33 in 1
Deluxe Electronic Exploration Kit

Instruction Manual

Stock# C6709

CHANEY ELECTRONICS, INC.

Isabella Uribe

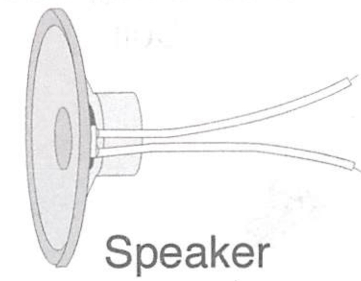
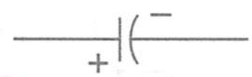
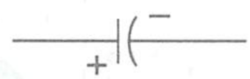
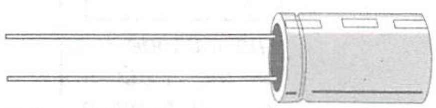
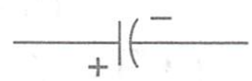
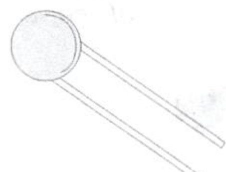
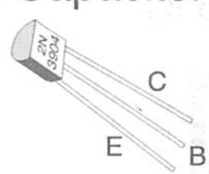
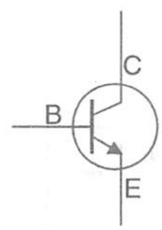
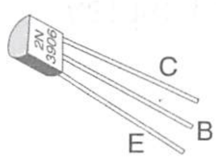
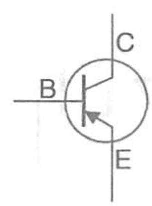
33 IN 1
DELUXE ELECTRONIC EXPLORATION KIT

PRODUCT STOCK# C6709

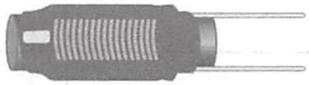
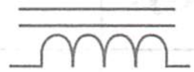
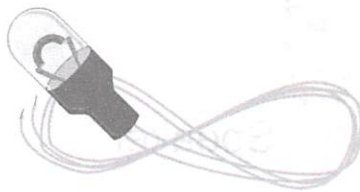
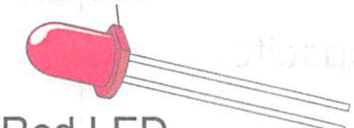
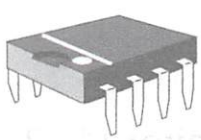
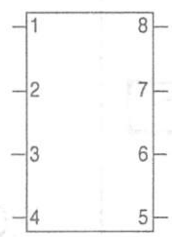
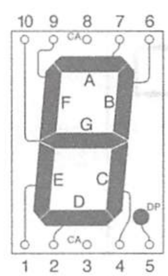
CHANEY
ELECTRONICS, INC.

PARTS INVENTORY

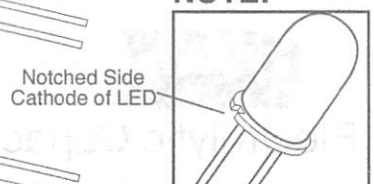
Before you begin to build the projects in this book, please check off the parts below to verify that you have everything that you need.

Qty.	Item	Schematic Symbol
1 ☐	 Speaker	
1 ☐	 1 µF Electrolytic Capacitor	
2 ☐	 10 µF Electrolytic Capacitor	
1 ☐	 1,000 µF Electrolytic Capacitor	
1 ☐	 .01µF Disc Capacitor (103)	
2 ☐	 2N3904 NPN Transistor	
2 ☐	 2N3906 PNP Transistor	

PARTS INVENTORY

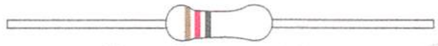
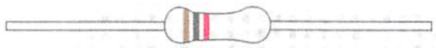
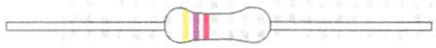
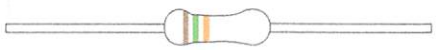
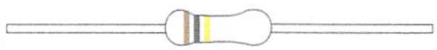
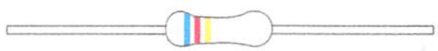
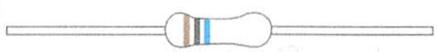
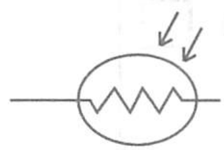
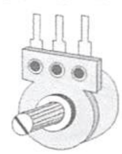
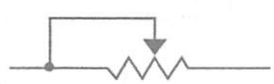
Qty.	Item	Schematic Symbol
1 ☑	 Electromagnetic Coil	
2 ☑	Lamp 	
1 ☑	Flat Side  Red LED	
1 ☑	 Green LED	
1 ☑	 Yellow LED	
1 ☑	 555 IC	
1 ☑	 7 Segment Display	
7 ☑	 Wire	

NOTE:



The cathode (C) of the LED is indicated by a <u>flat side</u> OR a <u>notch</u> in the base of the lens.

PARTS INVENTORY

Qty.	Item	Schematic Symbol
1	 Resistor-12Ω (brown, red, black)	
2	 Resistor-100Ω (brown, black, brown)	
1	 Resistor-1KΩ (brown, black, red)	
1	 Resistor-4.7KΩ (yellow, violet, red)	
2	 Resistor-15KΩ (brown, green, orange)	
2	 Resistor-100KΩ (brown, black, yellow)	
1	 Resistor-620KΩ (blue, red, yellow)	
1	 Resistor-10MegΩ (brown, black, blue)	
1	 CDS Cell	
1	 50KΩ Potentiometer	

PARTS INVENTORY

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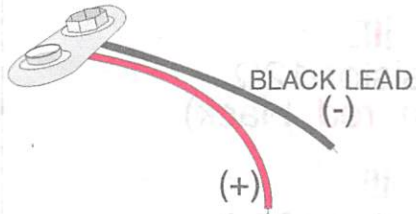
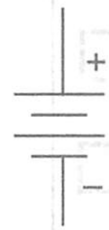
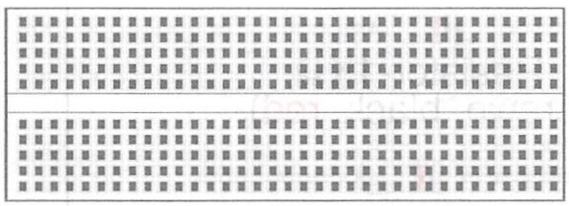
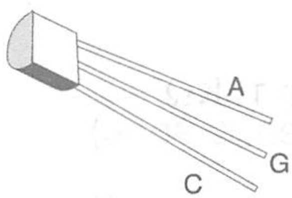
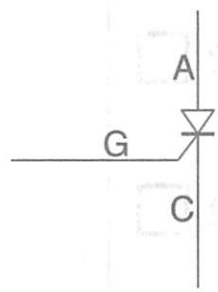
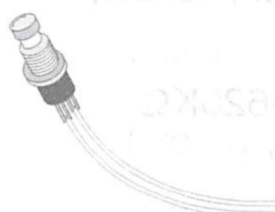
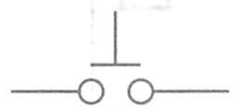
1 ☑	 Battery Snap	 (Battery)
1 ☑	 Breadboard	
1 ☑	 X0602 SCR	
1 ☑	 Pushbutton Switch	
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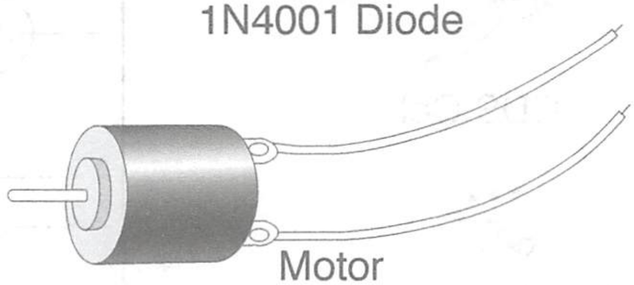
1 ☑	 Motor	

TIPS ON USING THE UNIVERSAL BREADBOARD

• The universal breadboard is used to create temporary circuits for learning and testing purposes. The breadboard has many columns of holes or sockets that you insert the leads of components or wires needed to build a circuit. If we could see inside the breadboard we would see that the columns of five sockets are connected. This means that each column of five sockets is the same point on a schematic diagram (See Fig. 1).

