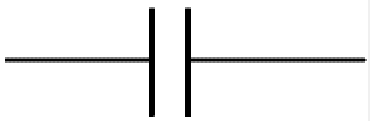
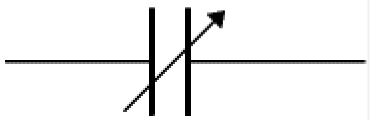
ELECTRIC WORKSHOP

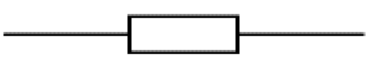
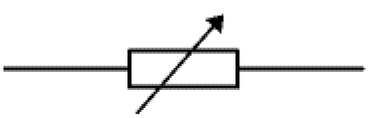
Significance Of This Workshop:

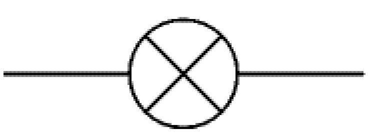
To have the basic understanding of electric symbols, circuit diagrams & electrical wiring used in our homes, electric appliances etc

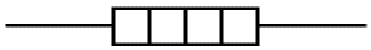
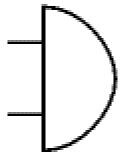
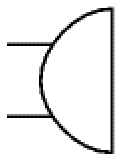
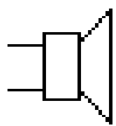
Related Theory:

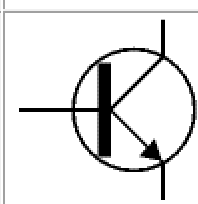
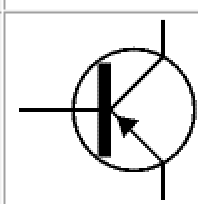
Electric Symbols:

Capacitors		
Component	**Circuit Symbol**	**Function of Component**
Capacitor		A capacitor stores electric charge. It can also be used as a filter, to block DC signals but pass AC signals.
Variable Capacitor		A variable capacitor is used in a radio tuner.

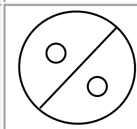
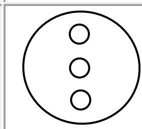
Resistors		
Component	**Circuit Symbol**	**Function of Component**
Resistor		A resistor restricts the flow of current, for example to limit the current passing through an LED. Some publications still use the old resistor symbol: 
Variable Resistor (Rheostat)		This type of variable resistor with 2 contacts (a rheostat) is usually used to control current. Examples include: adjusting lamp brightness, adjusting motor speed, and adjusting the rate of flow of charge into a capacitor in a timing circuit.

Output Devices: Lamps, Heater, Motor, etc.		
Component	**Circuit Symbol**	**Function of Component**
Lamp (indicator)		A transducer which converts electrical energy to light. This symbol is used for a lamp which is an indicator, for example a warning light on a car dashboard.

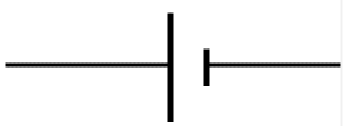
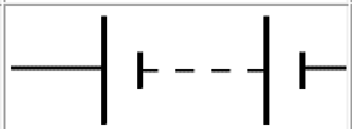
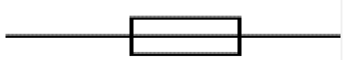
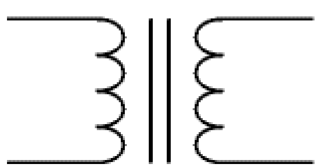
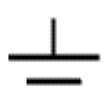
Heater		A transducer which converts electrical energy to heat.
Motor		A transducer which converts electrical energy to kinetic energy (motion).
Bell		A transducer which converts electrical energy to sound.
Buzzer		A transducer which converts electrical energy to sound.
Speaker		A transducer which converts electrical energy to sound.
Inductor (Coil, Solenoid)		A coil of wire which creates a magnetic field when current passes through it. It may have an iron core inside the coil. It can be used as a transducer converting electrical energy to mechanical energy by pulling on something.

