1.Effects of Electric Current

FOCUS AREA

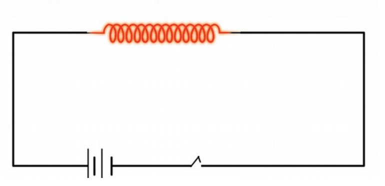
- Energy change in electrical devices
- Heating effect of electric current.
- Joule's Law & Mathematical problems related to these.
- Arrangement of Resistors in Circuits-Series Connection and Parallel Connection - Mathematical problems related to these.
- Electric heating appliances.
- Peculiarities of substances used as heating coil.
- Short circuit, Overloading.
- Working of Safety fuse.
- Peculiarities of substances used as fuse wire.
- Electric power & Mathematical problems related to these.

1. Energy change in electrical devices

Device	Use	Energy change
Electric bulb	To get light	Electrical energy → Light energy
Induction cooker	To get heat	Electrical energy → Heat energy
Storage battery (while charging)	To store current	Electrical energy → Chemical energy
Mixer grinder	For grinding	Electrical energy → Mechanical energy
Electric Fan	To get breeze	Electrical energy → Mechanical energy

2. Heating effect of electric current

* When electricity passes through any conductor, it generates heat energy.



One volt

* The potential difference between two points will be one volt if one joule of work is done in moving one coulomb of charge from one point to the other.

Joule Heating or Ohmic Heating.

* Heat is developed in a circuit on passing current through it is known as the Joule Heating or Ohmic Heating.

* What are the factors influencing the heat developed when a current passes through a conductor?

1. Intensity of electric current (I)
2. Resistance of the conductor (R)
3. The time of flow of current (t)

3. Joule's Law & Mathematical problems related to these.

The heat generated (H) in a current carrying conductor is directly proportional to the product of the square of the current (I) in the conductor, the resistance of the conductor (R) and the time (t) of flow of current.

$H \propto I^2 Rt$ $\therefore H = I^2 Rt$ joule

I is the current in ampere, R is the resistance in ohm and t is the time in second.

$H = I^2Rt$
$H = VIt$

$H = (V^2/R)\,t$

H - Heat energy
R -Resistance
V -Potential difference

I - Current
t - Time

Mathematical problems which are related to Joules Law.

1. How much will be the heat developed if 0.2 A current flows through a conductor of resistance 200 Ω for 5 minute?

Current I = 0.2 A
Resistance R = 200 Ω
Time t = 5 x 60 = 300 s
Heat H = ?

$H = I^2Rt$
$= (0.2)^2 \times 200 \times 300$
$= 2400$ J

* If 4.2 J is one calorie then H = 2400 / 4.2 = 571.4 calorie

2. Find out the heat developed in 3 minute by a device of resistance 920 Ω working under 230 V

Resistance R = 920 Ω

Voltage V = 230 V

Time t = 3 x 60 = 180 s

Heat H = ?

$H = (V^2/R)t$

$= (230^2/920)\times180$

$= 10350$ J

Ohm's law R = V/I

I = V / R

= 230 / 920 = 0.25 A

H = ?

$H = I^2Rt$

$= (0.25)^2\times920\times180$

$= 10350$ J

3. Let's calculate the heat developed when 3 A current flows through an electric iron box designed to work under 230 V for half an hour?

Current $I = 3\ A$
Voltage $V = 230\ V$
Time $t = 30 \times 60 = 1800\ s$

Heat $H = ?$

$$H = Vit$$
$$= 230 \times 3 \times 1800$$
$$= 1242000\ J$$

4. Arrangement of Resistors in Circuits-Series Connection and Parallel Connection - Mathematical problems related to these

1. Series Connection

When a circuit is completed by connecting the resistors one after the other, it is called series connection.

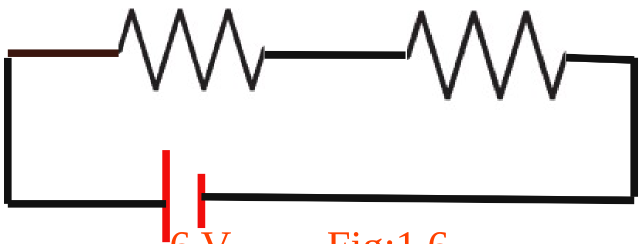


Fig:1.6

Effective resistance, $R = R_1 + R_2$

Effective resistance is the sum of the resistance of all the resistors when they are connected in series.

Ex. 1 (Fig.1.6)

$R_1 = 3\ \Omega$
$R_2 = 6\ \Omega$

Effective resistance, $R = R_1 + R_2$
$R = 3\ \Omega + 6\ \Omega$
$R = 9\ \Omega$

When resistors are connected in series,

* The potential difference gets divided

* The current through each resistor will be the same.

* The effective resistance increases.