• When inserting components into the universal breadboard, be sure to grasp the component near the end of the lead. If you hold the component itself when inserting it, you will probably bend and may even break the lead making it useless (See Fig.2).

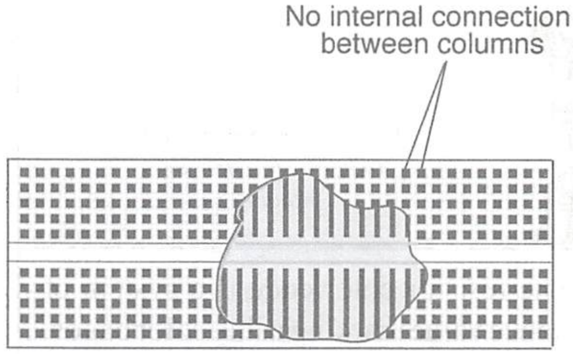


FIG. 1 - Cutaway view of a universal breadboard

• When installing the resistors, make sure that the correct value resistor is used. There is no polarity for resistors.

• When installing electrolytic capacitors the polarity (+) must be observed. If an electrolytic capacitor is marked with only a (-) symbol then the opposite lead is +.There is no polarity for disc capacitors.

• Make sure that you install LEDs with the flat side of the lens (cathode lead) in direction shown.

• Diodes are installed with a polarity indicated by a band (cathode).

• When installing transistors, make sure that you have the correct one per the parts list and install it observing the direction of the flat side.

• Install the IC with locating notch or locating dot in direction shown.

• Finally, always observe the color code polarity shown for the battery snap.

FIG. 2 - How to insert a component into the universal breadboard.

✓ RESISTOR COLOR CODE

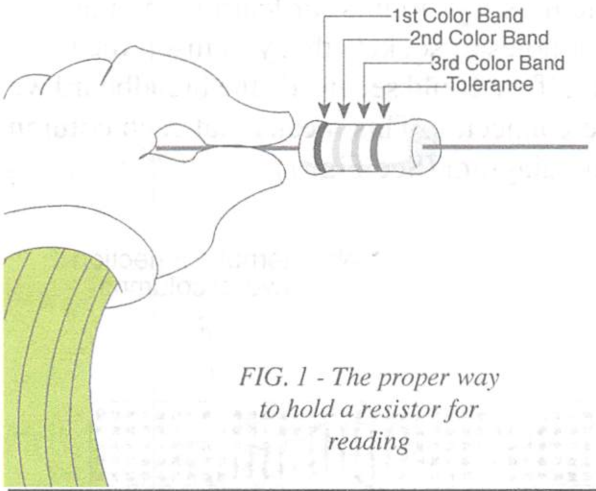


FIG. 1 - The proper way to hold a resistor for reading

The resistor color code is a system of resistance value marking using color bands. It is in common use for resistors used in electronic circuits. We have shown the decoding chart below.

To use the color code select a brown, green, orange resistor from the parts package. Hold it in your hand orienting it so the band that is closest to the resistor metal lead is next to your index finger and thumb (see fig. 1).

You should notice that the first color band is brown. Decoding the color brown from the table gives a 1 (see fig. 2). Next look at the 2nd color band and notice that it is green. Decoding the green color from the table gives a number 5 (see fig. 2). The third color band is orange which is the multiplier. Decoding the orange color from the table gives 1,000 for a multiplier (see fig. 2). The value of this resistor is 15K. The fourth band is the tolerance which, in this case, is gold which equals ±5%.

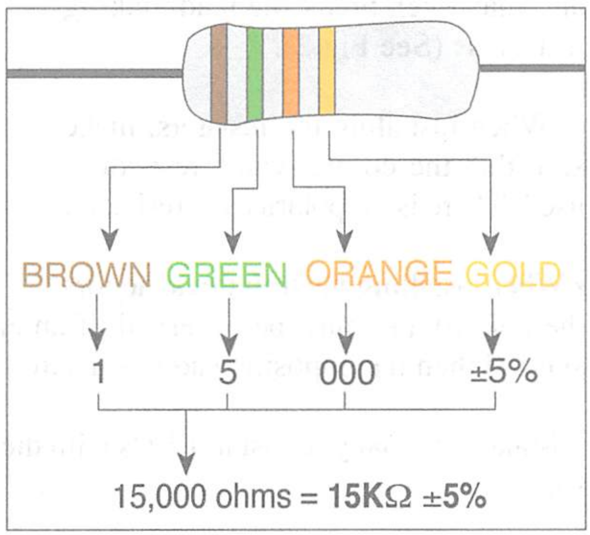


FIG. 3 - 15K resistor decoding

RESISTOR COLOR CODE

COLOR	1ST DIGIT	2ND DIGIT	MULTIPLIER
BLACK	0	0	1.
BROWN	1	1	10.
RED	2	2	100
ORANGE	3	3	1,000 (K)
YELLOW	4	4	10,000
GREEN	5	5	100,000.
BLUE	6	6	1,000,000. (M)
VIOLET	7	7	10,000,000.
GRAY	8	8	100,000,000.
WHITE	9	9	1,000,000,000.

TOLERANCE: NO COLOR 20%, SILVER 10%, AND GOLD ±5%.

FIG. 2 - Resistor Decoding Chart

Tolerance

The fourth band is the tolerance band which can be gold=5%, silver=10% or no band=20%. The tolerance is the amount that the resistance can vary from the value marked.

As an example: A 15K ohm gold tolerance band resistor can have an actual value of 15K ±5%=15,000 x 0.05=750. So the resistor can vary by 750 ohms greater or less.

Special Information Concerning the Color Code

When the third color band is gold, the value of the resistor is between 1 and 10 ohms and to find the value of the resistor determine the first 2 digits then multiply by (0.1).

When the third color band is silver, the value of the resistor is less than 1 ohm and to find the value of the resistor determine the first 2 digits then multiply by (0.01).

RESISTORS

JUST THE FACTS!

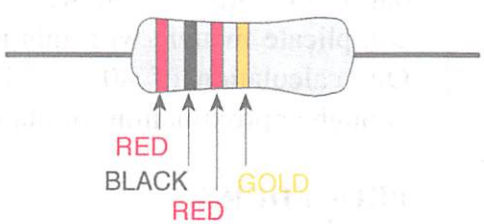
- Resistors of 5, 10, and 20 percent tolerance are typically made from carbon. The basic function of the resistor is to limit the current flowing in a circuit.