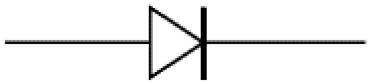
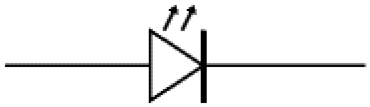
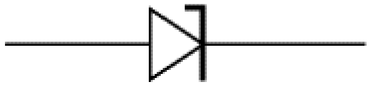
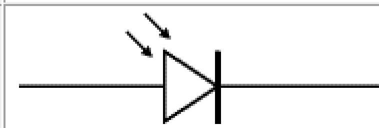
Transistors		
Component	**Circuit Symbol**	**Function of Component**
Transistor NPN		A transistor amplifies current. It can be used with other components to make an amplifier or switching circuit.
Transistor PNP		A transistor amplifies current. It can be used with other components to make an amplifier or switching circuit.

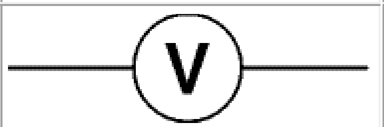
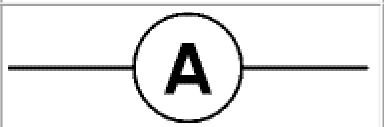
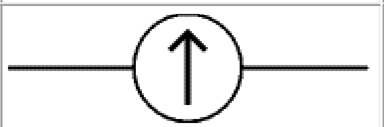
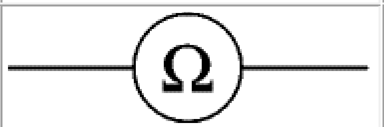
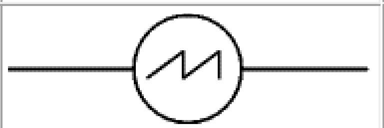
Switches

Component	Circuit Symbol	Function of Component
One Way Switch		A transistor amplifies current. It can be used with other components to make an amplifier or switching circuit.
Two Way Switch		A transistor amplifies current. It can be used with other components to make an amplifier or switching circuit.

Power Supplies

Component	Circuit Symbol	Function of Component
Cell		Supplies electrical energy. The larger terminal (on the left) is positive (+). A single cell is often called a battery, but strictly a battery is two or more cells joined together.
Battery		Supplies electrical energy. A battery is more than one cell. The larger terminal (on the left) is positive (+).
DC supply		Supplies electrical energy. DC = Direct Current, always flowing in one direction.
AC supply		Supplies electrical energy. AC = Alternating Current, continually changing direction.
Fuse		A safety device which will 'blow' (melt) if the current flowing through it exceeds a specified value.
Transformer		Two coils of wire linked by an iron core. Transformers are used to step up (increase) and step down (decrease) AC voltages. Energy is transferred between the coils by the magnetic field in the core. There is no electrical connection between the coils.
Earth (Ground)		A connection to earth. For many electronic circuits this is the 0V (zero volts) of the power supply, but for mains electricity and some radio circuits it really means the earth. It is also known as ground.

Diodes		
Component	**Circuit Symbol**	**Function of Component**
Diode		A device which only allows current to flow in one direction.
LED Light Emitting Diode		A transducer which converts electrical energy to light.
Zener Diode		A special diode which is used to maintain a fixed voltage across its terminals.
Photodiode		A light-sensitive diode.

Meters and Oscilloscope		
Component	**Circuit Symbol**	**Function of Component**
Voltmeter		A voltmeter is used to measure voltage. The proper name for voltage is 'potential difference', but most people prefer to say voltage!
Ammeter		An ammeter is used to measure current.
Galvanometer		A galvanometer is a very sensitive meter which is used to measure tiny currents, usually 1mA or less.
Ohmmeter		An ohmmeter is used to measure resistance. Most multimeters have an ohmmeter setting.
Oscilloscope		An oscilloscope is used to display the shape of electrical signals and it can be used to measure their voltage and time period.

OHM'S LAW

Ohm's Law deals with the relationship between voltage and current in an ideal conductor. This relationship states that: *"The potential difference (voltage) across an ideal conductor is proportional to the current through it. "*

The constant of proportionality is called the "resistance", **R**.

