Marconi Challenge

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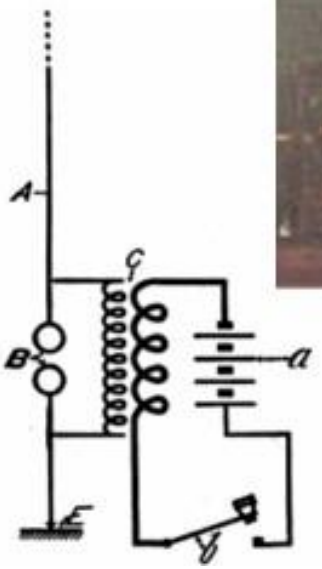
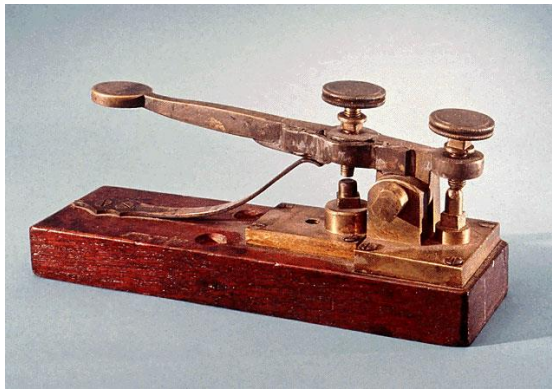
Guglielmo Marconi pioneered wireless telegraphy at a wavelength of 1500 meters (about 5000 feet or over 16 football fields long) and succeeded in sending a radio signal with kilowatts (1000s of watts) of power across the Atlantic Ocean in 1901





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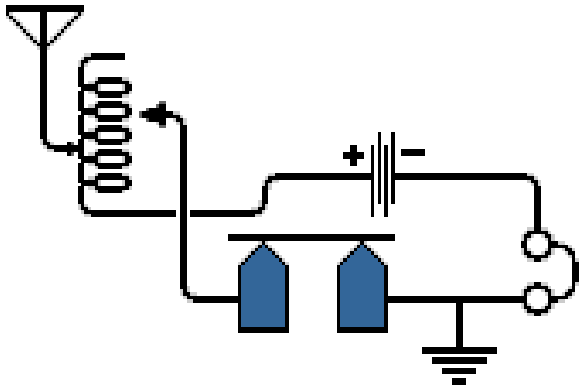
Crystal radio for amplitude modulation (AM) reception for stations like *KYW*



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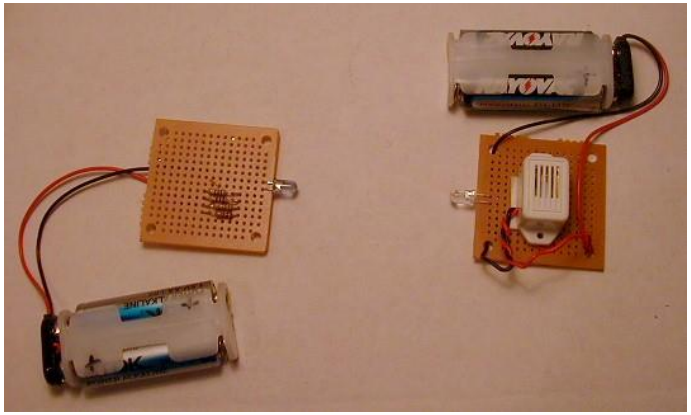
What do we want to do in the

- Introduce electrical circuits: voltage, current, resistors, schematics and circuit construction
- Introduce active electronic devices: light emitting diodes (visible and infrared), phototransistors, integrated circuits
- Demonstrate wireless infrared communication: semaphores, text messaging, frequency, wavelength



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Voltage*:*

- Alessandro Volta (1745-1827)
- Electrochemical cell of zinc, copper and sulfuric acid (like in an automobile battery)
- Measurement in *volts* (V)

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Voltage:

- Use a *voltmeter* to measure the voltage (V)
- For convenience a combination meter or *multimeter* is often used
- Dry cell batteries come in different voltages

1.5 volt

9 volt

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Current:

- Andre-Marie Ampere (1775-1836)
- Electrons flow from one place to another because of a difference in voltage (as in lightning)
- Measurement in *amperes* (A) for current (I)

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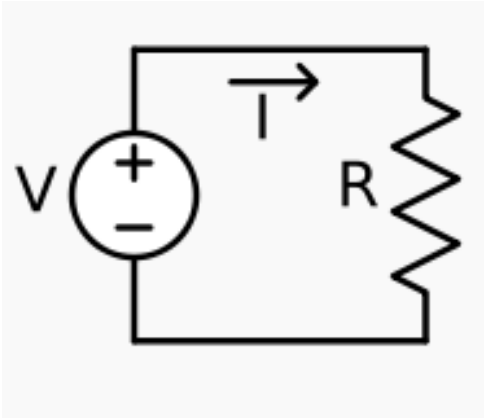
Resistance:

- Georg Ohm (1789-1854)
- Discovered the fundamental relationship between voltage and current (*Ohm's Law*) in a circuit
- Resistance (R) measurement in *Ohms* (Ω)
- Voltage = Current x Resistance

$V = I R$



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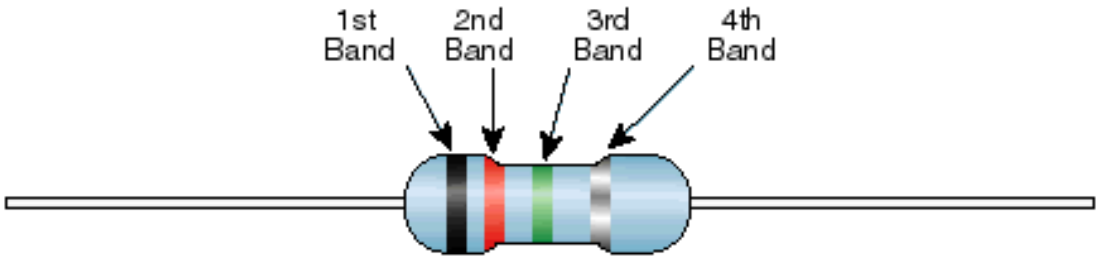
Resistors:

- Resistors often have color coded bands for the value in ohms

Standard EIA C



Color	1st Band (1st figure)	2nd Band (2nd figure)	3rd Band (multiplier)	4th Band (tolerance)
Black	0	0	10^0	
Brown	1	1	10^1	
Red	2	2	10^2	±2%
Orange	3	3	10^3	
Yellow	4	4	10^4	
Green	5	5	10^5	
Blue	6	6	10^6	
Violet	7	7	10^7	
Gray	8	8	10^8	
White	9	9	10^9	
Gold			10^{-1}	±5%
Silver			10^{-2}	±10%

Chart Provided By XICON

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Resistors:

- Resistors can be placed *in series* to increase the resistance:

$$R_{\text{eq}} = R_1 + R_2 + \cdots + R_n$$

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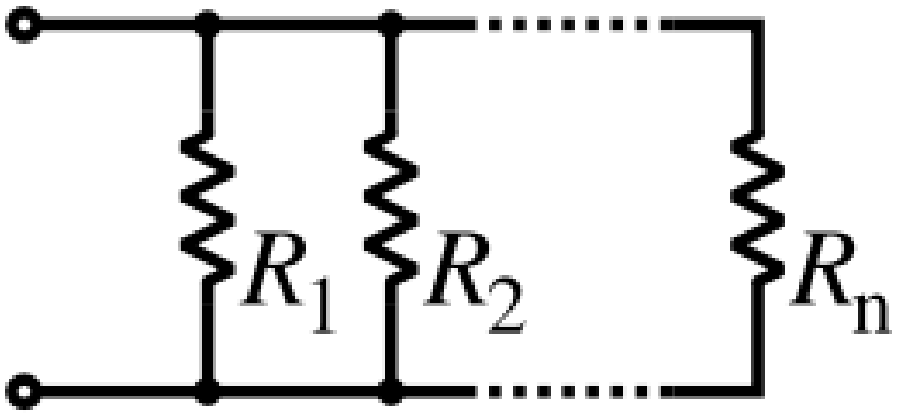
Resistors:

- Resistors can be placed *in parallel* to decrease the resistance:



$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n}$$

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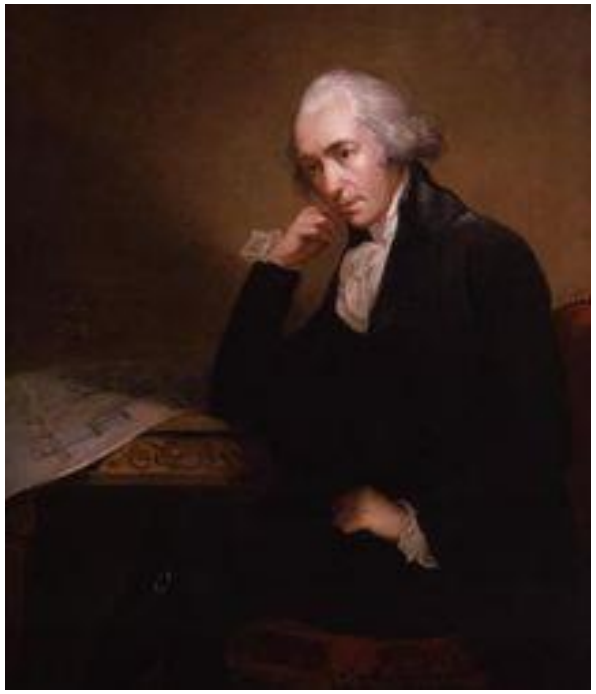
Watt:



- James Watt (1735-1819)
- Improved the steam engine for the Industrial Revolution
- The unit of power (P) is the watt (W)
- Electrical power is the multiplication of voltage (V) in volts and current (I) in amperes
- Power = Voltage x Current

  P = V x I the Power Equation

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Watt:

- Resistors here are only 0.25 (one quarter) Watt
- Some resistors are constructed for 10s or 100s of Watts

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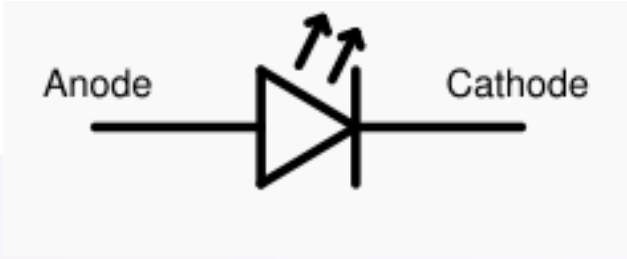
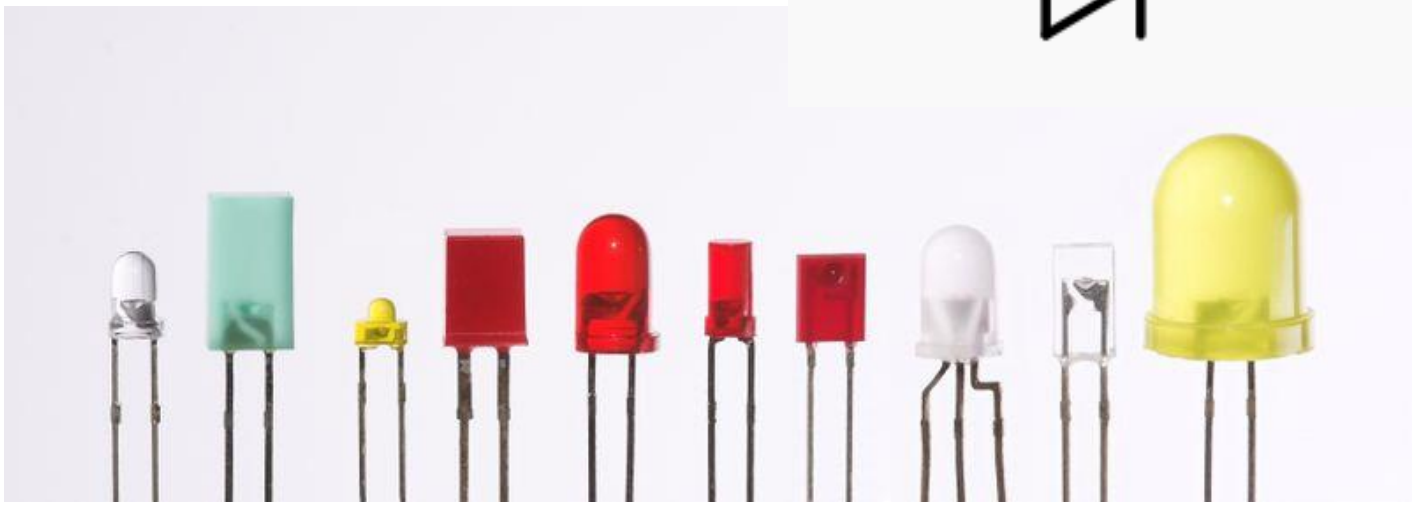
Light Emitting Diode (LED):

- Semiconductor device have no filament like an incandescent lightbulb
- *Diode* only conducts current in one direction (the *arrow*)





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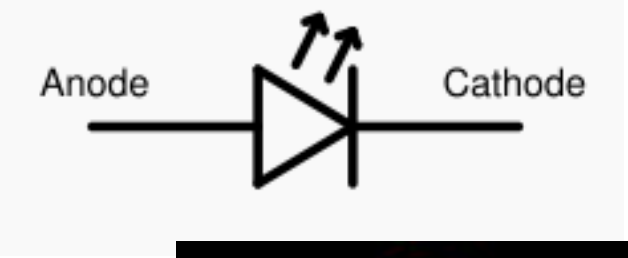
Light Emitting Diode (LED):