- There are many different sizes and shapes of resistors. Usually, the larger the physical size of the resistor, the larger the power rating of the resistor.

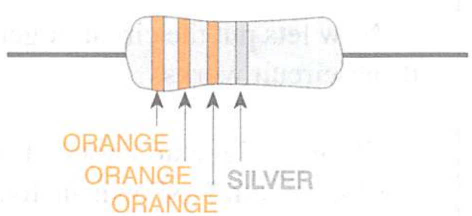
- Another type of resistor is the precision type which is usually made up of thin wire wrapped around a ceramic core and then it is covered with a ceramic coating.

ACTIVITY

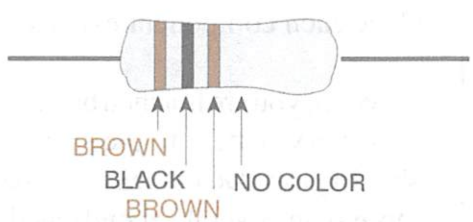
Decode the following resistors.

1.


value________
tolerance________

2.


value________
tolerance________

3.


value________
tolerance________

OHM'S LAW AND THE BASIC ELECTRONIC CIRCUIT

INSTRUCTIONAL 2 EXPERIMENT

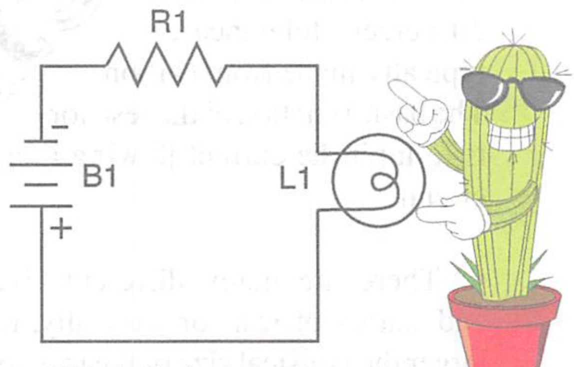


FIG. 1 - Basic electronic circuit

Probably one of the most basic of all circuits is the one you are about to build. It consists of a resistor (which we learned about in the last lesson), a small lamp and a battery. The components in our circuit are connected together by their wire leads. The wires are known as conductors because they conduct electricity. Metal is a conductor of electricity as opposed to dry wood, plastic, paper, etc. which are insulators. The lamp consists of a thin wire filament (usually made out of the metal tungsten) supported by connecting posts and placed inside of a glass globe which has had all the oxygen removed (vacuum).

Looking at the circuit in Fig. 1, we see the schematic (electrical drawing) of the circuit. This shows us how the components are electrically connected. It does not necessarily show us how they are physically connected. We need to look at the physical breadboard layout for that information. Looking at the schematic, we see the different symbols for the components that we will use. The battery is labeled B1, the resistor R1, and the lamp is labeled L1. If the circuit is wired correctly it is known as a complete circuit and electrons will flow from the battery, through the resistor, through the lamp and then back into the battery. This particular circuit is known as a **series circuit**. As electrons flow through the circuit, we call the electron flow "current" and it is measured in units of amps, milliamps or microamps (depending on the size of the current flow-1,000 milliamps = 1 amp).

In the particular circuit shown, B1 = 9VDC, R1 = 12 ohms and the lamp has a hot resistance of about 100 ohms. So the equivalent resistance for the lamp and the resistor is about 112 ohms.

A fundamental law in electronics is known as Ohm's Law. It basically states that :

$$\mathbf{I}\text{(current)} = \frac{\mathbf{E}\text{ (voltage)}}{\mathbf{R}\text{ (resistance)}}$$

In the circuit shown in Fig. 1, we could calculate the current flow by Ohm's Law to be:

$$I = \frac{E}{R} \qquad I = \frac{9}{112} \qquad I = 80\text{ma}$$

In advanced studies we would find out that the battery has an internal resistance that we would take into account, for our basic introduction we chose not to complicate matters with this information. Our calculation of 80 ma gives a close enough approximation for our purpose.

PROCEDURE:

Now lets put the circuit together and see if our circuit works.

1 - Refer to fig. 2 and notice how we build the "schematic" (shown in fig. 1) on our universal breadboard unit. Make sure you place each component exactly as shown.

2 - When you are finished building it, connect a fresh 9V battery to the snap and the lamp should glow. Do not leave the battery on for more than several seconds as the current

that the battery needs to supply to the circuit will quickly "drain" it.

3 - If you have a VOM, you may set it on a scale capable of indicating up to 500ma and insert it between the black lead(-) of the battery snap and one lead of the resistor.

4 - After reconnecting the battery notice the current reading. Any differences between the calculated value and what you read on the VOM are due to the following:

- *The 9V battery may have less than 9V available due to its condition.*
- *Internal resistance of the VOM.*
- *Internal resistance of the battery.*
- *Tolerance of the resistor and the variance of the lamp resistance.*

The above are just some of the facts to consider and there are of course others but your calculation and measurement will probably be fairly close anyway.

5 - After your experiment carefully remove R1, L1, and the wires. You may leave the battery snap connected.

JUST THE FACTS!

SERIES CIRCUITS

• In a series circuit all the resistors add together. So if you had 3 resistors: R1, R2, and R3 connected together the resistance value that you would use in your calculation of Ohm's Law would be:

$$R_{total} = R1+R2+R3.$$

• In the case of our circuit consisting of the lamp and a resistor, the equivalent
Rtotal = R1 + lamp resistance
Rtotal = 12 + 100. Rtotal = 112Ω.
In a series circuit the current flow is the same throughout the circuit.

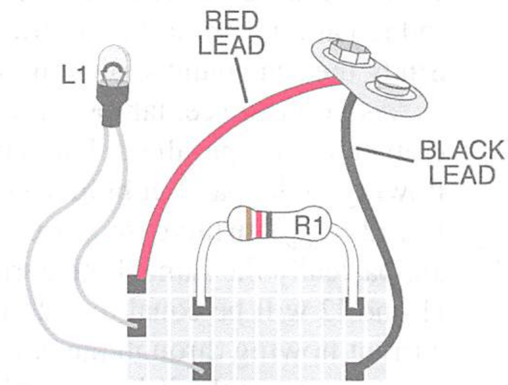


FIG. 2 - Physical hookup of a basic electronic circuit

PARTS LIST

R1---------- 12Ω Resistor
L1---------- Lamp
Misc.------- Battery Snap

ACTIVITY

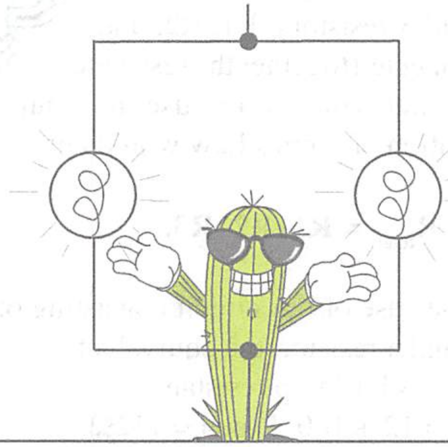
1. List several conductors and several insulators.

