UDAAN 3.0

PHYSICS

ELECTRICITY

Lecture No.- 06

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Today's Targets

1. THREE EFFECTS OF CURRENT
2. JOULE'S LAW OF HEATING
3. PRACTICAL APPLICATIONS OF HEATING EFFECTS
4. ELECTRICAL POWER
5. COMMERCIAL UNIT OF ENERGY

THREE EFFECTS OF CURRENT

1. **Chemical Effects of Current :** When Electric current is passed through the conducting solution, it causes chemical reactions to occur on cathode and anode. Example electroplating, Hydrolysis, Formation of Sodium Hydroxide (NaOH) (Class VIII and Class XII Electrochemistry)

2. **Magnetic Effects of Current :** When electric current is passed through a conductor, magnetic field is produced in the area around the conductor (Class X, Chapter ~~13~~ 12)

3. **Heating Effects of Current :** When current is passed through a conductor, due to repetitive collisions between moving charges and atoms, heat energy and power is dissipated. (Class X, Chapter ~~12~~ 11)

JOULE'S LAW OF HEATING

Heat $\propto$ (Current)^2 $\propto$ Resistance $\propto$ Time Period

$H \propto I^2$ $\propto R$ $\propto T$

It states that, "Heat produced in a conductor is directly proportional to the square the amount of Current flowing(I), Resistance(R) of the conductor, Time Period (T) of the flow of current".