2. Parallel Connection

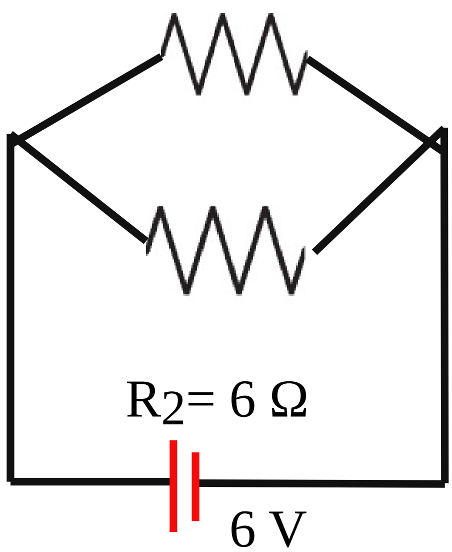


fig1.7

Effective resistance, $1/R = 1/R_1 + 1/R_2$

$$R = \frac{R_1 \times R_2}{R_1 + R_2}$$

Ex. 2 (Fig.1.7)

$R_1 = 3\ \Omega$

$R_2 = 6\ \Omega$

Effective resistance, $R = \frac{R_1 \times R_2}{R_1 + R_2}$

$$R = \frac{3\ \Omega \times 6\ \Omega}{3\ \Omega + 6\ \Omega}$$

$R = 2\ \Omega$

When resistors are connected in Parallel,

* The potential difference in each resistors are same.
* Current through each resistors are different.
* The effective resistance decreases.

If resistors of the same value are connected in parallel, then $R = \frac{r}{n}$, where n is the number of resistors and r is the resistance of one resistor.

5.Electric heating appliances

* Name the part in which electrical energy changes into heat energy.
  - Heating coils
* Which material is used to make this part?
- Nichrome(Nichrome is an alloy of nickel, chromium and iron)

6. Peculiarities of substances used as heating coil.

* What are the peculiarities of heating coil?
  - High resistivity
  - Ability to remain in red hot condition for a long time without getting oxidised
  - High melting point

7. Short circuit, Overloading.

Short Circuit

If the positive and the negative terminals of a battery or the two wires from the mains come into contact without the presence of a resistance in between, they are said to be short-circuited.

Overloading

A circuit is said to be overloaded if the total power of all the appliances connected to it is more than what the circuit can withstand.

8. Working of Safety fuse

Safety fuse is a device that works on the heating effect of electric current.

* Which material is used to make fuse wire?
  - Fuse wire, an alloy of tin and lead,

* Which are the circumstances that cause high electric current, leading to the melting of fuse wire?
  -Short Circuit and Overloading

* How is the fuse wire connected to a circuit?
- In series.

* How dose a fuse wire working?

When there is an overloading or short-circuit in the circuit.

↓

When electric current is increased.

↓

According to Joule s Law, more heat will be produced.

↓

The fuse wire melts.

↓

The circuit is broken

9. Peculiarities of substances used as fuse wire.

* What are the peculiarities of fuse wire?
  -low melting point, More ductility.

* When a fuse wire is included in a household wiring, what are the precautions to be taken?

• The ends of the fuse wire must be connected firmly at appropriate points.

• The fuse wire should not project out of the carrier base.

10. Electric power & Mathematical problems related to these

* The amount of energy consumed by an electrical appliance in unit time is its power.
* The unit of power is watt (W)

$$\text{Power, } P = \frac{\text{Work}}{\text{time}} = \frac{H}{t}$$

$$P = VI$$
$$P = I^2R$$
$$P = V^2/R$$

Amperage

* Amperage (A) is the ratio of the power of an equipment to the voltage applied. Amperage increases with the thickness of the conductor.

$$\text{Amperage} = \frac{\text{Wattage}}{\text{Voltage}} = \frac{W}{V}$$

1. An appliance of power 540 W is used in a branch circuit. If the voltage is 230 V, what is its amperage?

Power P = 540 W

Voltage V = 230 V

Amperage = Wattage / Voltage = W / V

Amperage = 540 / 230 = 2.34 A ≈ 2.4 A

2. A heating appliance has a resistance of 115 Ω. If 2 A current flows through it, what is the power of the appliance?

Resistance R = 115 Ω

Current I = 2 A

Power $P = I^2 R$

$= 2^2 \times 115 = 460$ W

3. A current of 0.4 A flows through an electric bulb working at 230 V. What is the power of the bulb?

Voltage V = 230 V

Current I = 0.4 A

Power P =VI

= 230 x 0.4 =92 W

4. Power of an electrical appliance is 1600 W. The device works at 400 V. If we give 200 V instead of 400 V. what is its power?

Power P = 1600 W

Voltage V = 400 V

Power $P = V^2 / R$

$R = V^2 / P = (400)^2 / 1600 = 100\ \Omega$

Power at 200V = $(200)^2 / 100 = 400$ W

* If voltage is decreased to half then power decreases to one fourth.