2. A series circuit consists of 2 resistors 12 Ω and 28 Ω connected in series to a 3V battery. What is the calculated current flow?

3. The same series circuit consisting of a 12 Ω and a 28Ω resistor is connected to an unknown battery. The current flow is 15ma. What is the battery voltage?

4. A series circuit consists of 4 resistors connected in series: 12Ω, 18Ω, 32Ω, and a 38Ω to a battery. What is the total equivalent resistance?

3 PARALLEL CIRCUIT WITH LAMP



In this experiment we will light up 2 lamps that are connected in parallel. The circuit is actually a series/parallel combination circuit because we will connect our lamps (which are in parallel) to a series resistor. Study the schematic shown in Fig. 1.

As you can see, lamps L1 and L2 are connected in parallel. The current (I) flowing in the parallel branch equals $I1 + I2 = I_{total}$. In this case, since both lamps are basically the same, both current flows I1 and I2 will be equal to 1/2 of the total current flowing through the circuit.

As an example, if I_{total} = 160ma, then I1 should be 80ma and I2 should be 80ma. We would expect both lamps to glow at the same brightness level. Each lamp will receive the same voltage which will be less than the battery voltage because of the dropping resistor R1. It is beyond the scope of this lesson to go into more detail on the parallel circuit but we will list a few facts that apply to series and parallel circuits.

- In a series circuit the current flow is the same throughout.
- In a parallel circuit, the current flowing through each branch can be different but when added together the current will be equal the total current flowing through the circuit.
- In a parallel circuit the voltage across each branch will be the same.

PROCEDURE:

Now it is time to connect up the schematic using the universal prototype board.

1 - Select the 12Ω resistor from the parts bag and connect the 2 lamps and battery snap exactly as shown (Fig. 2).

2 - Connect a 9V battery to the snap and both of the lamps should light up with equal brilliance.

3 - Remove the battery after a few seconds to prevent battery drain.

4 - If you have a VOM you can measure the current flowing through the entire circuit by connecting it in series between the black(-) lead of the battery snap and one lead of the resistor R1.

5 - After taking this measurement you can connect the VOM between a lead of lamp L1 and the prototype board. This reading should be about 1/2 of the total reading.

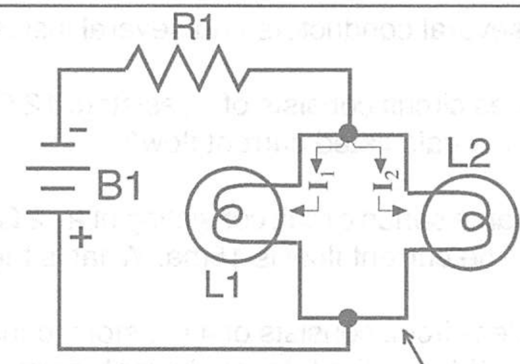


FIG. 1 - Parallel Circuit

6 - Repeat the above step for lamp L2.

7 - After finishing the above experiment, disassemble the circuit components from the prototype board.

RESISTOR NETWORKS

JUST THE FACTS!

- When resistors are connected in series their total equivalent value is calculated by:

$$RT=R1+R2+R3$$

- When resistors are connected in parallel their equivalent total value is calculated by:

$$RT=\frac{R1 \times R2}{R1 + R2}$$

(for only 2 resistors)

or

$$RT=\frac{1}{\left(\frac{1}{R1}+\frac{1}{R2}+\frac{1}{R3}\right)}$$

(for more than 2 resistors)

PARTS LIST

L1, L2----- Lamp
R1---------- 12Ω Resistor
Misc.------- Battery Snap

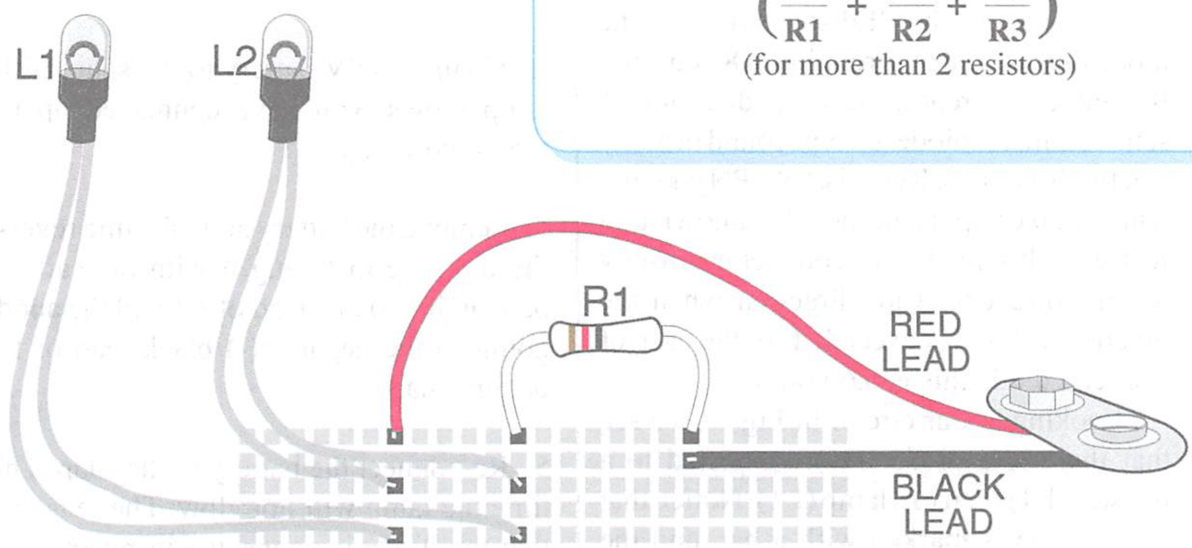


FIG. 2 - Physical hookup of parallel circuit

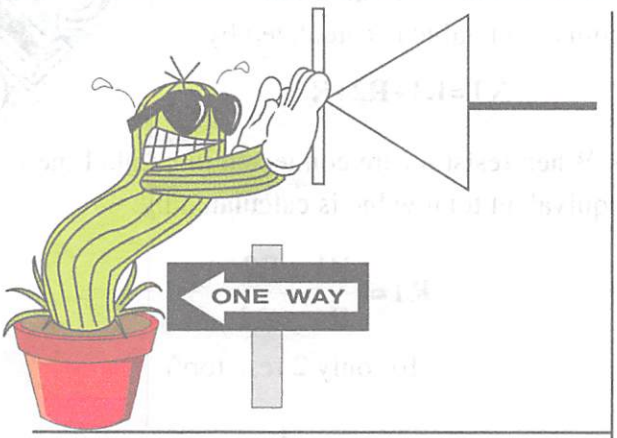
ACTIVITY

1. Is the current flowing through each leg of a parallel circuit the same as the total current flow?

2. In a home do you think the lights are wired in series or parallel?

3. Does Ohm's law apply to parallel circuits or just to series circuits?

4 DIODE ACTION



An important development in electronics was the discovery of the diode. At first it was known as the "Edison Effect". The diode changes AC current into DC current. It conducts current in only one direction. A semiconductor diode is a type found in many electronic circuits. It consists of a PN junction which makes up the diode (also known as a rectifier). It will start to conduct electricity in the correct forward direction when the junction voltage is exceeded (in the case of a silicon diode this is 0.6 volts).