- LEDs come in different colors (*wavelengths*) and have different *voltage drops* (Vf)



Color	Potential Difference (Vf)
Infrared	1.6 V
Red	1.8–2.1 V
Orange	2.2 V
Yellow	2.4 V
Green	2.6 V
Blue	3.0–3.5 V
White	3.0–3.5 V
Ultraviolet	3.5 V

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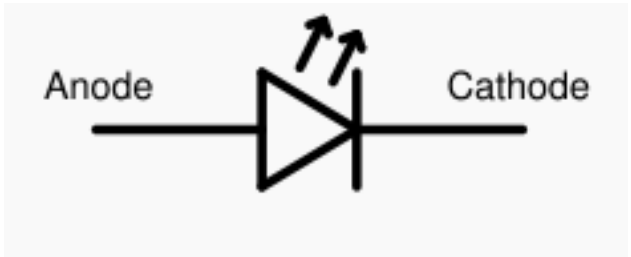
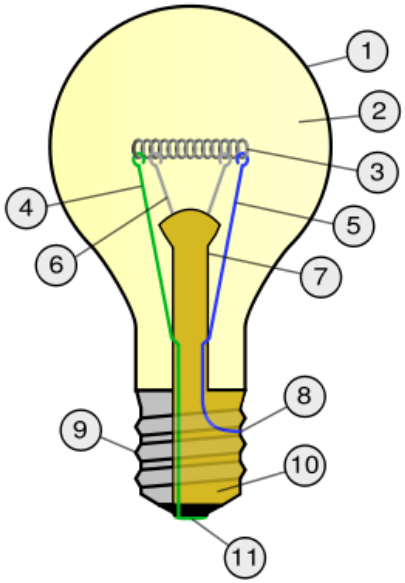
Light Emitting Diode (LED):

- Small LEDs here are low power: 0.01 watt (10 milliwatts)
- A household light bulb is typically 25 to 150 Watts





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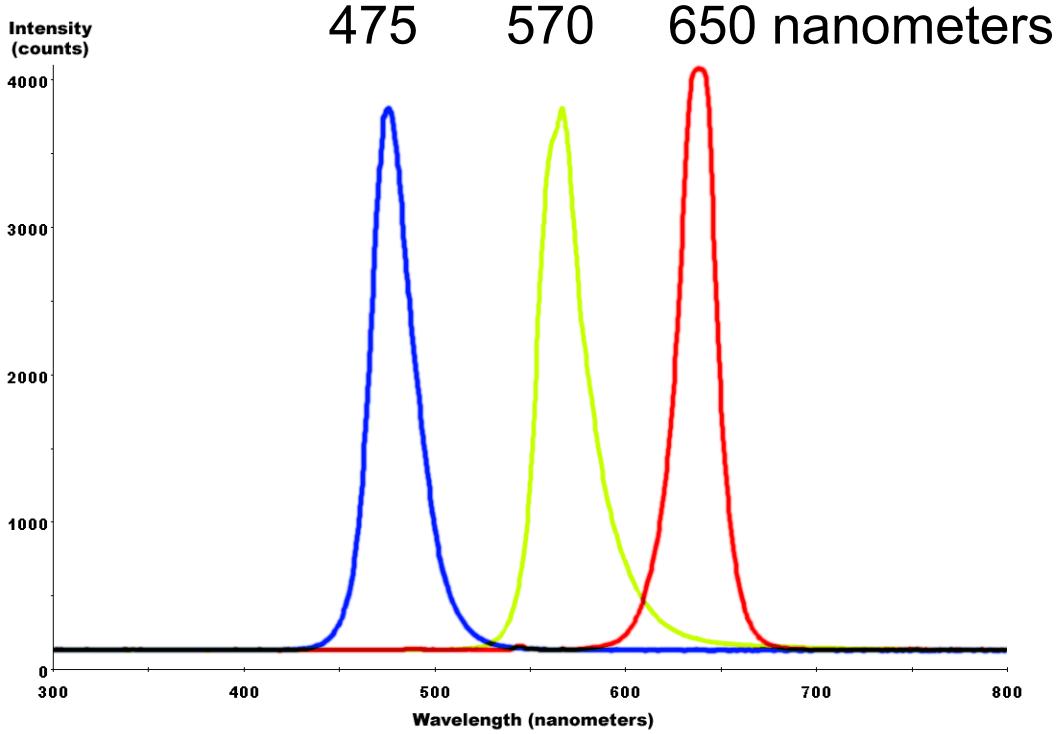
Light Emitting Diode (LED):

- Visible light wavelengths are measured in nanometers (about 0.000000570 meters)



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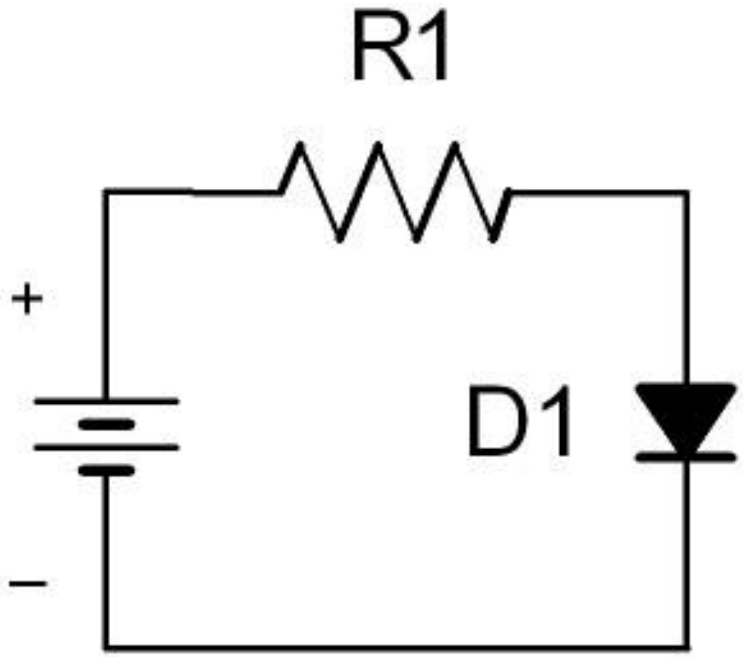
LED Circuit Challenge:

- Use a 9 volt battery and a resistor to make a *light emitting diode* (LED) shine:



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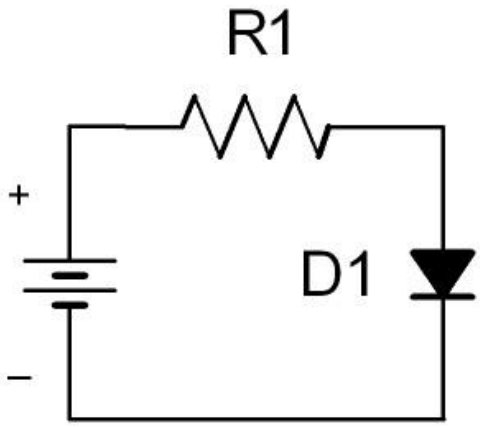
LED Circuit Challenge:

- The voltage source is a 9 volt battery. You need to know the positive (+) and negative (–) terminals
- The battery connector is color coded as **red** for positive and **black** for negative



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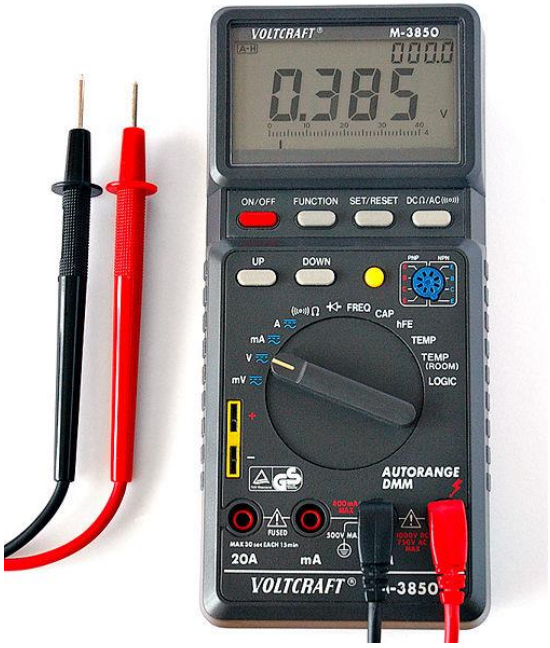
LED Circuit Challenge:

- Let's the voltmeter to measure the battery voltage. Turn the voltmeter selector switch to 20 V (left side of OFF). This is a good full scale reading for a 9 volt battery.



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LED Circuit Challenge:

• Hold the **red** lead of the voltmeter to the positive (+) terminal of the battery and the **black** lead of the voltmeter to the negative (–) terminal of the battery. What reading did you get?

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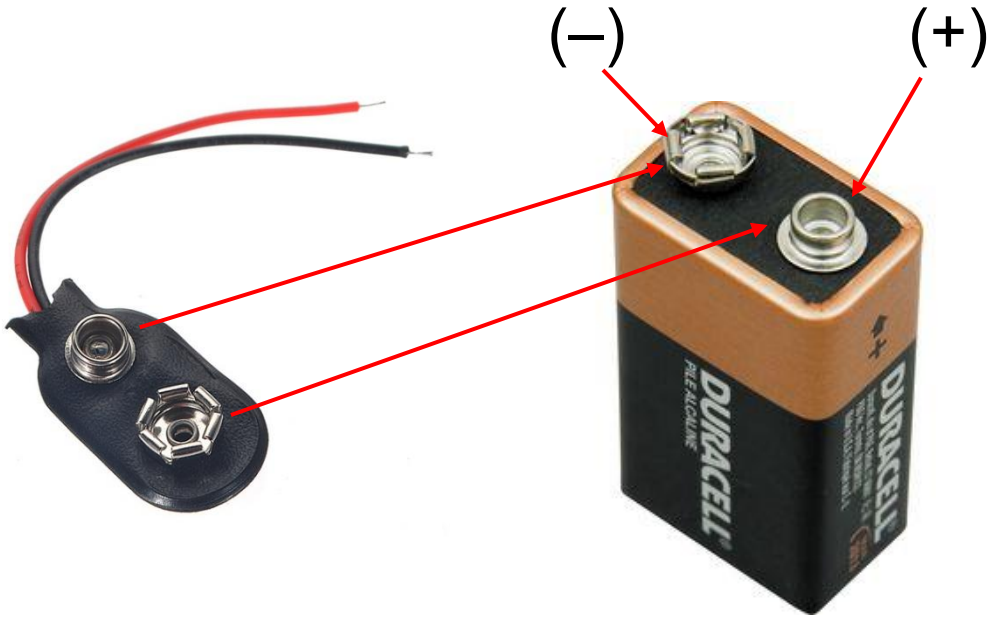
LED Circuit Challenge:

- Now connect the battery terminal to the battery. You'll see that it only goes on one way with a snap. The battery connector is color coded as **red** for positive and **black** for negative



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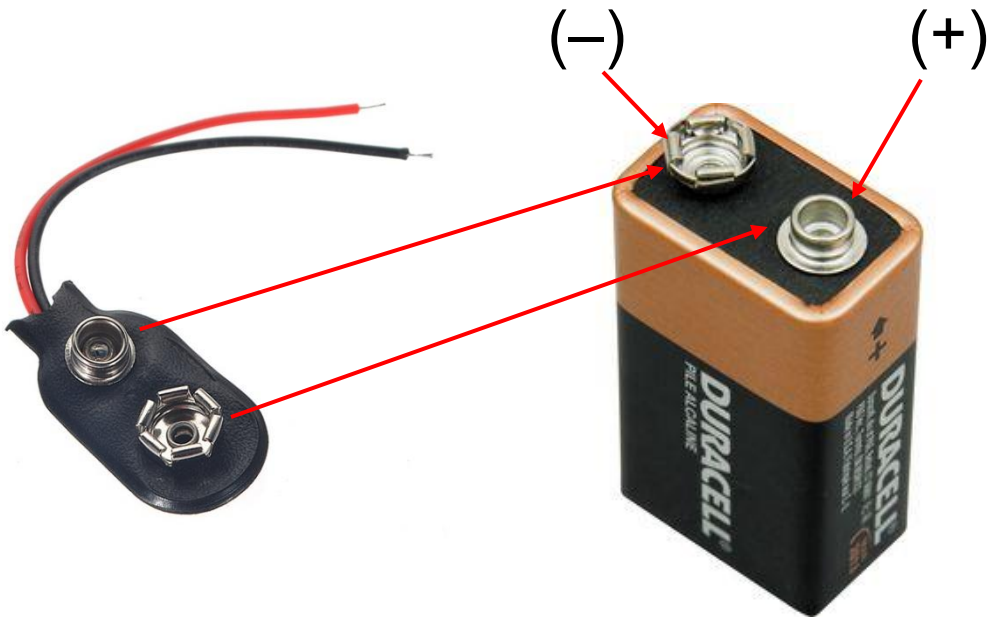
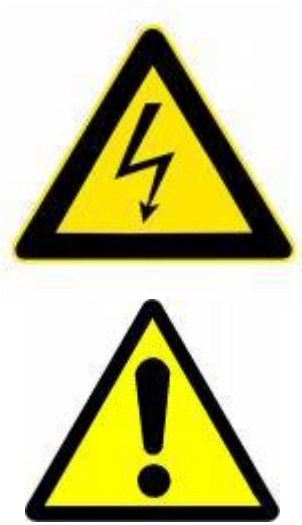
LED Circuit Challenge:

- Be careful not to connect (or *short out*) the **red** and **black** battery terminal wires as this will cause the 9 volt battery to lose its charge and overheat!





