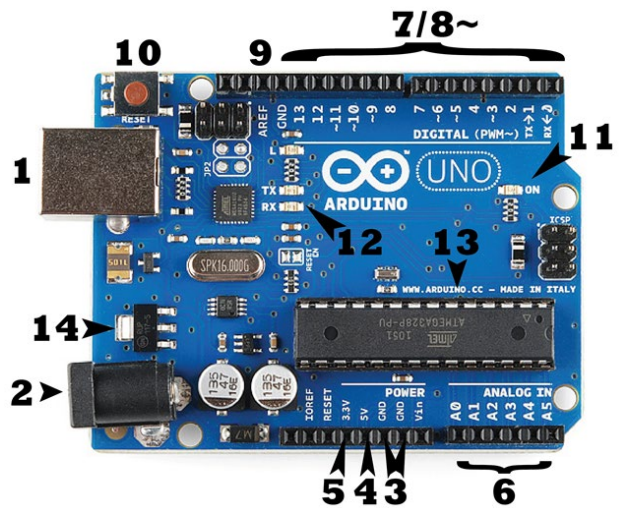
### RESISTOR CODES

0	1	2	3	4	5	6	7	8	9	x0.01	x0.1	±10%	±5%	±2%	±1%
BLACK	BROWN	RED	ORANGE	YELLOW	GREEN	BLUE	VIOLET	GREY	WHITE	SILVER	GOLD	SILVER	GOLD	RED	BROWN

Source a full list of symbols [HERE](https://www.rapidtables.com/electric/electrical_symbols.html). [https://www.rapidtables.com/electric/electrical\\_symbols.html](https://www.rapidtables.com/electric/electrical_symbols.html)

# Introduction to Arduino Boards

Open-source electronic prototyping platform used to create interactive electronic objects.



- 1. Power (USB / Barrel Jack)** - The Arduino UNO can be powered from a USB cable coming from your computer or a wall power supply. The USB connection is also how you will load code onto your Arduino board. The recommended voltage for most Arduino models is between 6 and 12 Volts.
  - 2. Barrel Jack** – connects to power
- Pins (5V, 3.3V, GND, Analog, Digital, PWM, AREF)** - The pins on your Arduino are the places where you connect wires to construct a circuit plus a breadboard and some wire. Black plastic ‘headers’ plug a wire right into the board. The Arduino has several different kinds of pins labeled on the board and used for different functions.
- 3. GND** - Short for ‘Ground’. GND pins on the Arduino can be used to ground your circuit.
  - 4. 5V Pin** - 5V pin supplies 5 volts of power.
  - 5. 3.3V Pins** - 3.3V pin supplies 3.3 volts of power.
  - 6. Analog** - A0 through A5 on the UNO are Analog In pins. These pins can read the signal from an analog sensor (like a temperature sensor) and convert it into a digital value.
  - 7. Digital** - Digital pins (0 through 13 on the UNO) can be used for both digital input and digital output.
  - 8. PWM** - The tilde (~) symbol next to some digital pins (3, 5, 6, 9, 10, and 11 on the UNO) means these pins act as normal digital pins, but they can also be used for Pulse-Width Modulation (PWM).
  - 9. AREF** - Analog Reference is not used often but can be used to set an external reference voltage (between 0 and 5 Volts) as the max limit for analog input pins.
  - 10. Reset Button** - Temporarily connect the reset pin to ground and restart any code that is loaded on the Arduino. This can be very in testing code multiple times.
  - 11. Power LED Indicator** - This LED next to the “ON” should light when the Arduino is powered.
  - 12. TX RX LEDs** - TX is short for transmit, RX is short for receive and indicate the pins responsible for serial communication. TX and RX appear by digital pins 0 and 1, and a second time next to the TX and RX indicator LEDs. These light up when the board is transmitting or receiving.
  - 13. Main IC** - Integrated Circuit is black with little metal legs and acts as the Arduino’s brainpower and varies from board to board.
  - 14. Voltage Regulator** - The voltage regulator controls the amount of voltage that is let into the Arduino board. It will turn away an extra voltage that might harm the circuit, like including ANYTHING greater than 20 volts.

# REFERENCES & RESOURCES

## VIDEO

Learn more about engineering electrical products. <https://youtu.be/3nB1Ntku06w>

Basic Electrical Knowledge – View This Playlist <https://www.youtube.com/playlist?list=PLzqS33DOPhJmtM2QVfic-eojEGmePEvWN>

Battery Power – View This Playlist <https://www.youtube.com/playlist?list=PLzqS33DOPhJkyAjXYEudx3Pwx bq8-1K8F>

Find a full list of electronic circuit symbols [HERE](https://www.rapidtables.com/electric/electrical_symbols.html). [https://www.rapidtables.com/electric/electrical\\_symbols.html](https://www.rapidtables.com/electric/electrical_symbols.html)

Individual components used in electrical projects. <https://www.youtube.com/c/Afrotechmods/videos>

Learn to read circuit diagrams. [https://youtu.be/5\\_O9i2VarXg](https://youtu.be/5_O9i2VarXg) & <https://youtu.be/pmApobc3W1U>

AfroTechMods – Intro to Arduino Video <https://youtu.be/nL34zDTPkcs>

Learn more about how computers work. [www.youtube.com/playlist?list=PLzdnOP1iJNcsRwJhvksEo1tJqjlqWbN-](http://www.youtube.com/playlist?list=PLzdnOP1iJNcsRwJhvksEo1tJqjlqWbN-)

Watch “How Wi-Fi Works” <https://youtu.be/hePLDVbULZc>

How Bluetooth Works <https://youtu.be/jzxZUJmOu3o>

Adaptive vs Assistive Tech <https://youtu.be/Slm2MuJUcTE>

PacerCenter Intro to Assistive Tech <https://youtu.be/DB9pKkZoJDC>

Examples of Adaptive and Assistive Tech Playlist [www.youtube.com/playlist?list=PLMe9zDtTPTVe62Gb6b9Dkk\\_IPBUTGQHoD](http://www.youtube.com/playlist?list=PLMe9zDtTPTVe62Gb6b9Dkk_IPBUTGQHoD)

Current Assistive and Adaptive Tech Uses from TodayOnline <https://youtu.be/TyBXBLa5YUo>

Microsoft Europe City Project [https://youtu.be/JYM\\_mNnvuS4](https://youtu.be/JYM_mNnvuS4)

## INTERACTIVE URLS

Design and Test Circuits (including Arduino) at TinkerCad <https://www.tinkercad.com/learn/circuits>

Download 3D Modeling Files <https://www.thingiverse.com>

Download 3D Modeling Components for Pictorial Diagrams <http://info.traceparts.com>

## READING & TUTORIALS

Read: Tech Terminology Resource <https://techterms.com/definition/switch>

Read more about breadboards and how they work at ScienceBuddies.org <https://youtu.be/6WReFkfrUIk>

Read more about Arduino. <https://learn.sparkfun.com/tutorials/what-is-an-arduino/all>

Read more about Bluetooth. <https://learn.sparkfun.com/tutorials/bluetooth-basics/all>

Access “Art of the Spark” from ArtofSTEMOnline.com or iNSLmember.org Teacher Resources.

Access “FREE CAD Resources for Students” from iNSLmember.org Teacher Resources