Looking at our circuit in Fig. 1, we see that there is a diode (D1) connected to a resistor (R1) then to a lamp (L1). Notice that the cathode is marked with a bar, and the anode is shown as a triangle sideways. If we connect the cathode to the negative side of the battery as shown, the diode should allow current to flow through the circuit lighting up the lamp.

PROCEDURE:

1. Build the circuit shown in Fig. 1 by carefully wiring the universal breadboard as shown in Fig. 2. Be careful when connecting the battery snap (observe polarity) and when connecting the diode. The diode must be installed with the cathode (marked by a band) in the direction shown.

2. Select the 12Ω resistor for R1.

3. Connect a 9V battery to the snap. If the lamp glows, you have connected up the circuit correctly.

4. Remove the battery and this time reverse the diode re-installing it with the cathode band going to one lead of R1 and the anode going to the negative(-) black lead of the battery snap.

5. Re-connect the battery to the snap. This time the lamp will not glow. The reason is that the diode is connected in reverse and is blocking the flow of electricity through the circuit.

6. Disassemble the components from the breadboard.

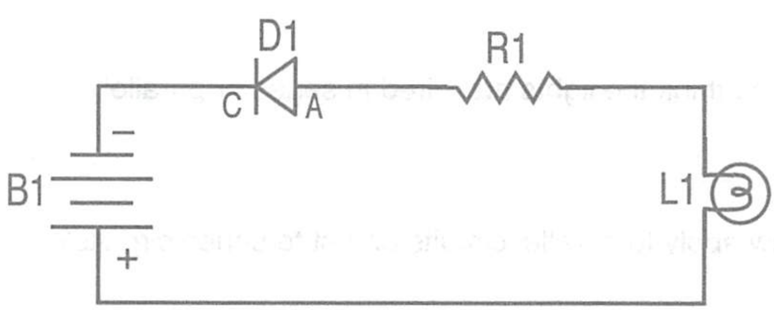


FIG. 1 - Diode Circuit

DIODES

- Diodes come in many shapes and sizes. The smaller ones typically are used to transform low current AC to DC or to make logic gates, demodulate radio frequencies, etc. Larger size diodes typically are used to rectify large AC currents. They are found in all types of power supplies, AC adaptors, TV's, etc.

- There are other special purpose diodes such as LED (Light Emitting Diodes) that light up, zener diodes which regulate voltage, tuning diodes (used in RF circuits), photodiodes (light sensitive diodes), and many other specialized types.

PARTS LIST

R1---------- 12Ω Resistor
D1---------- 1N4001 Diode
L1 ---------- Lamp
Misc.------- Battery Snap

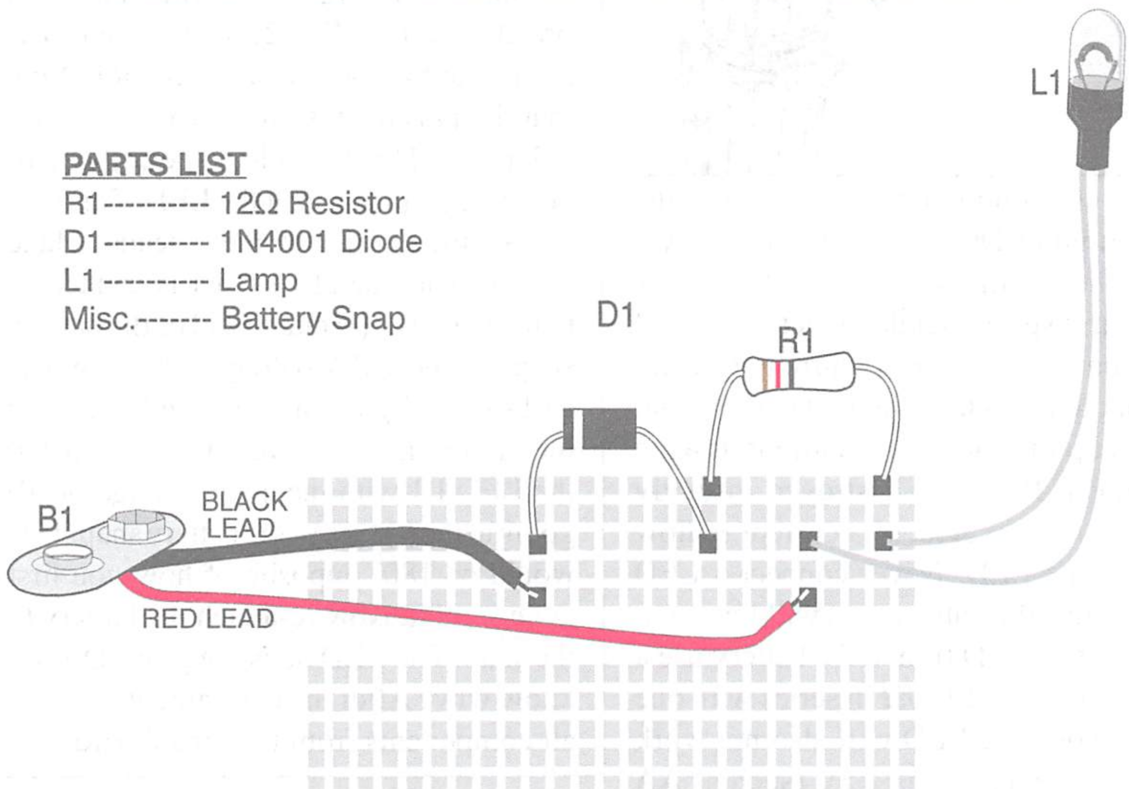


FIG. 2 - Physical hookup of diode circuit

ACTIVITY

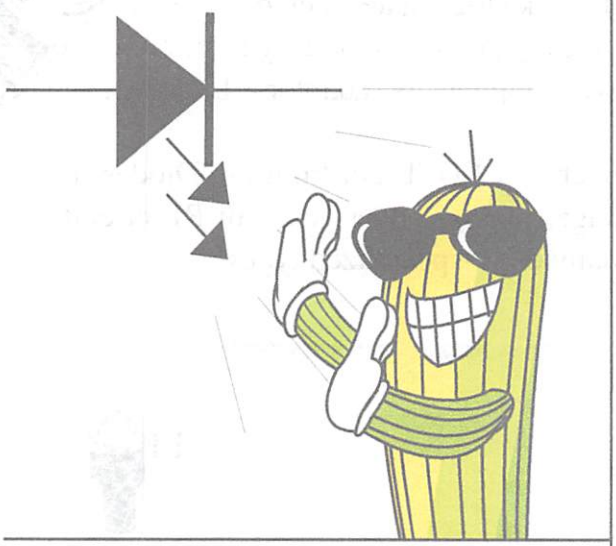
1. Describe the purpose of a diode.

2. What is the junction voltage drop of a silicon diode?

3. What was the "first diode" discovered referred to as?

5 INSTRUCTIONAL EXPERIMENT

LIGHT EMITTING DIODES



Another important discovery was the Light Emitting Diode or LED as it is known. The light emitting diode consists of a PN junction of special semiconductor material that converts electrical current directly into photons (light). The LED emits light in direct proportion to the current flowing through it. It can be destroyed instantly by allowing too great of a current to flow through the LED. Never connect a LED directly to a 9V battery as it will burn out. To operate a LED from a 9V battery use a resistor of at least 100Ω in series with one of its leads. The LED will also not work with voltage as low as 1.5V (such as AA batteries). Typically, the LED will require at least 2.3 VDC to operate.