$H \propto I^2Rt$

$H = I^2Rt$ =

Proof of Joule's Law:-

$V = \frac{W}{Q}$

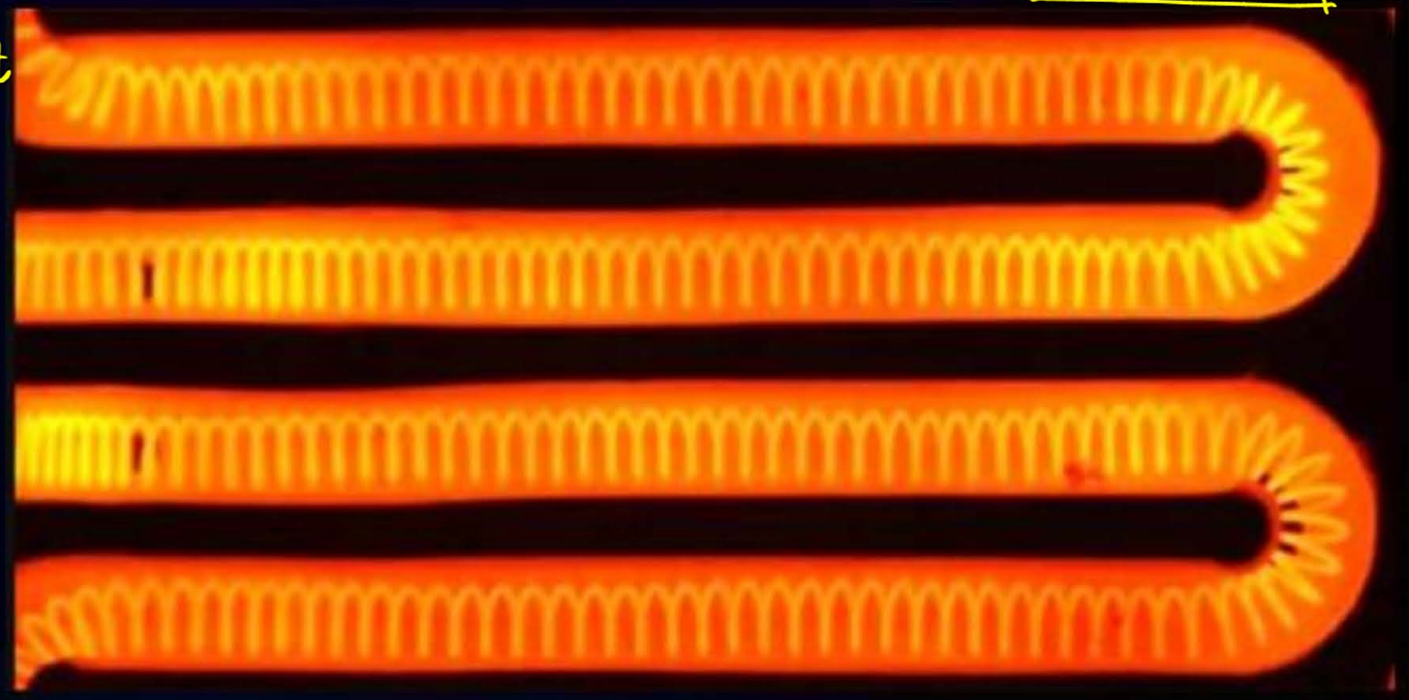
$W = QV$

$W = ItIR$

$H = I^2Rt$

$I = \frac{Q}{t} \Rightarrow Q = It$

$V = IR$



$H = I^2Rt$

Question

An electric iron of resistance 20 Ω takes a current of 5 *A*. Calculate the heat developed in 30 s.

$R = 20\,\Omega$
$I = 5\,A$
$t = 30\,s$

$H = I^2Rt$

$= 5^2 \times 20 \times 30$

$= 25 \times 2 \times 3 \times 100$

$H = 15000\,J$

Question

100 J of heat are produced each second in a 4 Ω resistance. Find the potential difference across the resistor.

$H = 100\ J$

$t = 1s$

$R = 4\Omega$

$V = ?$

$V = IR$

$= 5 \times 4 = 20V$

$H = I^2 R t$

$100 = I^2 \times 4 \times 1$

$\frac{100}{4} = I^2$

$I^2 = 25$

$I = 5A$

PRACTICAL APPLICATIONS OF HEATING EFFECTS

1. Electric Bulb:

↓

Filament

↓

Tungsten (W)

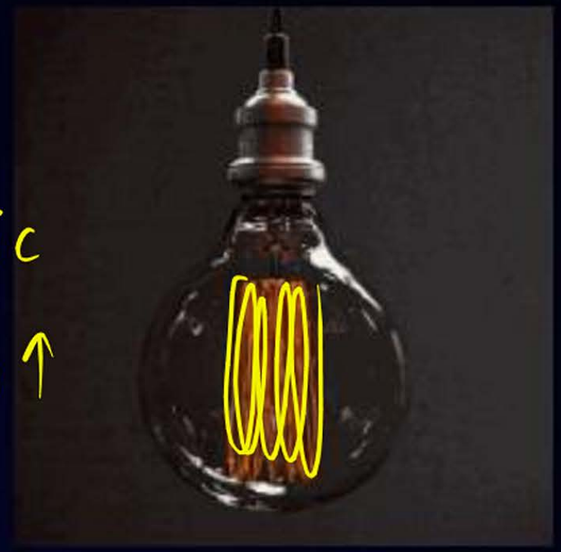
(Pure Metal)