Ohm's Law is given by: **V = I R**

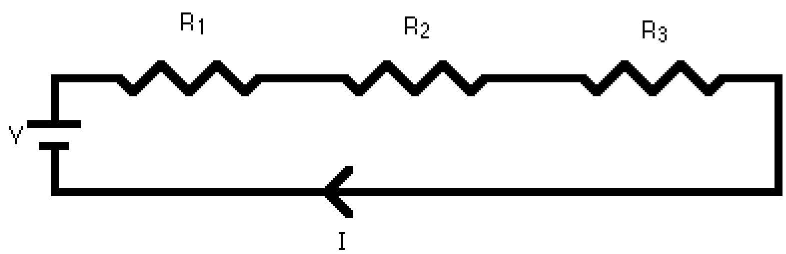
where V is the potential difference between two points which include a resistance R. I is the current flowing through the resistance. Material that obeys Ohm's Law is called "**ohmic"** or "**linear"** because the potential difference across it varies linearly with the current.

SERIES AND PARALLEL CIRCUITS

Series Circuits

A series circuit is a circuit in which resistors are arranged in a chain, so the current has only one path to take. The current is the same through each resistor. The total resistance of the circuit is found by simply adding up the resistance values of the individual resistors:

equivalent resistance of resistors in series : $R = R_1 + R_2 + R_3 + ...$



A series circuit is shown in the diagram above. The current flows through each resistor in turn. If the values of the three resistors are:

$R_1 = 8\ \Omega$, $R_2 = 8\ \Omega$, and $R_3 = 4\ \Omega$, the total resistance is $8 + 8 + 4 = 20\ \Omega$.

With a 10 V battery, by V = I R the total current in the circuit is:

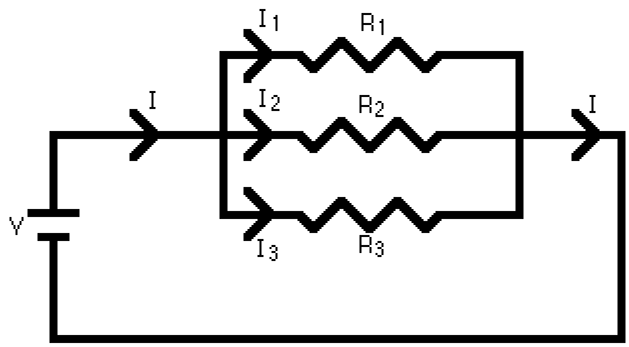
I = V / R = 10 / 20 = 0.5 A. The current through each resistor would be 0.5 A.

Parallel Circuits

A parallel circuit is a circuit in which the resistors are arranged with their heads connected together, and their tails connected together. The current in a parallel circuit breaks up, with some flowing along each parallel branch and re-combining when the branches meet again. The voltage across each resistor in parallel is the same.

The total resistance of a set of resistors in parallel is found by adding up the reciprocals of the resistance values, and then taking the reciprocal of the total:

equivalent resistance of resistors in parallel: $1 / R = 1 / R_1 + 1 / R_2 + 1 / R_3 + \ldots$



A parallel circuit is shown in the diagram above. In this case the current supplied by the battery splits up, and the amount going through each resistor depends on the resistance. If the values of the three resistors are:

$R_1 = 8\ \Omega$, $R_2 = 8\ \Omega$, and $R_3 = 4\ \Omega$, the total resistance is found by:

$1 / R = 1 / 8 + 1 / 8 + 1 / 4 = 1 / 2$. This gives $R = 2\ \Omega$.

With a 10 V battery, by V = I R the total current in the circuit is: I = V / R = 10 / 2 = 5 A.

The individual currents can also be found using I = V / R. The voltage across each resistor is 10 V, so:

$I_1 = 10 / 8 = 1.25$ A
$I_2 = 10 / 8 = 1.25$ A
$I_3 = 10 / 4 = 2.5$ A

Note that the currents add together to 5A, the total current.

Resistance and Resistivity

Electric resistance is measured in ohms**:**

$$1 \text{ ohm} = \frac{1 \text{ volt}}{1 \text{ amp}}$$

The resistance of a wire or rod to the flow of electric current depends both on its geometry and its composition. Wires with large cross-sections (thin ones) have **small** resistance; thick ones have **large** resistance. Short wires have small resistance; long ones have large resistance.