A LED is a narrow wavelength type device and, as opposed to a lamp, it emits one color light and not broad spectrum white light. The typical wavelengths for LEDs are approximately 565nM green, 590nM yellow, 650nM red and 900nM infrared. These are just approximations and there are variances in wavelength available in each color group. A typical red LED might be made from a gallium arsenide silicon chip.

To study the red LED look at the circuit in Fig. 1. You will notice that the LED symbol is very similar to the diode and, in fact, LEDs do conduct electricity in only one direction (just like a diode). Connected to the LED is a resistor (R1) and a battery (B1).

Build the circuit shown by the schematic as shown in Fig. 1 on the universal breadboard (see Fig. 2) Select a red LED for L1 and a 100Ω resistor for R1. Note that the plastic lens on the LED (L1) has a flat side. This flat side is the cathode or negative (-) junction of the LED. This lead is also the shorter of the 2 leads. Make sure the cathode of LED L1 is connected to the negative (-) black lead of the battery snap. Connect a 9V battery to the snap. The LED should glow a bright red. Remove the battery and remove L1 and re-install the LED L1 with the anode (longer lead) going to the (-) lead of the battery snap. This would be 180° opposite of how you first connected it. Now re-attach the battery to the snap. The LED does not glow. Do you know why? After the experiment, remove all components from the breadboard.

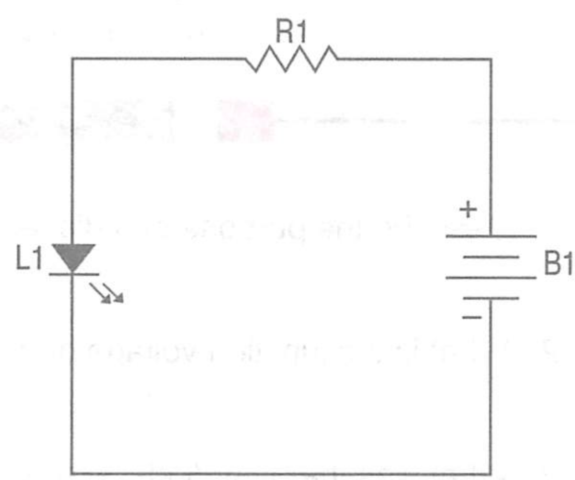


FIG. 1 - Light Emitting Diode Circuit

LIGHT EMITTING DIODES

JUST THE FACTS!

• LEDs come in all shapes, sizes and colors including red, orange, green, yellow and blue. Not only are they much more reliable than filament type lamp indicators, they are also more efficient.

• Most of the high tech electronic products found in our homes contain LEDs. Digital number displays that glow are typically made from 7 LEDs installed in a small plastic assembly. This is known as a 7 segment LED display

• Sometimes several semiconductor chips are installed in one plastic package providing dual color or tri-color outputs. These LEDs are usually referred to as bi-polar LEDs.

• Some LEDs even have built-in current limiting resistors or built-in circuits to cause them to blink.

PARTS LIST

R1---------- 100Ω Resistor
L1 ---------- Red LED
Misc.------- Battery Snap

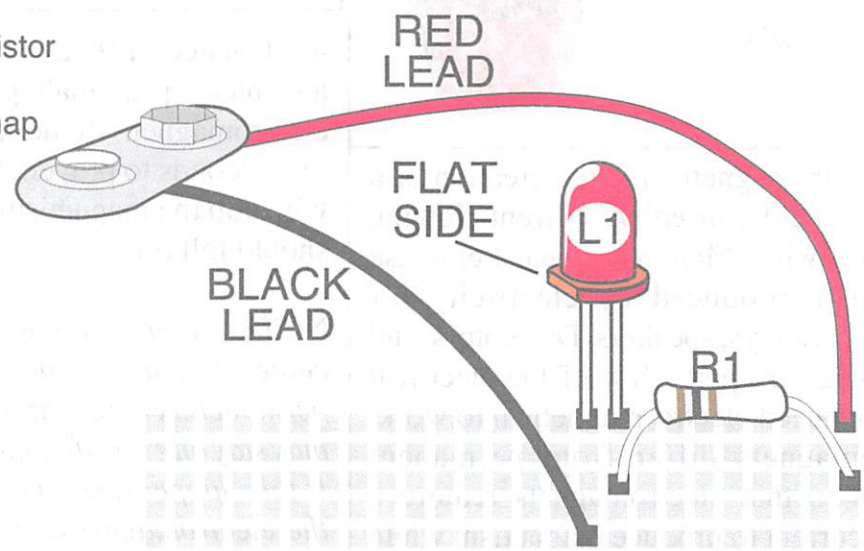


FIG. 2 - Physical hookup of LED circuit

ACTIVITY

1. Do LEDs have a polarity?

2. Can a single chip LED produce white light?

3. Can a LED be connected directly to a 9V battery?

4. What are the 2 common ways of designating the cathode lead on a LED?

VARIABLE RESISTOR LED DIMMER

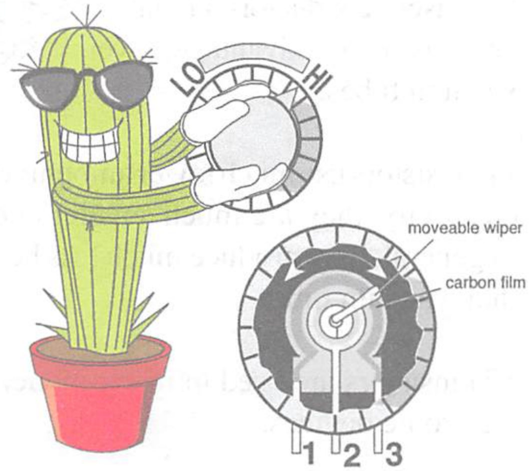


FIG. 1 - Inside a Variable Resistor

Another common component found in many radios, TV's, stereos, etc. is the variable resistor. There are many varieties of variable resistors but a common type used in many of these devices is the potentiometer. The potentiometer is used for the volume, tone, or balance control in many of these devices. It is a variable resistor and it consists of a carbon film in the shape of an incomplete circle. There are 2 terminals attached to the ends of this (see Fig. 1). In addition, there is a moveable arm or wiper which makes contact against the carbon film. This wiper is mechanically attached to a shaft and the entire assembly is installed inside a metal outer case. As the shaft is rotated, the resistance between the wiper (center lead) and the outer leads vary. As the resistance goes up between the center lead (2) and the lead marked 3, the resistance goes down between the center lead and the lead marked 1 (see Fig. 1).

This fact makes the potentiometer a very useful electronic component. In the schematic shown in Fig. 2 a potentiometer is used to dim the light output of a red LED.

Per the schematic shown in Fig. 2 notice that the battery B1 is series connected through dropping resistor R1 and terminal 2 of variable resistor (potentiometer P1), then through the carbon film inside the potentiometer to terminal 3. Finally, terminal 3 is connected to the anode of red LED L1. As the shaft on P1 is rotated, the resistance between the anode of LED L1 and resistor R1 will vary between a very high value to a very low value. This change in resistance will cause less or more current to flow through the circuit. As more current flows, the LED will become brighter.