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LED Circuit Challenge:

- If you bought yourself an inexpensive voltmeter you can test the batteries at your house to see if they are good.

(–) (+)

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LED Circuit Challenge:

- 9 volt batteries should read at least 8.9 volts
- 1.5 volt batteries should read at least 1.4 volts

9 volt

1.5 volt AAA or AA

1.5 volt C or D

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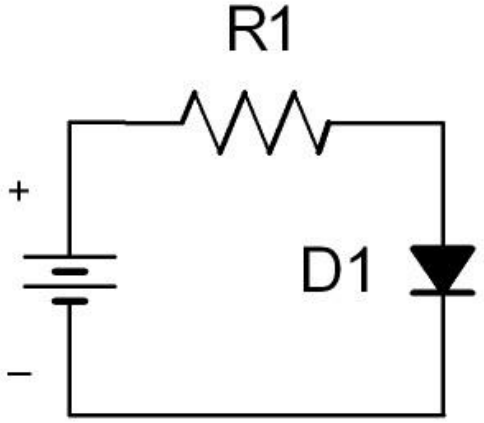
LED Circuit Challenge:

- The resistor R1 limits (or holds back) the current from the 9 volt battery so that the LED diode D1 does not get damaged
- How do we figure how what value of resistor to use? We use Ohm's Law and the Power Equation!



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LED Circuit Challenge:

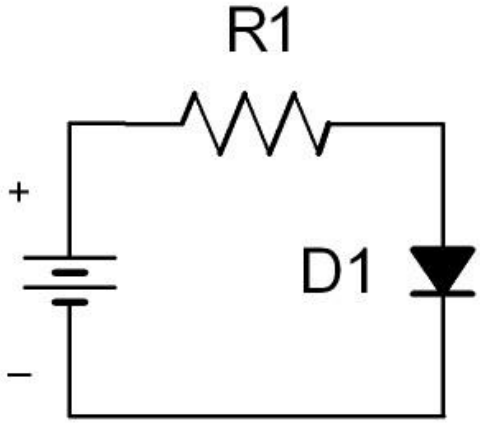
- The battery is about 9 volts (more or less)
- The red LED needs a voltage of about 2 volts
- The LED wattage is 0.01 W
- So the LED current by the Power Equation is:

P = V x I

0.01 W = 2 V x I < solve for I

I = 0.01 W / 2 V = 0.005 A

and that's why we need algebra!



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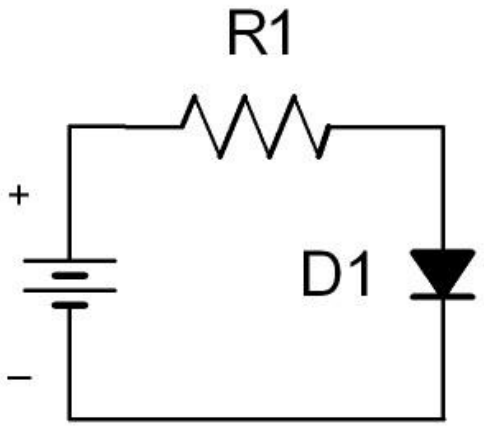
LED Circuit Challenge:

- The battery is about 9 volts (more or less)
- The red LED needs a voltage of about 2 volts
- The resistor R1 will take the rest of the voltage or 7 volts (9 – 2 = 7 V)
- Using Ohm's Law with this LED current I of 0.005 A we can solve for the resistance R1:

V = I x R
R = V / I = 7 V / 0.005 A = 1400 Ohms



To be on the safe side use 1500 Ohms (brown-green-red color code)

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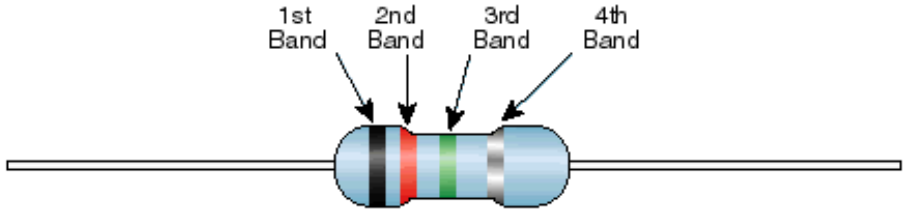
LED Circuit Challenge:

Use 1500 Ohms (brown-green-red color code)

Standard EIA Color Code Table 4 Band: ±2%, ±5%, and ±10%



Color	1st Band (1st figure)	2nd Band (2nd figure)	3rd Band (multiplier)	4th Band (tolerance)
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Red	2	2	10^2	±2%
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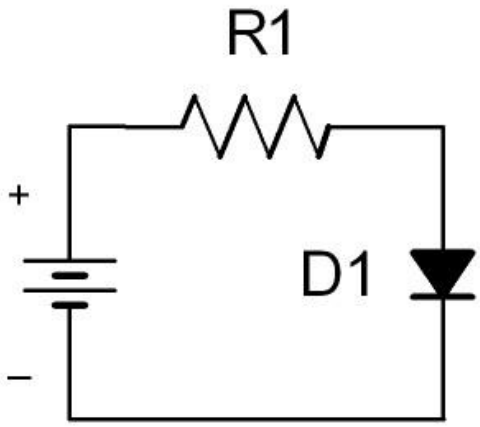
Gray	8	8	10^8	
White	9	9	10^9	
Gold			10^{-1}	±5%
Silver			10^{-2}	±10%

Chart Provided By XICON



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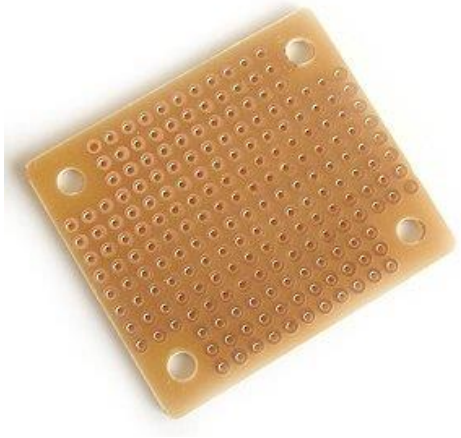
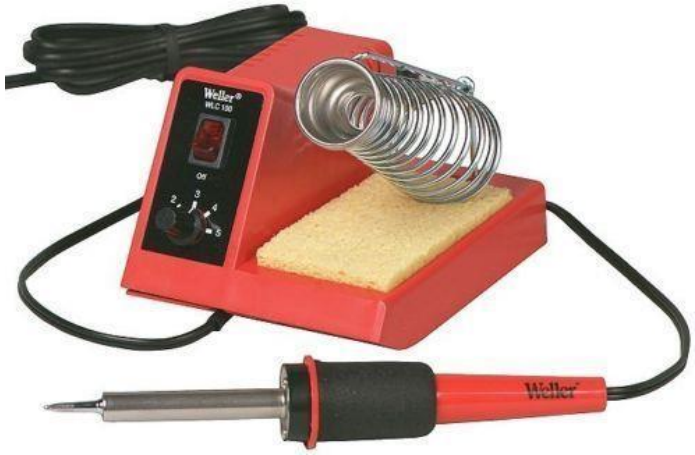
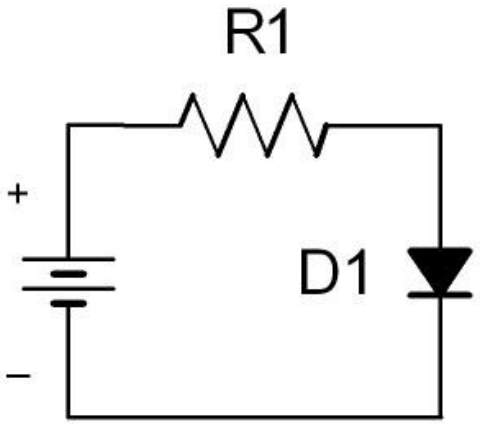
LED Circuit Challenge:

- We use a *perforated board* to hold the components
- Normally they would be permanently connect by *soldering*.
- But here we will just **insert** the components through the holes in the board and **twist** the wires together to make connection







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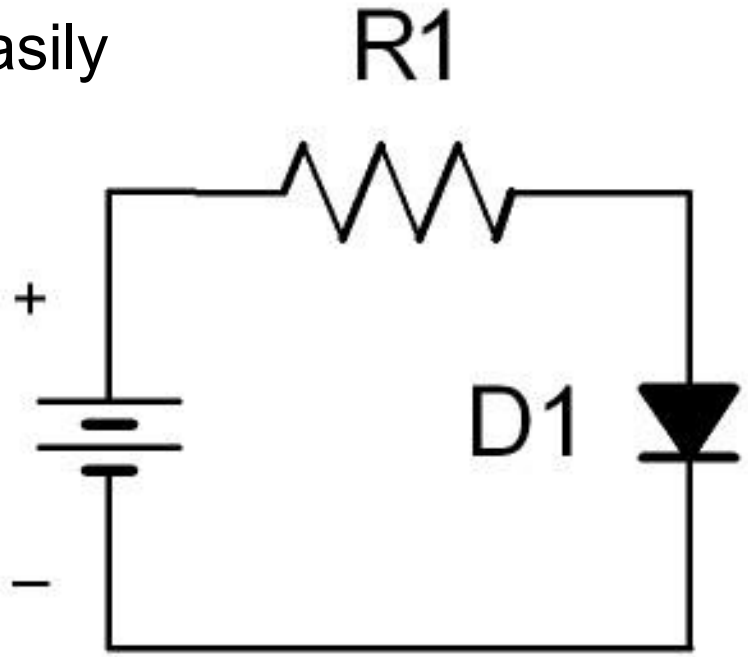
LED Circuit Challenge:

- Don’t connect the 9 volt battery yet!
- Let me check your circuit!
- The visible LED can be easily destroyed with no or a wrong value resistor R1!



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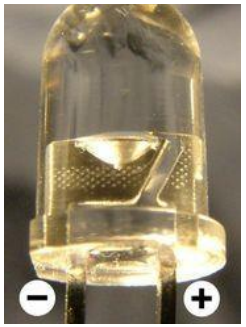
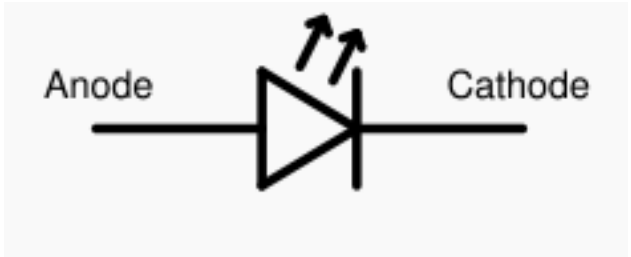
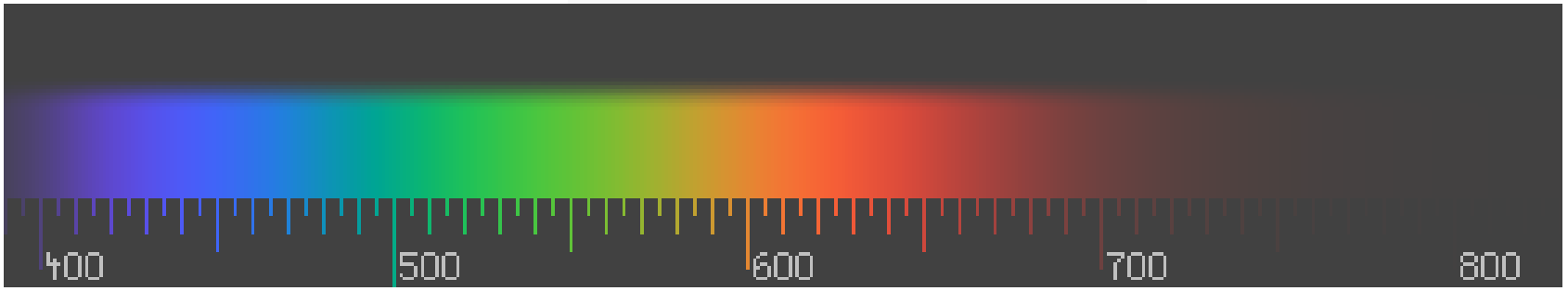
Infrared (IR) LED:



- Ultraviolet, visible and infrared wavelengths in nanometers:





Ultraviolet | Visible | Infrared

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Infrared (IR) LED:

- Infrared wavelengths are the *heat* generated in the environment and can be *seen* with special electronic circuits

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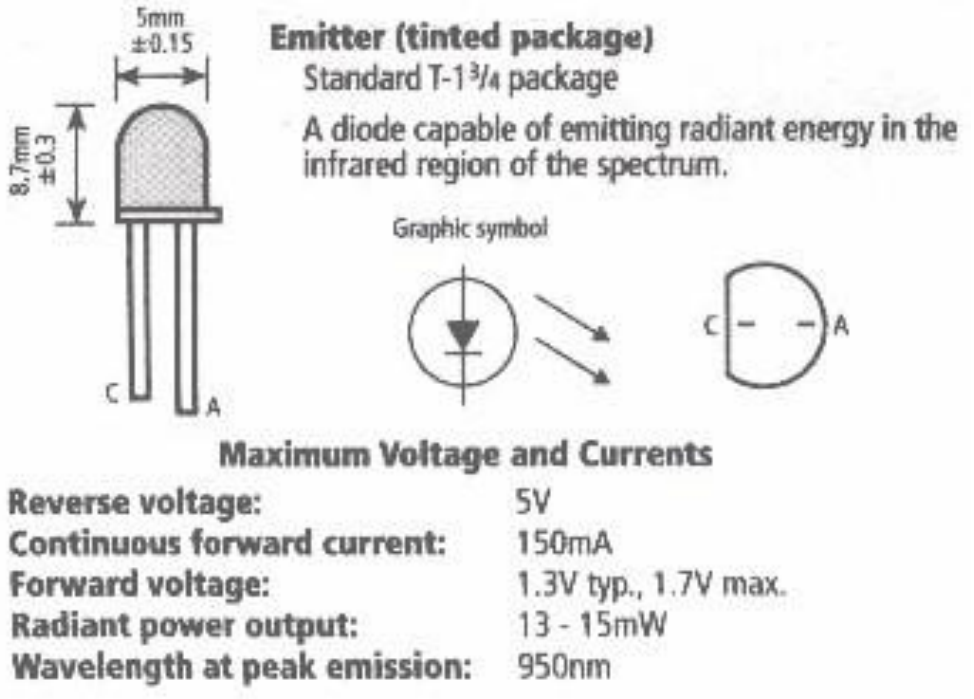
Infrared (IR) LED:

- Invisible IR LED at a 950 nanometers
- Higher power levels than visible light LEDs, typically 0.15 W (150 milliwatts)
- Voltage required is 1.3 V (typical)



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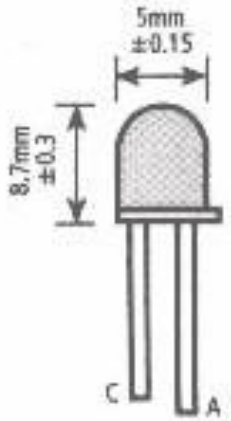
Infrared (IR) LED:

- IR LED are not very efficient
- 150 milliwatts input power but only 15 milliwatts of radiant output power
- Efficiency:

  15/150 x 100

  = 10%



Emitter (tinted package)

Standard T-1¾ package

A diode capable of emitting radiant energy in the infrared region of the spectrum.