Different materials have different **resistivities**. The units of resistivity are **ohm-meters**.

The resistance of a wire or rod of uniform cross section can be calculated as

(resistivity) * (length)
Resistance = ------------------------
(cross section area)

The resistivity of a material depends on its temperature. Most metals have lower resistance as the temperature drops. The **temperature coefficient of resistivity** describes the change in resistivity as a function of temperature:

resistivity (T) = resistivity (T0) * [1 - a*(T - T0)]

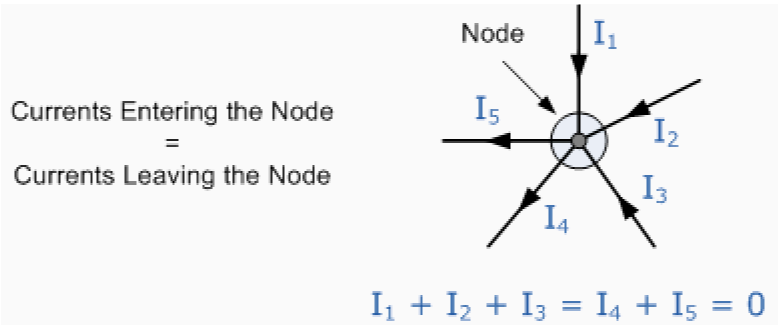
where
a = temperature coefficient of resistivity
T0 = reference temperature

Some materials become **superconductors** when they fall below a critical temperature. They offer zero resistance to the flow of current.

<u>Kirchoff's First Law - The Current Law, (KCL)</u>

Kirchoff's Current Law or KCL, states that the "*total current or charge entering a junction or node is exactly equal to the charge leaving the node as it has no other place to go except to leave, as no charge is lost within the node*". In other words the algebraic sum of ALL the currents entering and leaving a node must be equal to zero, $I_{(exiting)} + I_{(entering)} = 0$. This idea by Kirchoff is commonly known as the **Conservation of Charge**.

<u>Kirchoff's Current Law</u>

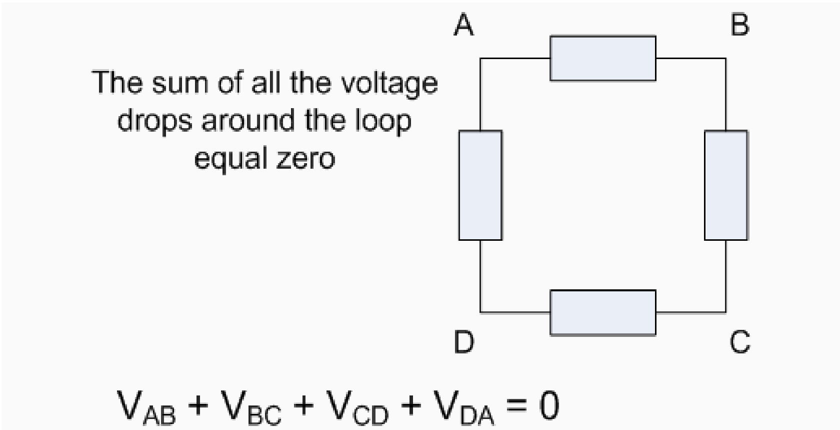


The term **Node** in an electrical circuit generally refers to a connection or junction of two or more current carrying paths or elements such as cables and components. Also for current to flow either in or out of a node a closed circuit path must exist. We can use Kirchoff's current law when analysing parallel circuits.

Kirchoff's Second Law - The Voltage Law, (KVL)

Kirchoff's Voltage Law or KVL, states that "*in any closed loop network, the total voltage around the loop is equal to the sum of all the voltage drops within the same loop*" which is also equal to zero. In other words the algebraic sum of all voltages within the loop must be equal to zero. This idea by Kirchoff is known as the **Conservation of Energy**.