PROCEDURE:

Build the circuit per the universal breadboard shown in Fig. 3.

1 - Make sure the LED is installed with the flat side (cathode) in the direction shown.

2 - Choose a 100Ω resistor for R1.

3 - Connect the battery snap observing the polarity shown.

4 - Install potentiometer P1 exactly as shown. Install wire jumper as shown.

5 - After building the circuit rotate the shaft on P1 fully counter-clockwise.

6 - Attach a 9V battery to the snap and slowly turn the shaft of P1 clockwise. As you rotate the shaft you should notice that the LED becomes brighter.

7 - This concludes the experiment. You may disassemble the components from the breadboard.

VARIABLE RESISTORS

- Not all potentiometers are round and not all potentiometers are made using carbon film.

- Precision potentiometers use a fine wire as the resistive element.

- Rheostats are variable resistors which are designed to handle high amounts of current and have a larger wire as the resistive element.

- Some other types of potentiometers are the slide potentiometer that has a shaft which moves in a straight line and a trimmer potentiometer which have a simple screwdriver adjust slot instead of a long shaft.

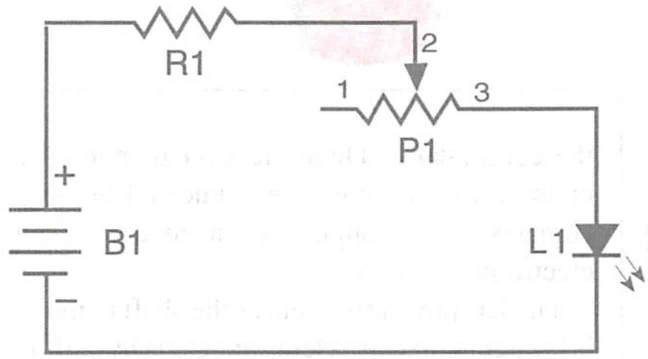


FIG. 2

PARTS LIST

L1----------- Red LED
P1---------- 50KΩ Potentiometer
R1---------- 100Ω Resistor
Misc.------- Battery Snap,
1 pc Wire

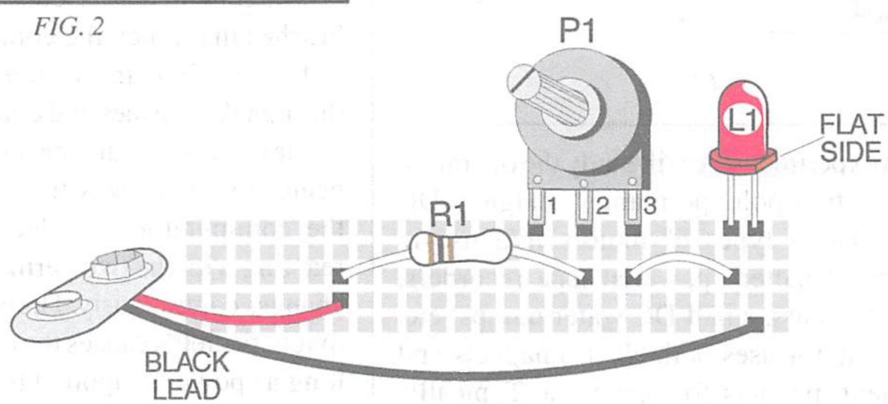


FIG. 3

ACTIVITY

1. What is another common name for a variable resistor?

2. In the diagram of a potentiometer shown in Fig. 1, does the resistance between terminals 1 and 3 vary?

3. What is the typical substance used to make the resistive component in standard potentiometers?

DC MOTOR EXPERIMENT

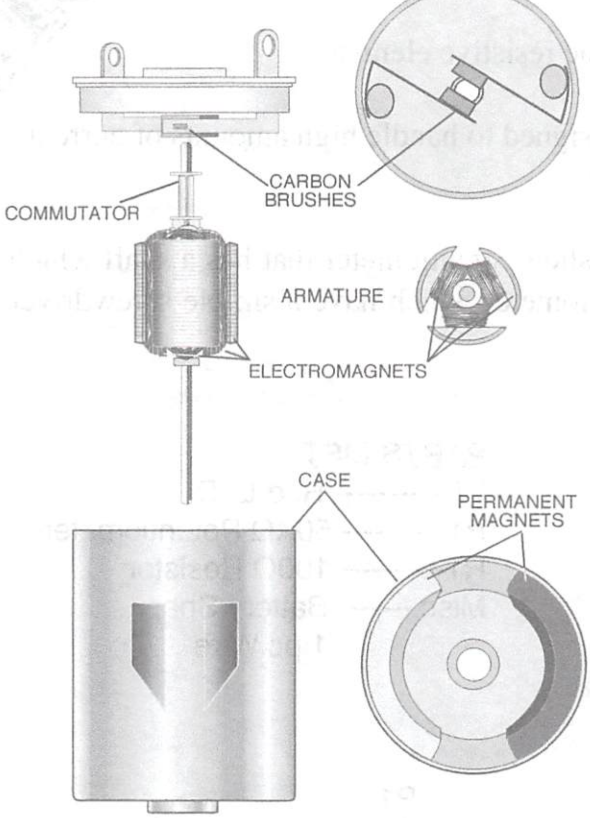


FIG. 1

In this experiment we will study the operation of small two-pole permanent magnet DC motors. These types of motors find use in all types of battery powered tape recorders, toy electric cars, small DC water pumps, etc. The DC motor uses both electromagnets and permanent magnets for operation. Typically, the small DC motor will use 2 curved shaped permanent magnets inside of a soft iron cylindrical shaped case. One magnet has a north-seeking pole for its face and the opposing magnet will have a south-seeking pole (facing the north seeking magnet face). The shaft on the motor is assembled to a core called an armature. The armature core is made up of slotted iron plates glued together. Around the armature are many windings of wire making up typically three separate electromagnets (some DC motors have 6 or even more, but ours has 3). The shaft also has a set of 6 contact points on it called the commutator. Three electromagnetic wire coils on the armature are connected to these contacts. (Two contacts are needed for each electromagnet coil.)

The DC power that causes the shaft to move is brought into these electromagnets by carbon brushes that touch the commutator. As power is brought into the different electromagnets through the brushes and commutator, the shaft rotates. This occurs because the coils have been wound in a way that in conjunction with the commutator, the electromagnetic forces reacting with the two permanent magnet fields changes continuously. The constantly changing magnetic fields causes the armature to rotate as long as power is applied (see Fig. 1).

PROCEDURE:

1 - Assemble the circuit shown in Fig. 2 using the motor from the parts bag, the battery snap, and the universal breadboard as shown in Fig. 3.

2 - After connecting up the circuit, connect a 9V battery to the snap and the shaft on the motor should spin. Remove the battery momentarily.

3 - Place a piece of tape onto the shaft. You now have a simple fan blade. Reconnect the battery to the snap.

4 - Remove the battery snap and remove tape from the shaft after you have completed the experiment.