Graphic symbol

Maximum Voltage and Currents

Reverse voltage:	5V
Continuous forward current:	150mA
Forward voltage:	1.3V typ., 1.7V max.
Radiant power output:	13 - 15mW
Wavelength at peak emission:	950nm

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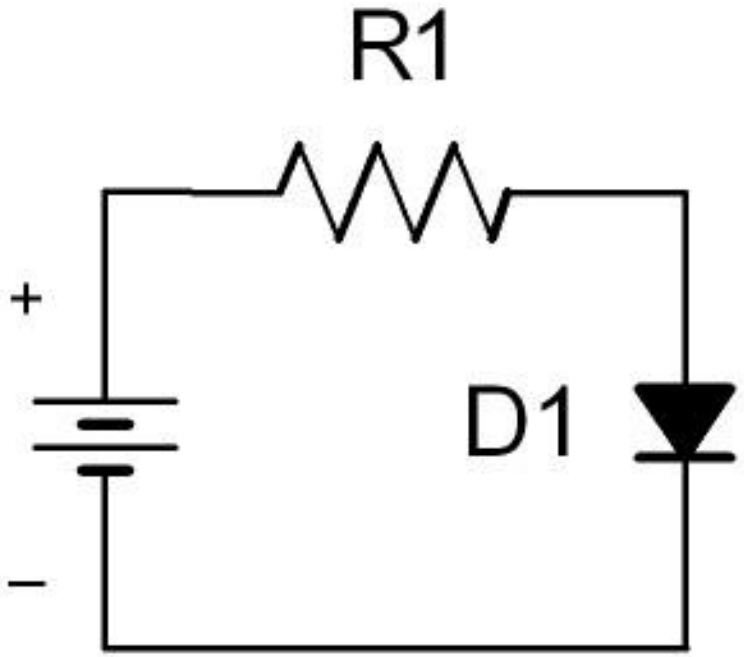
IR LED Circuit Challenge:

- Use a 9 volt battery and a resistor to make an invisible IR LED radiate
- Calculate the value of resistance needed just like we did for the visible LED using the Power Equation and Ohm's Law



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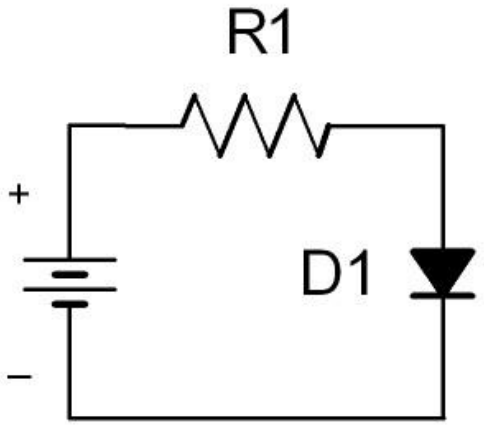
LED Circuit Challenge:

- The battery is about 9 volts (more or less)
- The IR LED needs a voltage of about 1.3 volts
- The IR LED wattage is 0.15 W
- So the IR LED current by the Power Equation is:

P = V x I
0.15 W = 1.3 V x I < solve for I

I = 0.15 W / 1.3 V = 0.115 A

and that's why we need algebra!



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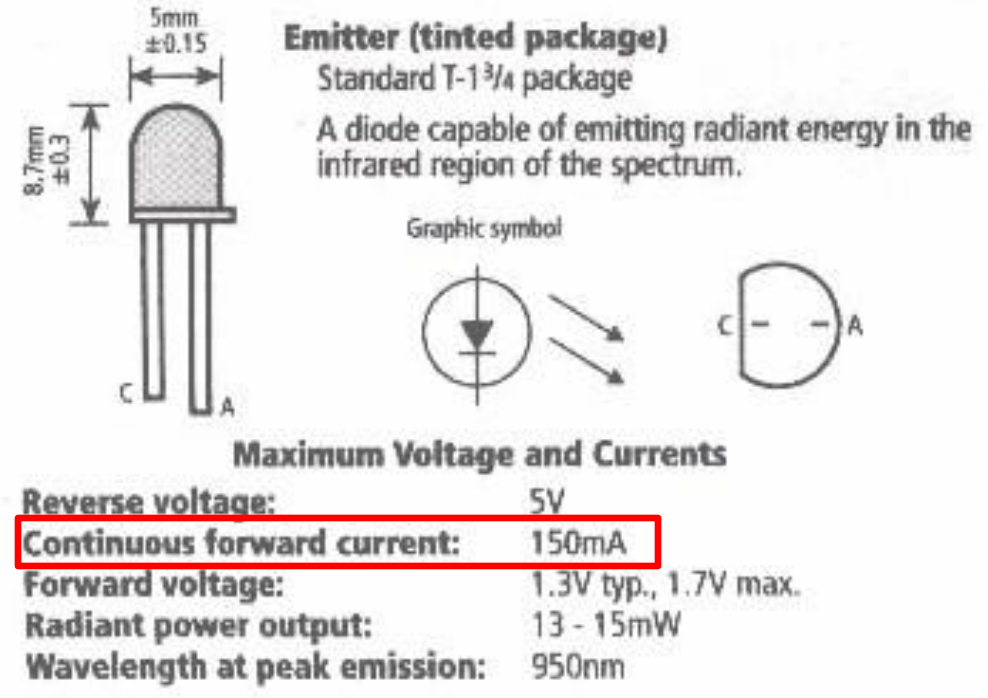
Infrared (IR) LED:

- This IR LED current of 0.115 A that we calculated is less than the maximum current of 0.15 A (which is good practice!)



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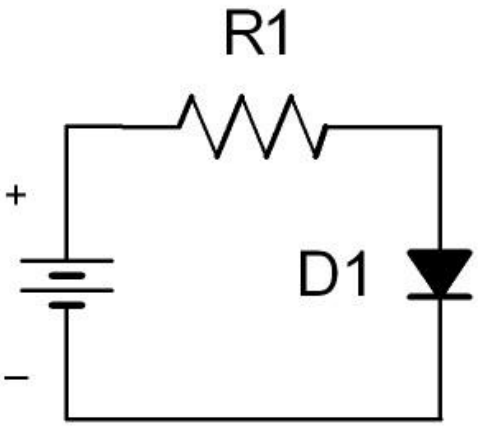
LED Circuit Challenge:

- The battery is about 9 volts (more or less)
- The IR LED needs a voltage of about 1.3 volts
- The resistor R1 will take the rest of the voltage or 7.7 volts (9 – 1.3 = 7.7 V)
- Using Ohm's Law with this LED current I of 0.115 A we can solve for the resistance R1:

V = I x R
R = V / I = 7.7 V / 0.115 A = 67 Ohms



To be on the safe side use 100 Ohms (brown-black-brown color code)

Marconi Challenge

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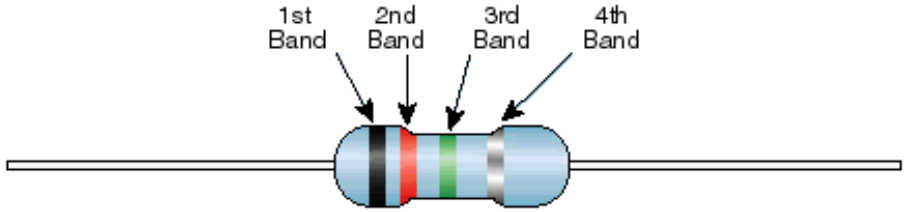
LED Circuit Challenge:

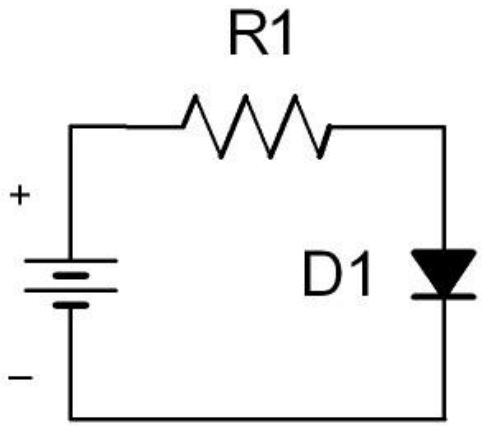
Use 100 Ohms (brown-black-brown color code)

Standard EIA Color Code Table 4 Band: ±2%, ±5%, and ±10%



Color	1st Band (1st figure)	2nd Band (2nd figure)	3rd Band (multiplier)	4th Band (tolerance)
Black	0	0	10^0	
Brown	1	1	10^1	
Red	2	2	10^2	±2%
Orange	3	3	10^3	
Yellow	4	4	10^4	
Green	5	5	10^5	
Blue	6	6	10^6	
Violet	7	7	10^7	
Gray	8	8	10^8	
White	9	9	10^9	
Gold			10^{-1}	±5%
Silver			10^{-2}	±10%

Chart Provided By XICON



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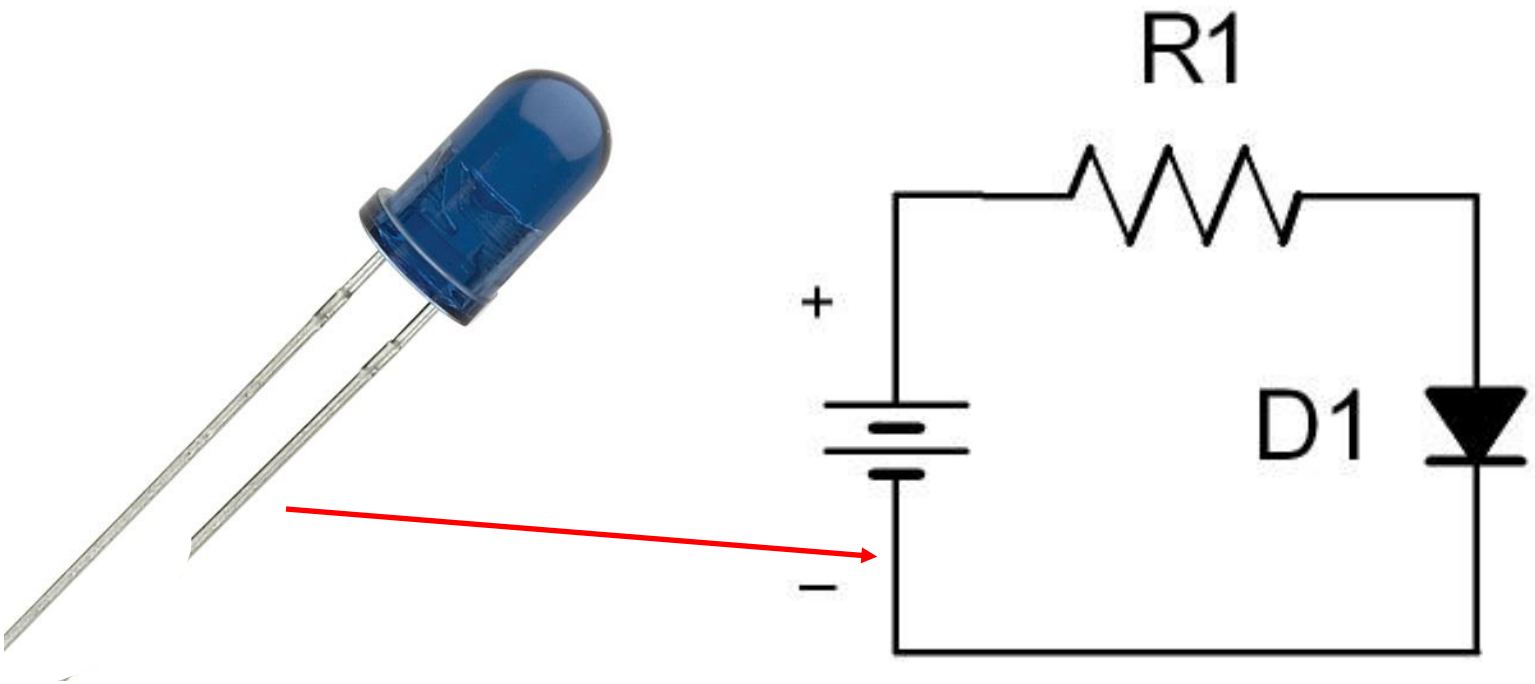
IR LED Circuit Challenge:

Orientation of the IR LED: short lead goes to the negative (**black** wire) terminal of the battery



Marconi Challenge

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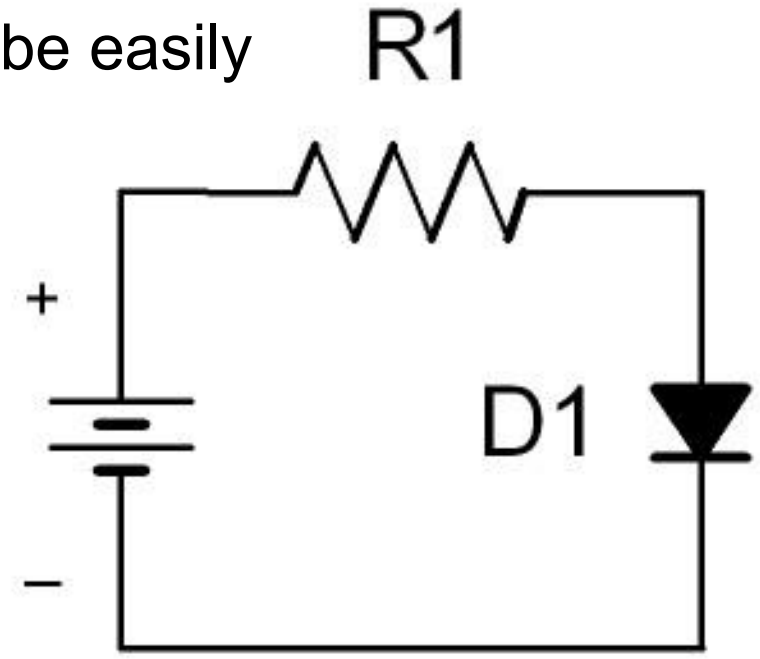
IR LED Circuit Challenge:

- Don’t connect the 9 volt battery yet!
- Let me check your circuit!
- The invisible IR LED can be easily destroyed with no or a wrong value resistor R1!



Marconi Challenge

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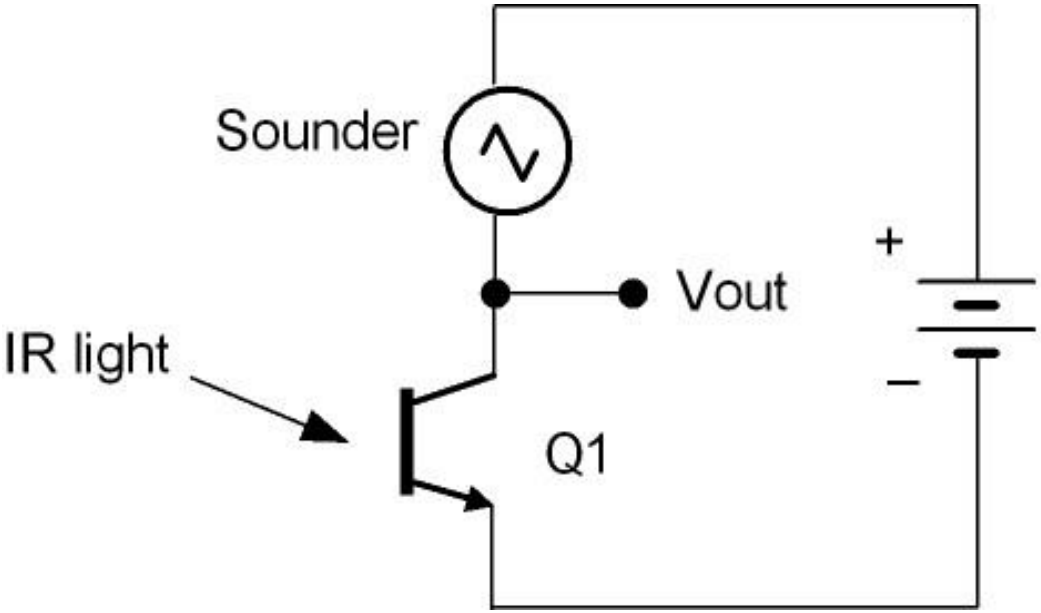
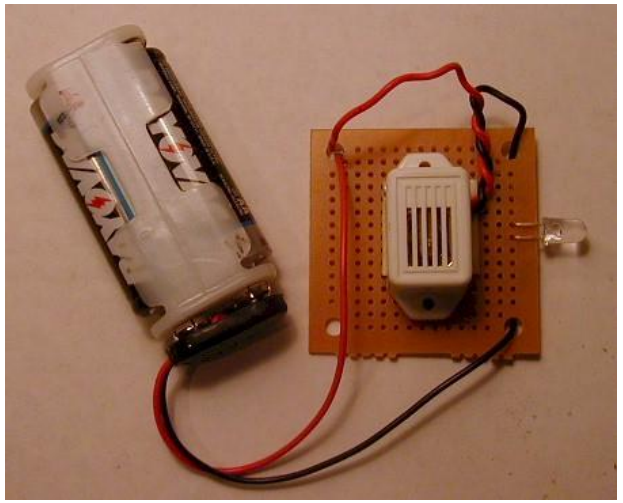
IR LED Circuit Challenge:

- Use an pre-built *IR detector circuit* with a *sounder* to test your IR LED circuit challenge





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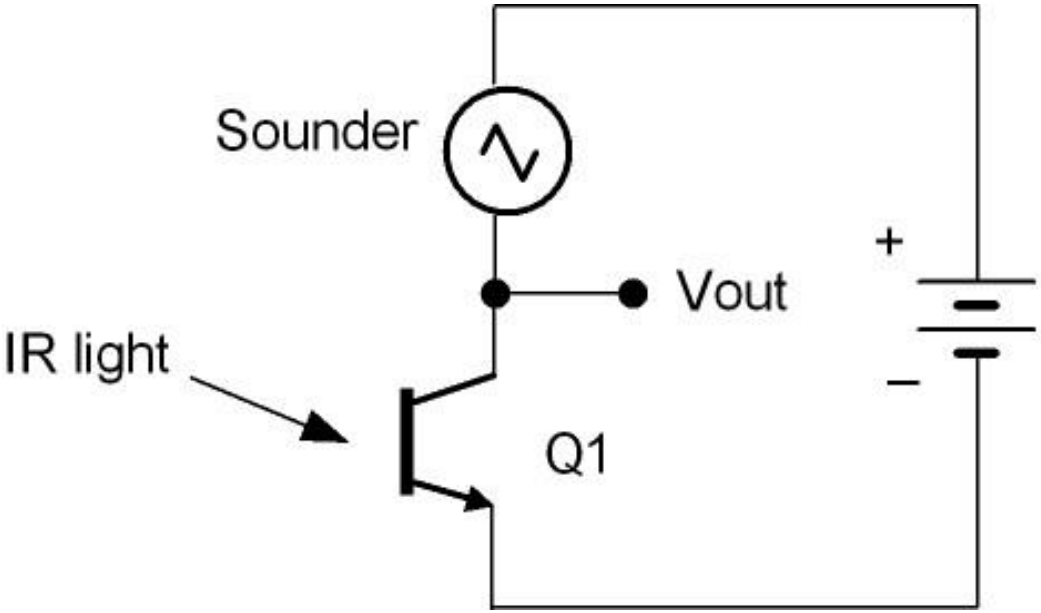
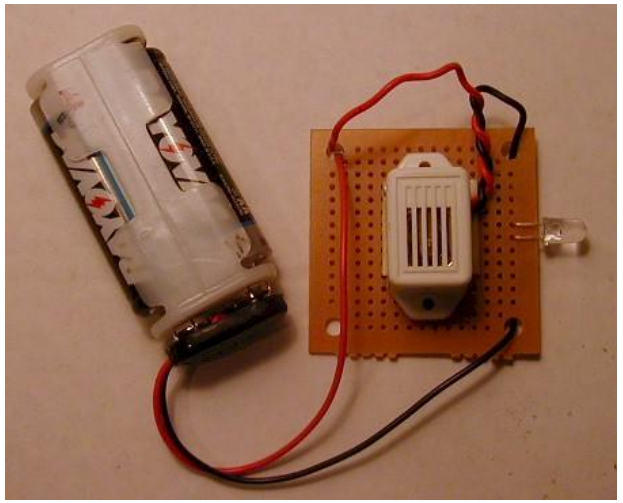
IR LED Circuit Challenge:

- The IR detector circuit using a IR *phototransistor to* convert the IR light back to an electrical conductor





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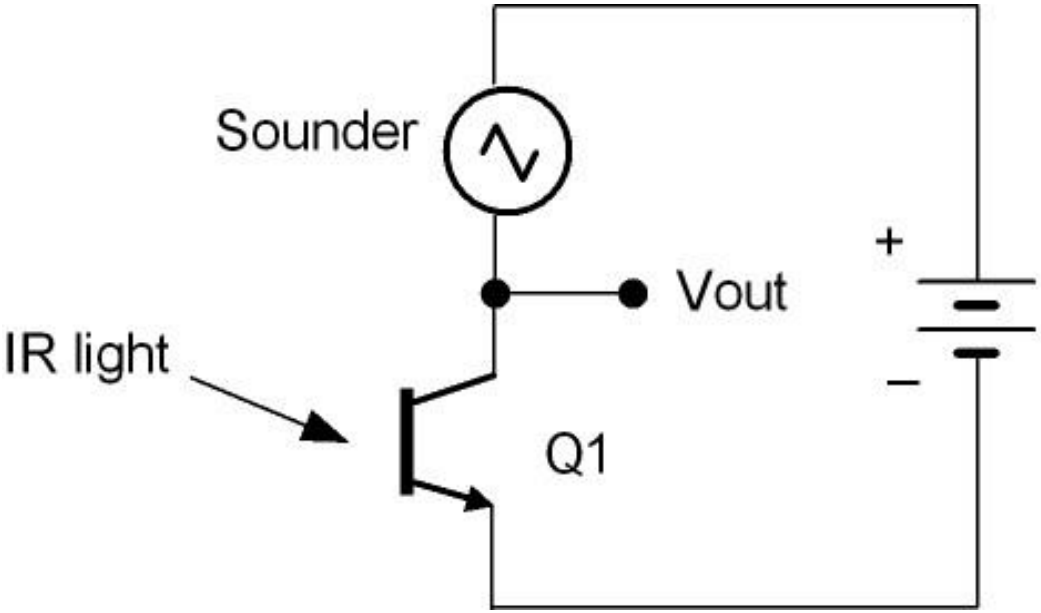
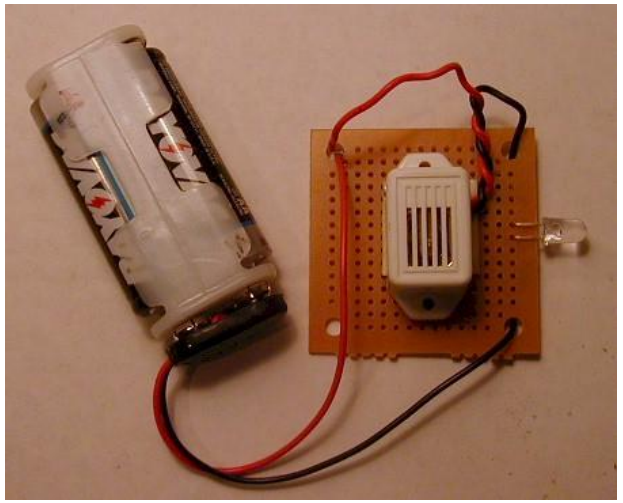
IR LED Circuit Challenge:

- The electrical current from the battery source is turned *on* and *off* by the IR phototransistor which makes the sounder work





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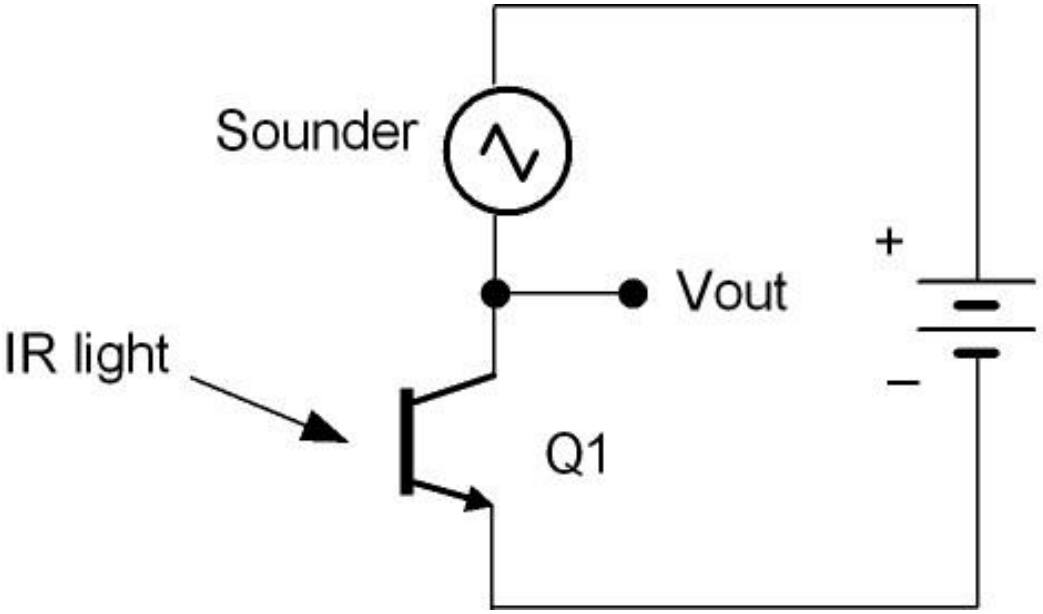
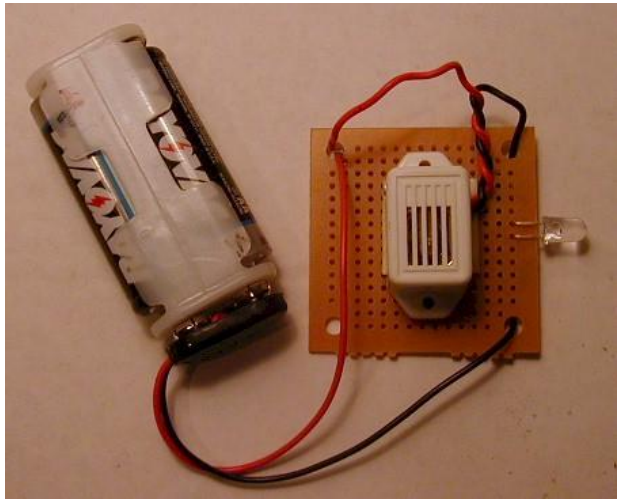
IR LED Circuit Challenge:

- The IR detector circuit will be designed and built by you later as part of the Marconi Challenge





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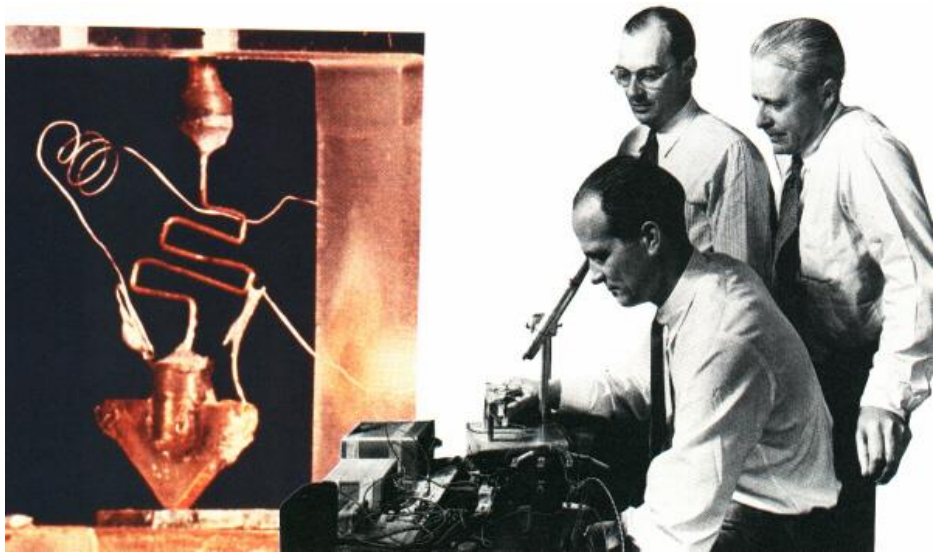
Transistors:

- The first transistor was demonstrated in 1947 at Bell Laboratories, Holmdel NJ, by William Shockley, who won the Nobel Prize in Physics in 1956 for the invention.



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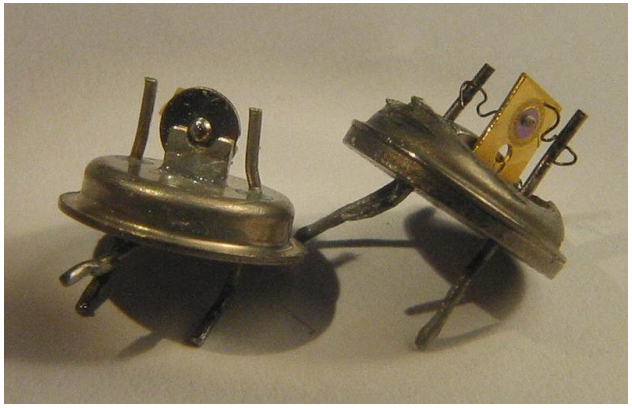
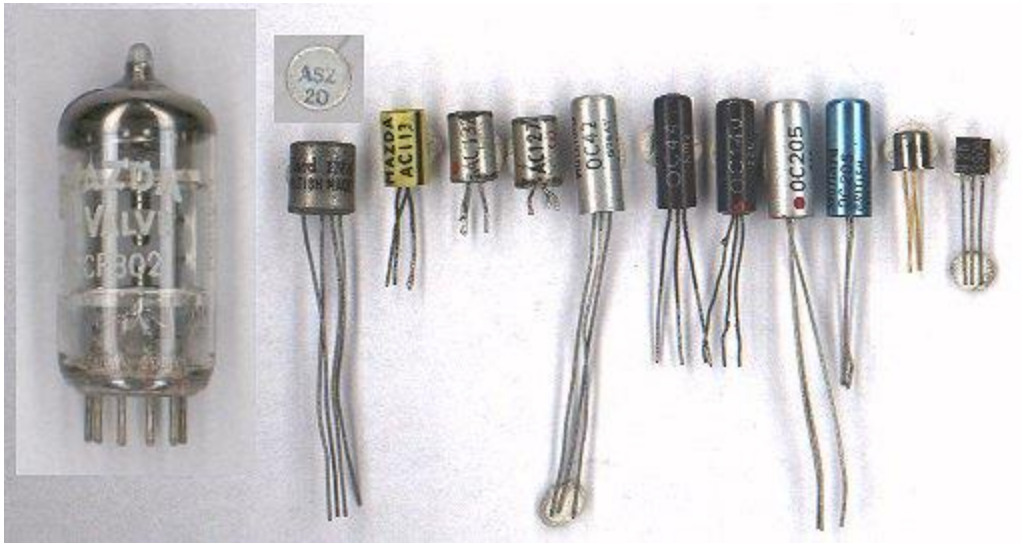
Transistors:

- Transistors in the 1950s were quite large. The transistor soon replaced the *vacuum tube* in electronics by 1960.





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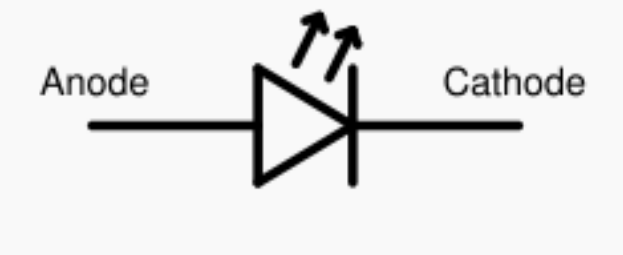
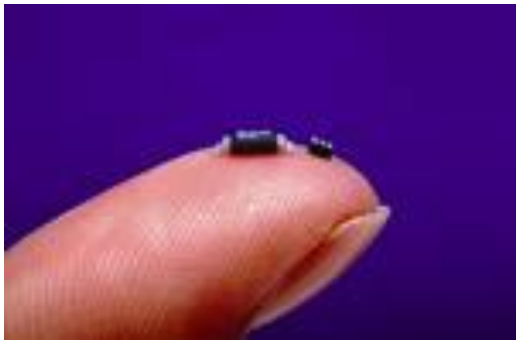
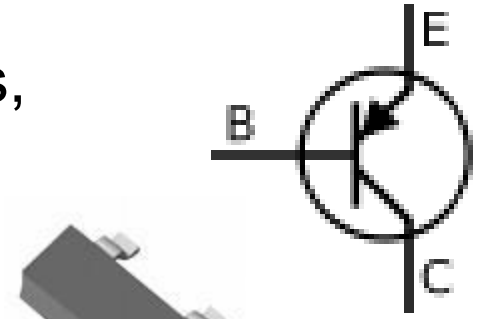
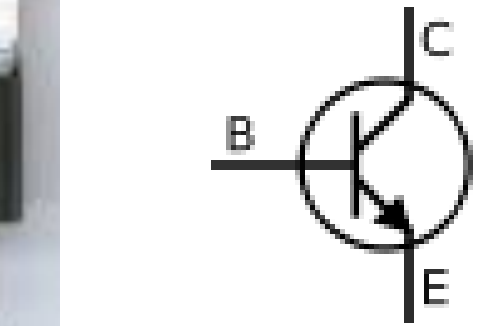
Transistors:

- Diodes (like the LED) have two leads, but the transistor *usually* has three leads:









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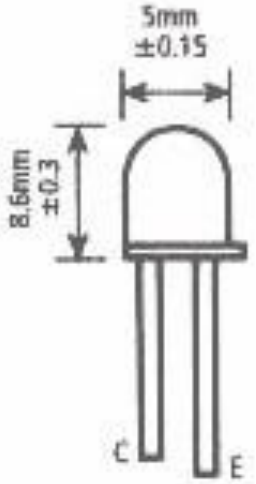
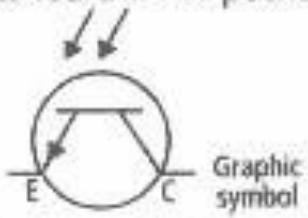
Infrared (IR) Phototransistor:

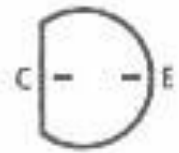
- IR phototransistor has only two leads. The third lead is replaced by the IR *photon* input.

Detector (photo transistor—clear package)

Standard T-1 3/4 package







Maximum Voltage and Currents

V_{CEO} Collector to emitter:	70V
V_{ECO} Emitter to collector:	5V
I_C Collector current:	50mA
Total power dissipation:	150mW
Peak sensitivity wavelength:	850nm
Spectral bandwidth range:	620 - 980nm
Angle of half sensitivity:	±20°

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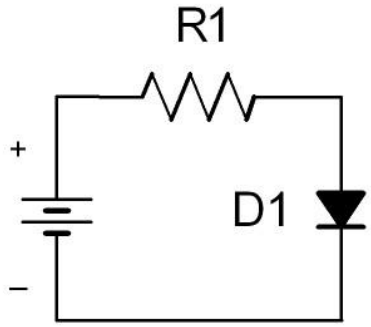
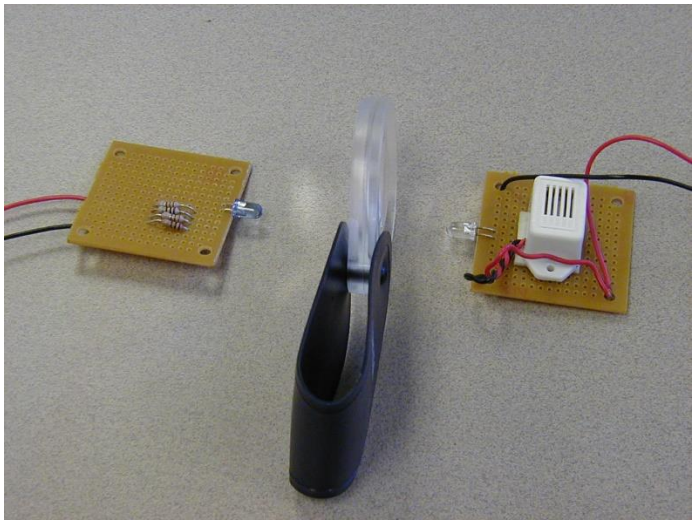
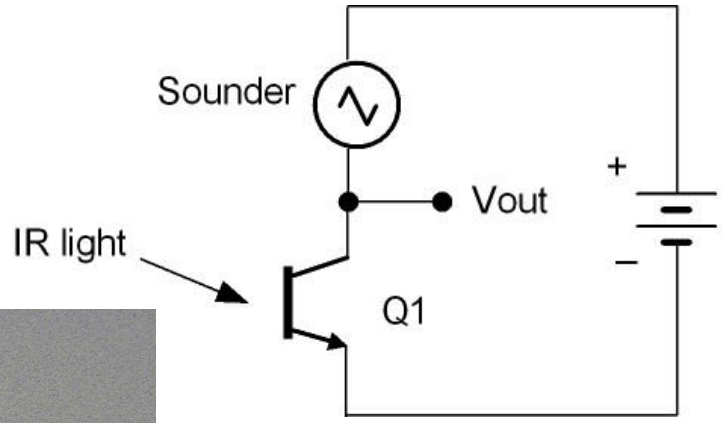
IR Transmission

The IR signal can be improved with optics!