Kirchoff's Voltage Law



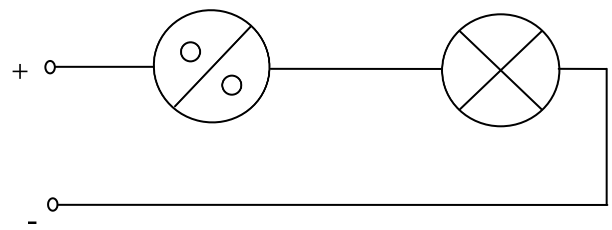
Starting at any point in the loop continue in the **same direction** noting the direction of all the voltage drops, either positive or negative, and returning back to the same starting point. It is important to maintain the same direction either clockwise or anti-clockwise or the final voltage sum will not be equal to zero. We can use Kirchoff's voltage law when analysing series circuits.

EXPERIMENT # 1

To control one lamp with one switch.

Apparatus:
Switch, bulb holder, bulb, screw driver, connecting wires, wire cutter, AC supply

Circuit Diagram:



Procedure:
1. Draw the circuit diagram and get them approved by staff in charge.
2. Prepare the list of tools and materials required for the work and collect them.
3. Cut the connecting wires into suitable length and make the connections according to the circuit diagram.
4. Positive terminal of the battery is connected with the switch, and one wire is connected with the second point of switch and with the bulb. The negative terminal is then connected with the other point of the bulb to make a complete circuit.
5. The circuit is then checked by providing the AC supply to the circuit and shown to the supervisor.

Precautions:
1. Neat and tight connections must be ensured.

Result:
The circuit was wired up to control one lamp by one switch and verified.

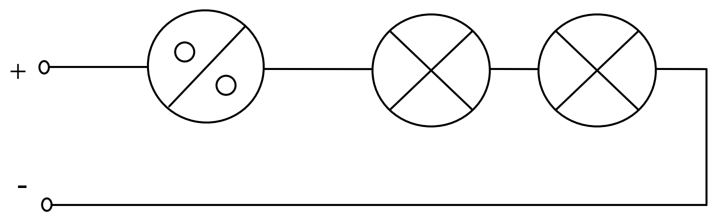
EXPERIMENT # 2

To control two lamps (in series) with one switch.

Apparatus:

Switch, two bulb holders, two bulbs, screw driver, connecting wires, wire cutter, AC supply

Circuit Diagram:



Procedure:

1. Draw the circuit diagram and get them approved by staff in charge.
2. Prepare the list of tools and materials required for the work and collect them.
3. Cut the connecting wires into suitable length and make the connections according to the circuit diagram.
4. In series circuit voltage drops across the two bulbs (resistances) but current remains the same. Overall resistance in series circuit is higher than the individual resistances in the circuit.
5. Positive terminal of the battery is connected with the switch, and one wire is connected with the second point of switch and with the bulb. The negative terminal is then connected with the other point of the 2nd bulb to make a complete circuit.
6. The circuit is then checked by providing the AC supply to the circuit and shown to the supervisor.

Precautions:

1. Neat and tight connections must be ensured.

Result:

The circuit for two lamps in series with one switch was wired up and tested .

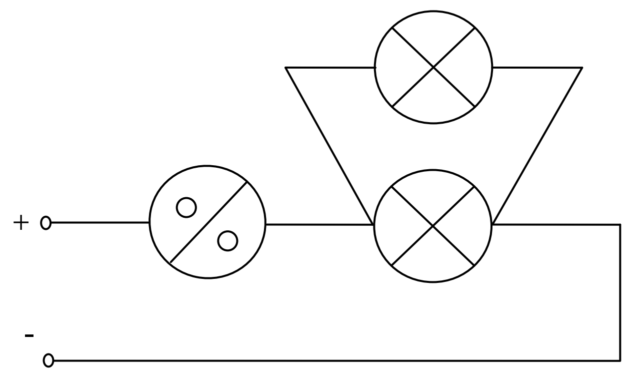
EXPERIMENT # 3

To control two lamps (in parallel) with one switch.

Apparatus:

Switch, two bulb holders, two bulbs, screw driver, connecting wires, wire cutter, AC supply

Circuit Diagram:



Procedure:

1. Draw the circuit diagram and get them approved by staff in charge.
2. Prepare the list of tools and materials required for the work and collect them.
3. Cut the connecting wires into suitable length and make the connections according to the circuit diagram.
4. In parallel circuit voltage remains the same across the two bulbs (resistances) but current varies. Overall resistance in parallel circuit is smaller than the individual resistances in the circuit.
5. Positive terminal of the battery is connected with the switch, and one wire is connected with the second point of switch and with the bulb. Two bulbs are connected in parallel as shown in the figure. The negative terminal is then connected with the other point of the 2nd bulb to make a complete circuit.
6. The circuit is then checked by providing the AC supply to the circuit and shown to the supervisor.