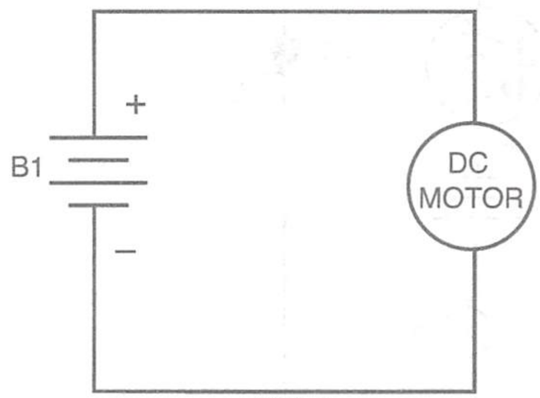


FIG. 2

JUST THE FACTS!

DC MOTORS

- In general, the greater the amount of DC voltage applied to a motor the greater the amount of current that will flow in the circuit and the faster the shaft will spin.

- If you reverse the polarity of the voltage going to the motor power leads, the shaft will spin in the opposite direction.

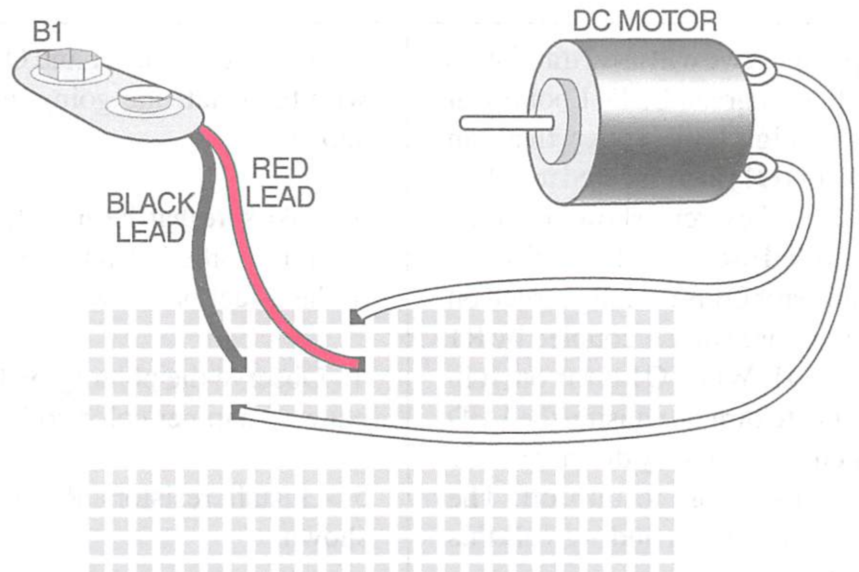


FIG. 3

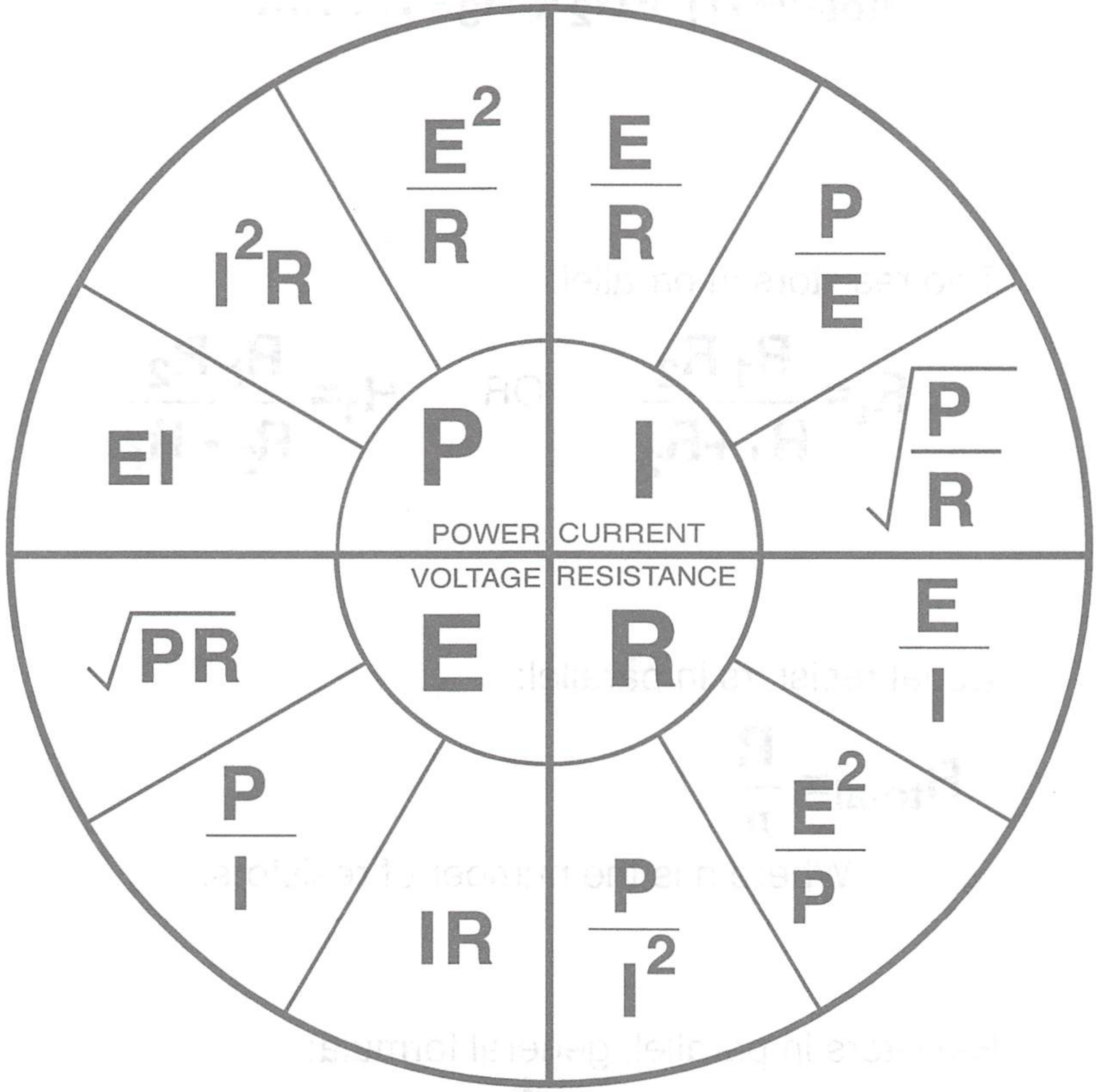
ACTIVITY

1. What happens if you reverse the polarity of the voltage applied to a DC motor?

2. What do the brushes come into contact with inside the motor?

3. Does a DC motor rely on permanent magnets, electromagnets, or both for operation?

OHM'S LAW FOR DC CIRCUITS



RESISTANCE FORMULAS

Resistors in series:

$$R_{total} = R_1 + R_2 + R_3 + \ldots\ldots\ldots\ldots$$

Two resistors in parallel:

$$R_t = \frac{R_1 R_2}{R_1 + R_2} \quad \text{OR} \quad R_1 = \frac{R_t R_2}{R_2 - R_t}$$

Equal resistors in parallel:

$$R_{total} = \frac{R}{n}$$

Where n is the number of resistors.

Resistors in parallel, general formula:

$$R_{total} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots\ldots\ldots\ldots}$$

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