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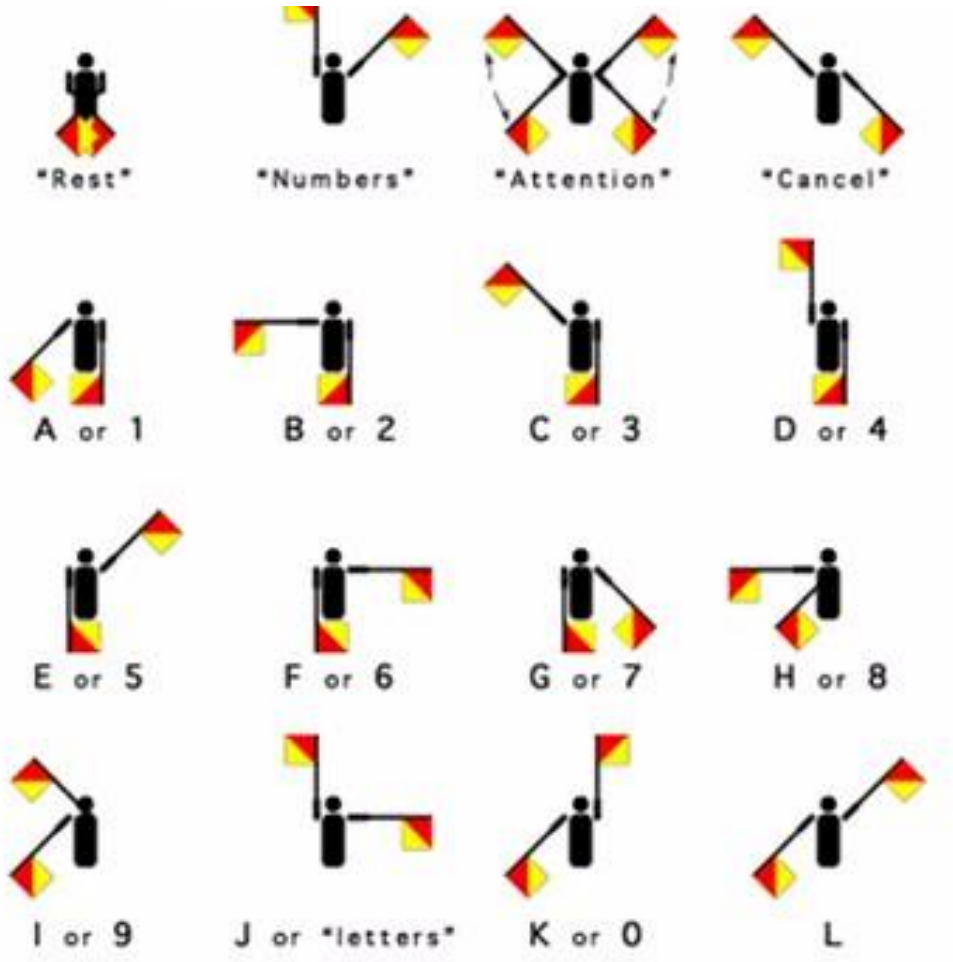
Messages by Semaphores:

- How do we send wireless messages using the IR diode and photodetector circuit?

Flag semaphores:



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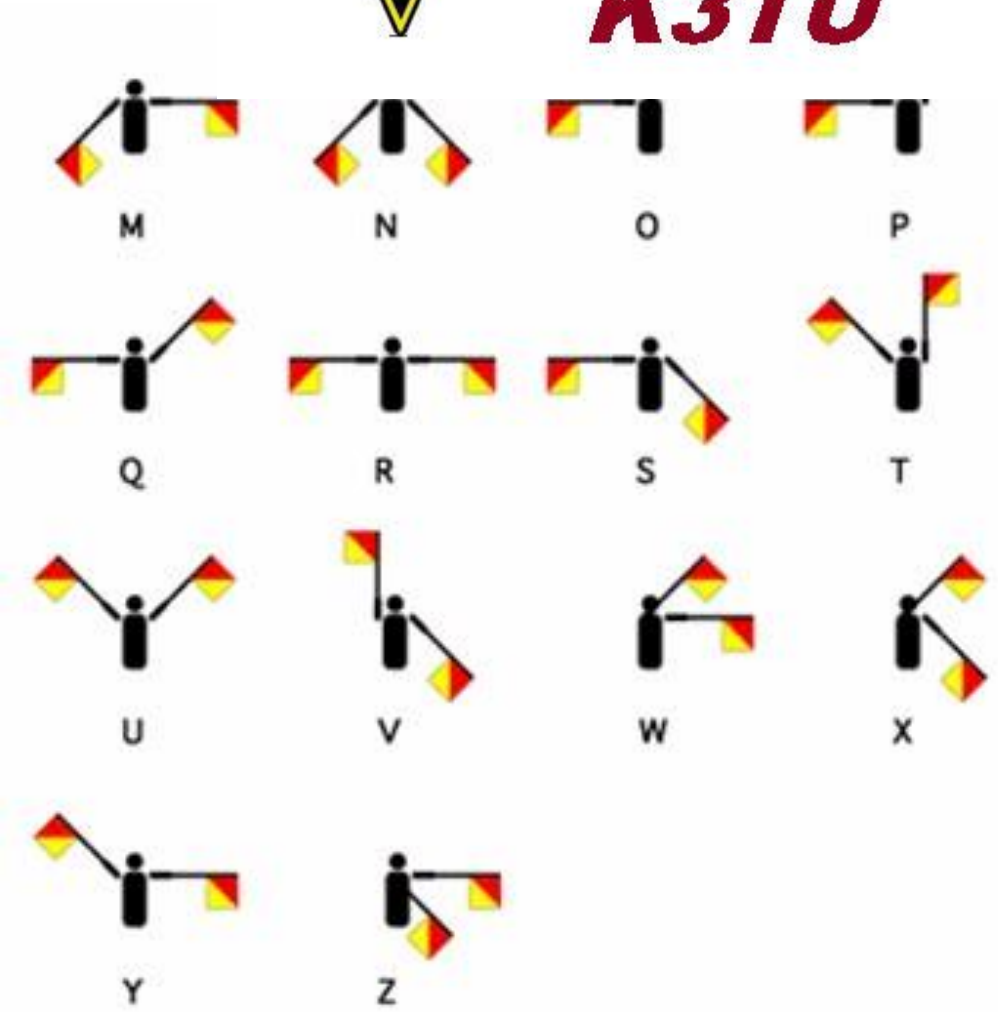
Messages by Semaphores:

Flag semaphores:



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Messages by Semaphores:

- Flag semaphores were popular for ship-to-ship communication.

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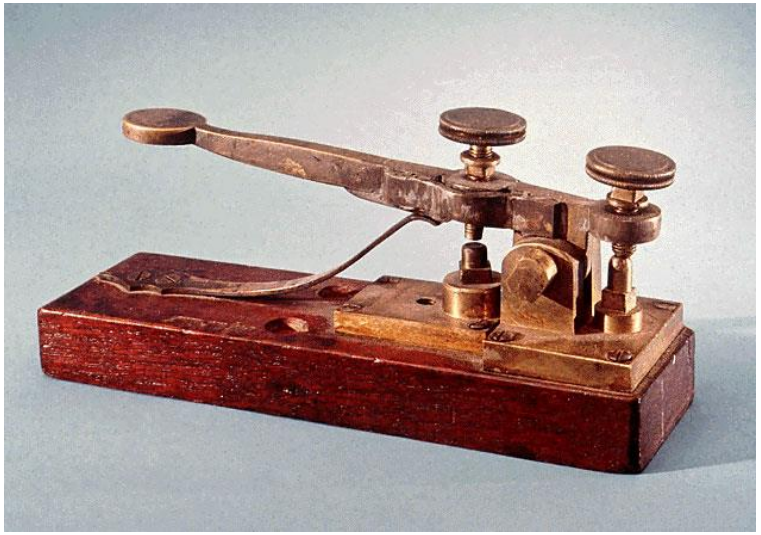
Messages by Semaphores:

- Morse code was developed for electrical sounder communication by Samuel F.B. Morse in 1836. The invention was called the *telegraph*.

Marconi Challenge

Messages by Semaphores:

- The telegraph key connected the wired electrical circuit with a battery and the sounder produced a buzz.



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Messages by Semaphores:

- Morse code can be used for *wireless communication* with a powerful searchlight on a ship to replace the flag semaphore especially at night!

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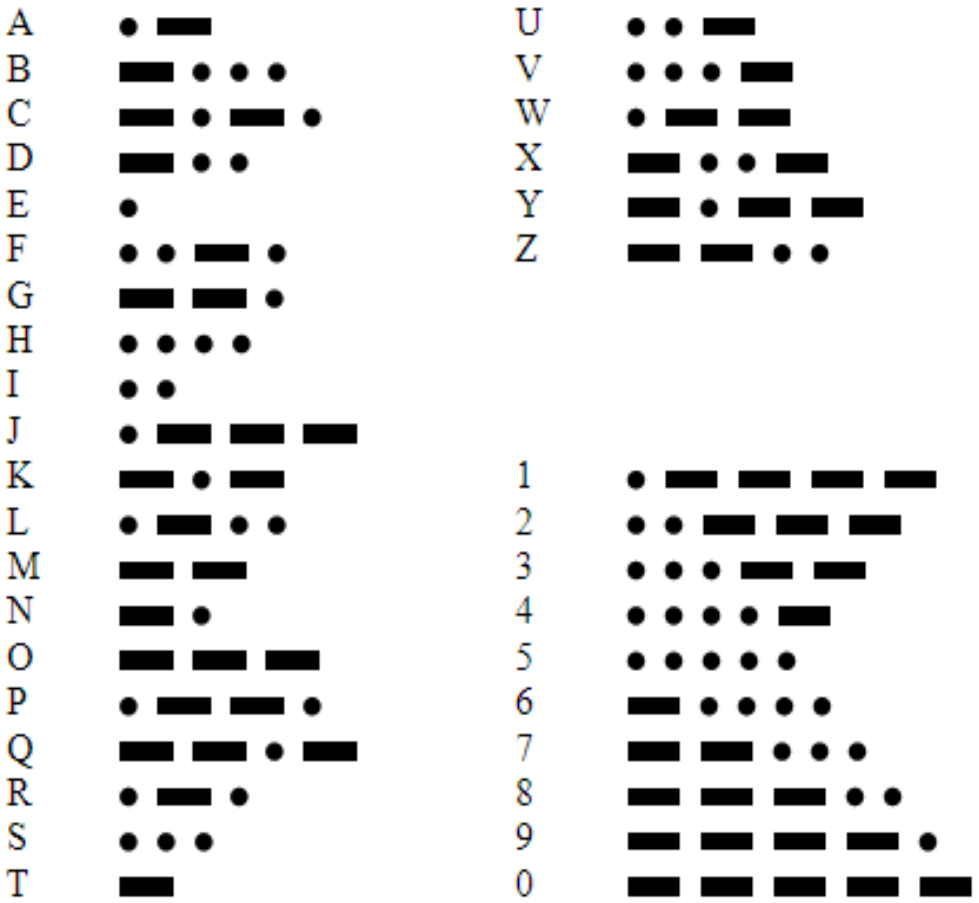
Messages by Semaphores:

- Morse code sends *short* and *long* signals which are run together to make the letters of the alphabet and the numbers.



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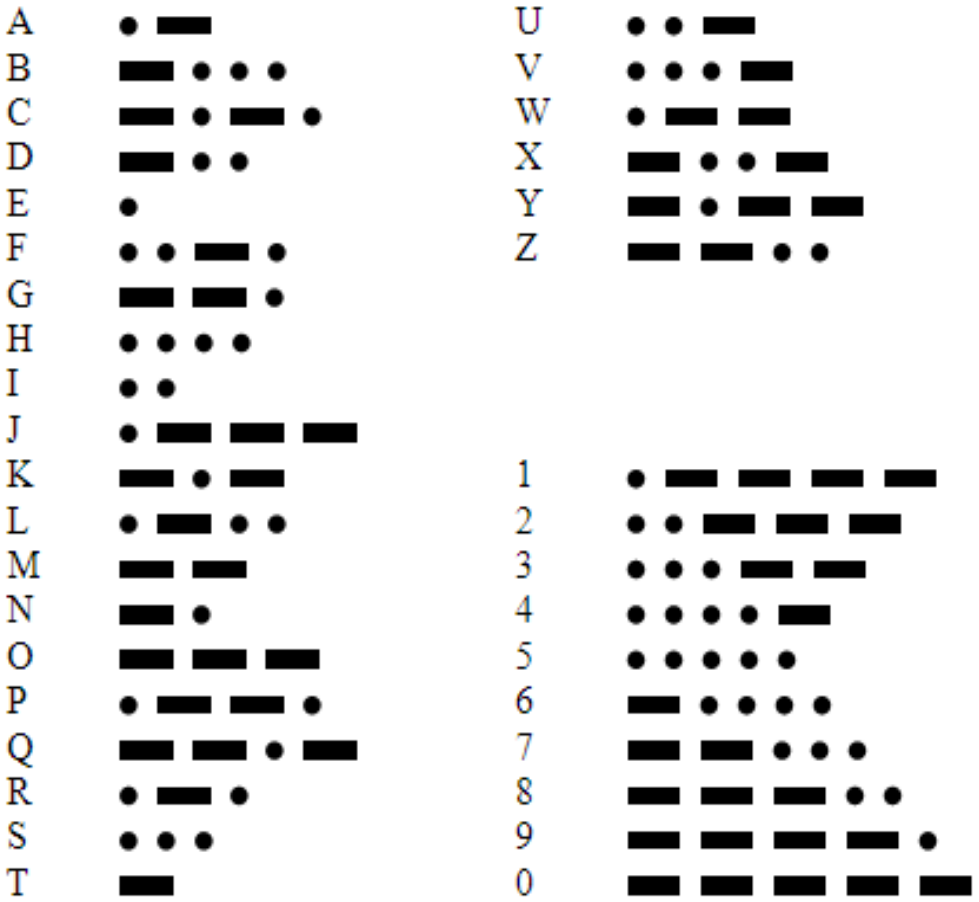
Messages by Semaphores:

- For example, the letter A is a *short* and *long* run together.