Precautions:

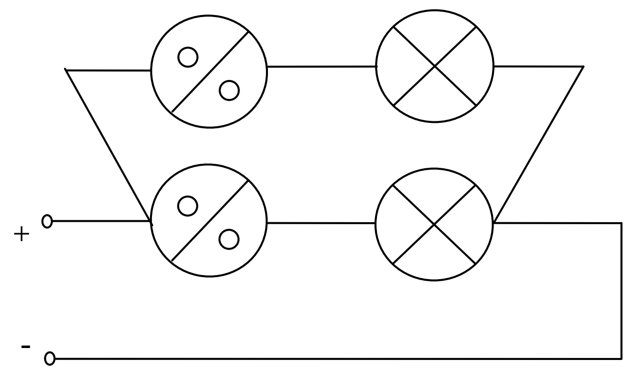
1. Neat and tight connections must be ensured.

Result:

The circuit for two lamps in parallel with one switch was wired up and tested .

EXPERIMENT # 4
To control two lamps with two switches individually.
Apparatus:
Two Switches, two bulb holders, two bulbs, screw driver, connecting wires, wire cutter, AC supply

Circuit Diagram:



Procedure:
1. Draw the circuit diagram and get them approved by staff in charge.
2. Prepare the list of tools and materials required for the work and collect them.
3. Cut the connecting wires into suitable length and make the connections according to the circuit diagram.
4. Positive terminal of the battery is connected with the switch, and one wire is connected with the other switch.
5. Two connecting wires are used for the connection of bulbs with individual switches. Two bulbs are connected in parallel as shown in the figure. The negative terminal of the battery is connected with the 2nd end of bulb.
6. The circuit is then checked by providing the AC supply to the circuit and shown to the supervisor.

Precautions:
1. Neat and tight connections must be ensured.

Result:
The circuit for two lamps controlled individually with switches was wired up and tested .

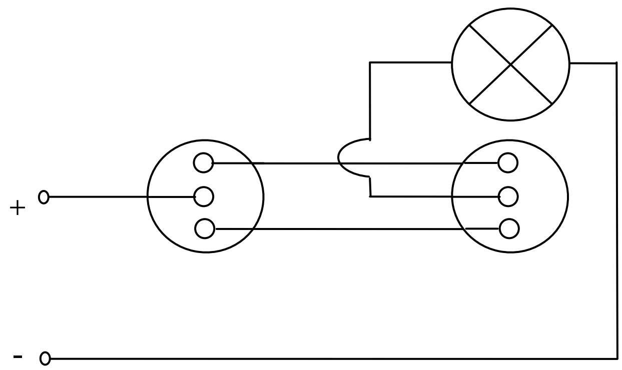
EXPERIMENT # 5

To control one lamp with two two-way switches.

Apparatus:

2 two way switches, connecting wires, bulb holder, bulb, screw driver, wire cutter, AC supply

Circuit Diagram



Procedure:

1. Draw the circuit diagram and get them approved by staff in charge.
2. Prepare the list of tools and materials required for the work and collect them.
3. Cut the connecting wires into suitable length and make the connections according to the circuit diagram.
4. Positive terminal of the battery is connected with the centre point of two-way switch. Two connecting wires are then taken and the extreme points of two-way switches are joined together as shown in the figure.
5. One cross wire is connected with the center point of 2nd two-way switch and with the bulb. The negative terminal is then connected with the other point of the bulb to make a complete circuit.
6. The circuit is then checked by providing the AC supply to the circuit and shown to the supervisor.

Precautions:

1. Neat and tight connections must be ensured.

Use:

This type of circuit is usually made at stairs of houses where we need to have two switches for the on-off of bulb.

Result:

The circuit for controlling one lamp with two way switches was wired up and tested .