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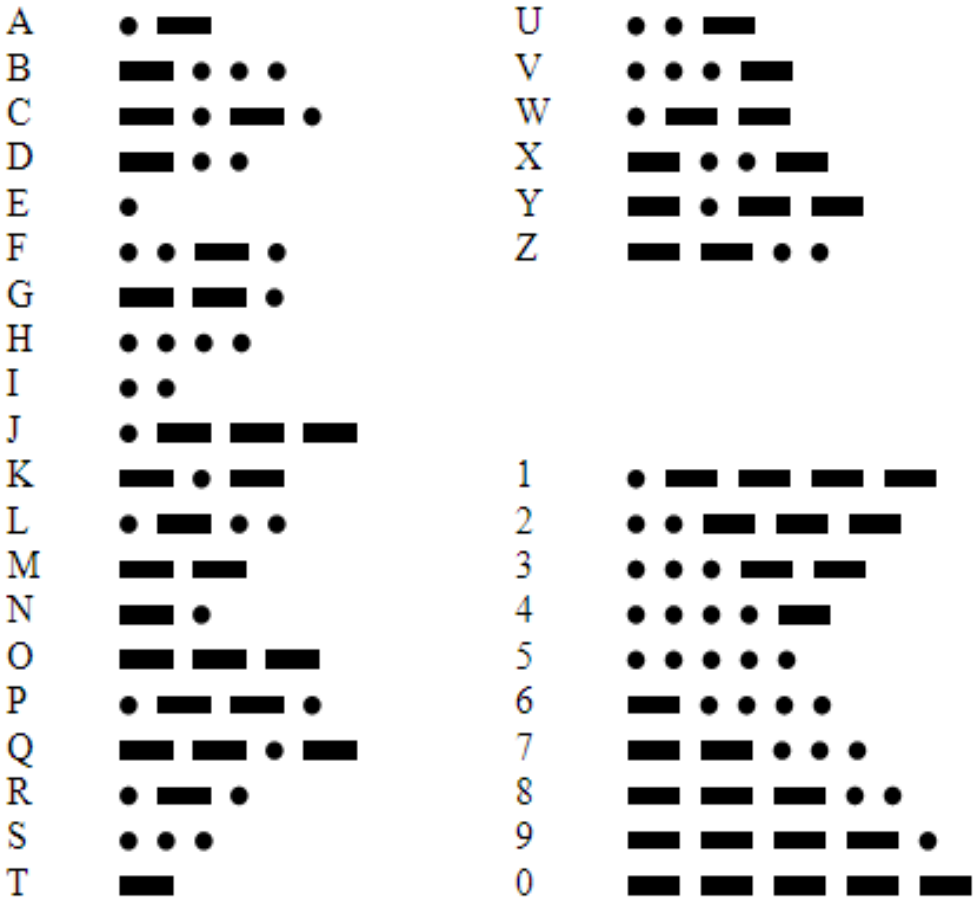
Can You Decode Morse Code

- *Listen* and *guess* what letters and numbers are being sent.



Marconi Challenge

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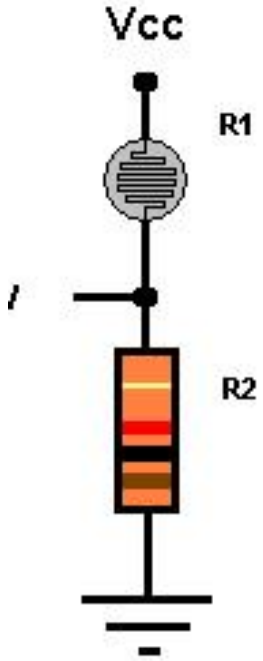
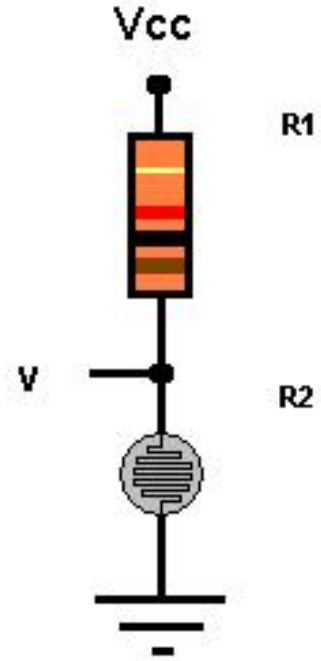
Photoresistor:

- A *photoresistor* changes its resistance in response to light. Photoresistors are used as camera light meters.





Marconi Challenge

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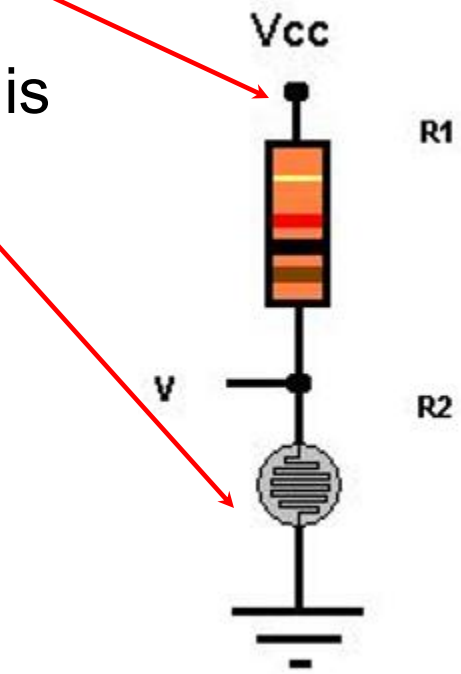
Photoresistor Circuit Challenge:

- Use the 9 volt battery, the photoresistor and a resistor, wire the circuit as shown
- The positive (**red** wire) of the battery terminal is connected at Vcc. The negative (**black** wire) of the battery terminal is connected at the ground symbol
- Use the 1500 ohm resistor for R1

R2



Marconi Challenge

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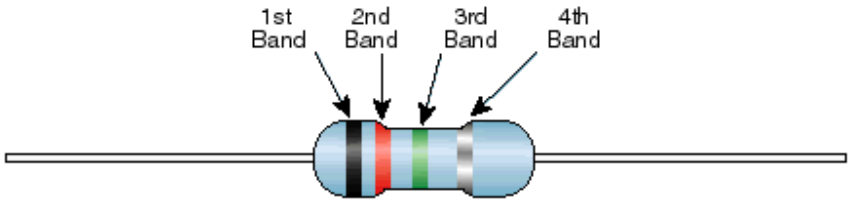
Photoresistor Circuit Challenge:

- Use the 1500 ohm resistor for R1 (brown-green-red color code)

Standard EIA Color Code Table **4 Band**: ±2%, ±5%, and ±10%



Color	1st Band (1st figure)	2nd Band (2nd figure)	3rd Band (multiplier)	4th Band (tolerance)
Black	0	0	10^0	
Brown	1	1	10^1	
Red	2	2	10^2	±2%
Orange	3	3	10^3	
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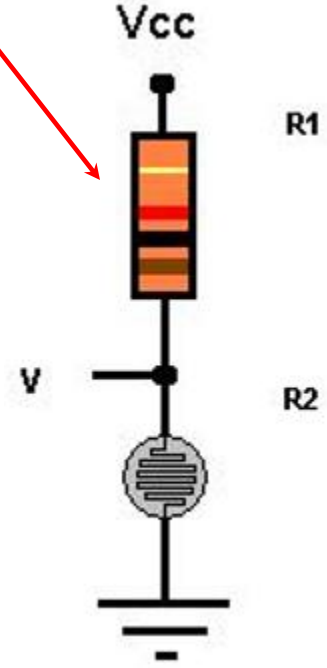
Chart Provided By XICON



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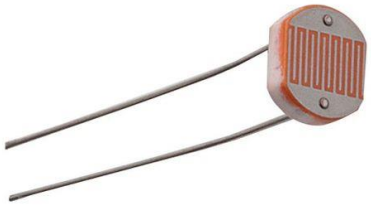
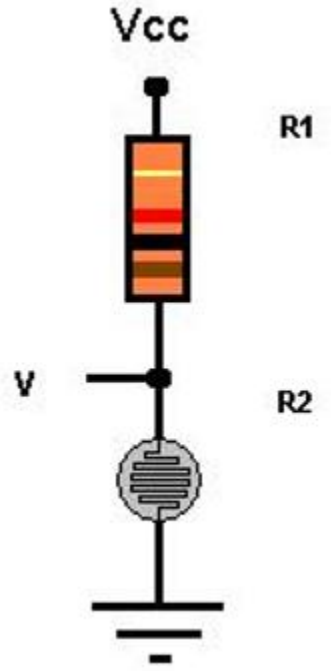
Photoresistor Circuit Challenge:

- The photoresistor, unlike the red LED and IR LED diodes, does not have a preferred connection. Any orientation will do.

- Other examples of a photoresistor:





Marconi Challenge

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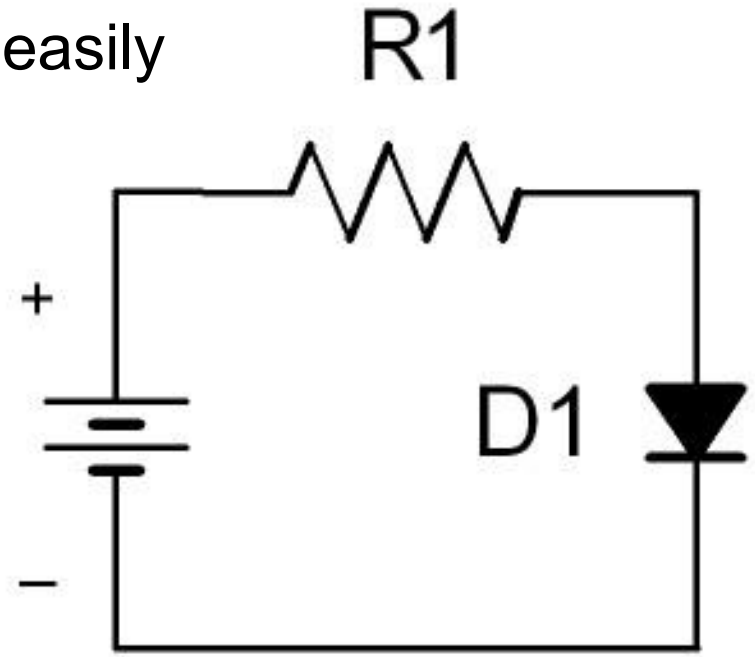
Photoresistor Circuit Challenge:

- Don’t connect the 9 volt battery yet!
- Let me check your circuit!
- The photoresistor can be easily destroyed with no or a wrong value resistor R1!



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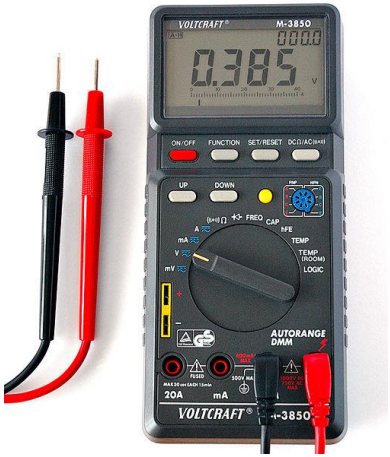
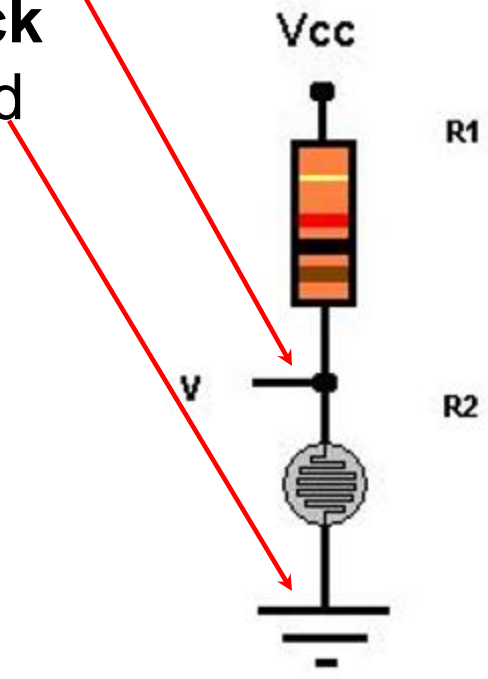
Photoresistor Circuit Challeng

- Measure the voltage at the junction between the photoresistor R2 and the resistor R1 with the **red** lead of the voltmeter and the **black** lead of the voltmeter at the ground symbol light changes.



R2



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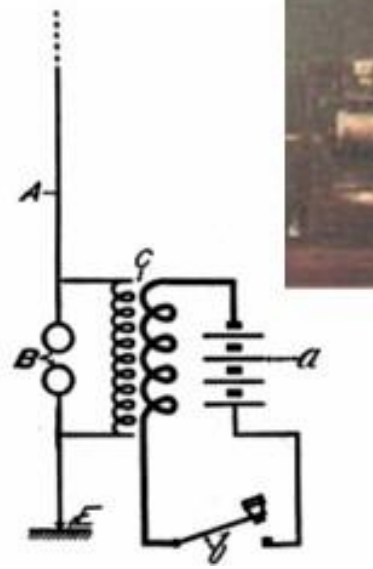
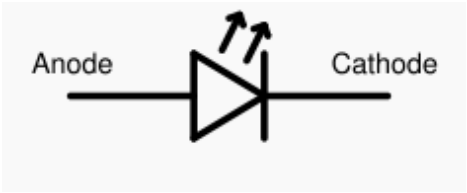
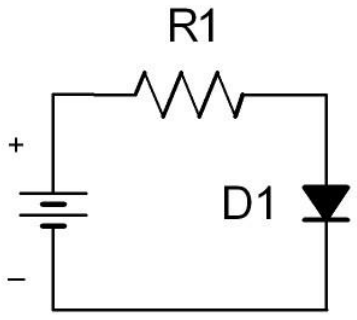
Great! You have learned quite a lot about *electronics* and *data transmission*!







Marconi Challenge

TUARC Amateur Radio K3TU

TUARC K3TU is willing to help you learn more about *Amateur Radio* as an exciting hobby!

www.temple.edu/k3tu