→ M.P. V. High 3380°C

→ Heat Retention ↑

⇓

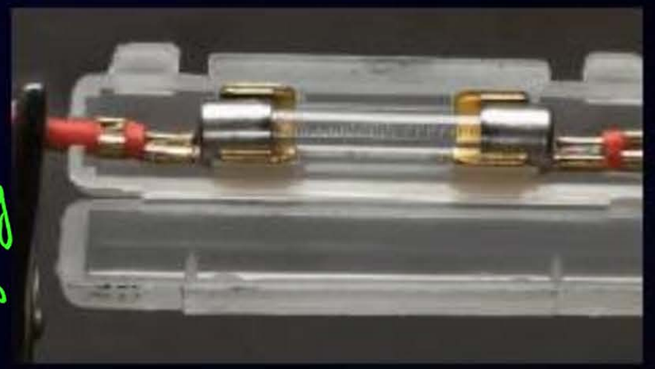
Glow

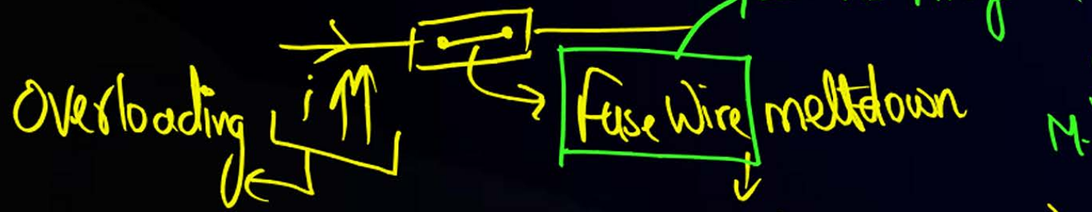


2. Electric Fuse:

Tin-lead Sn-Pb Alloy OR Cu-Ni Alloy

↓ M.P ↓ low

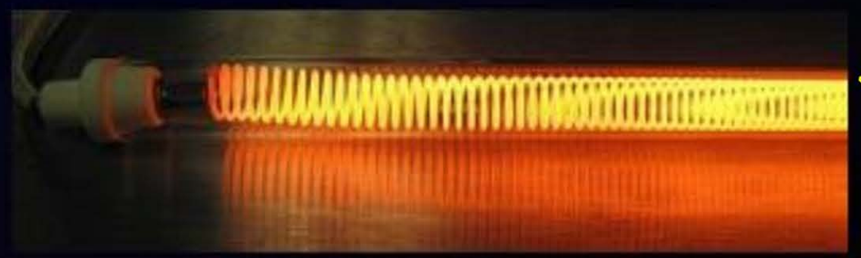




Ckt. Breaks (I = 0)

3. Heating Element:

↳ Heater, Geyser, Kettle etc.



P↑ R↑ H↑

↑

Nichrome Alloy

↑

Question

Which element is used to make:

A. Filament of the bulb → Tungsten

B. Connecting Wires → Copper

C. Heating Element → Nichrome Alloy

D. Fuse Wire → Sn-Pb Alloy

Question

Why does the cord of the electric heater does not glow but coil does ?

Wire

→ Cord is a pure metal made up of Copper which has low ρ R H

Glow

→ whereas Coil is an Alloy made up of Nichrome which has high ρ R H

ELECTRICAL POWER

$$\text{Power} = \frac{\text{Workdone}}{\text{time}} = \frac{\text{Energy transfer}}{\text{time}}$$

$$P = \frac{W}{t} = \frac{E}{t}$$

Watt ← $P = \frac{W}{t} = \frac{E}{t}$ → Joule/sec

SI unit ⇒ Watt or J/s

Derivation

$P = \frac{W}{t}$ ← $W = QV$ ← $V = \frac{W}{Q}$

$P = \left(\frac{Q}{t}\right)V$

$I = \frac{Q}{t}$

1. $P = VI$

$V = IR$ → $P = IRI$

2. $P = I^2R$

Series (I = Same)

$I = V/R$ → $P = V \times \frac{V}{R}$

3. $P = \frac{V^2}{R}$

Parallel (V = Same)

Energy

$P = \frac{\mathcal{E}}{t}$

$\boxed{\mathcal{E} = P \times t}$

$P = VI$ ✓

$P = \frac{V^2}{R}$ ✓

$P = I^2 R$ ✓

$\mathcal{E} = VIt$ ✓

$\mathcal{E} = \frac{V^2}{R} t$ ✓

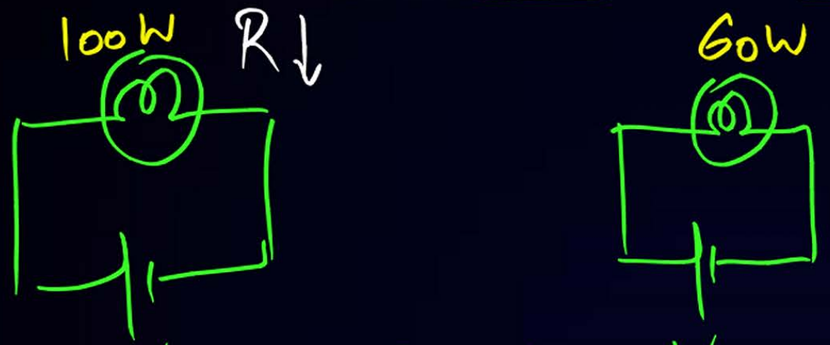
$\mathcal{E} = I^2 R t$ ✓

Question

Which has more resistance a 100 W bulb or a 60 W bulb?

P P

$P = \frac{V^2}{R}$



domestic Supply

$P = \frac{V^2}{R}$

$100 = \frac{V^2}{R_1}$

$100R_1 = V^2$

$60 = \frac{V^2}{R_2}$

$60R_2 = V^2$

$100R_1 = 60R_2$

$\frac{R_1}{R_2} = \frac{3}{5}$

$P_1 > P_2$

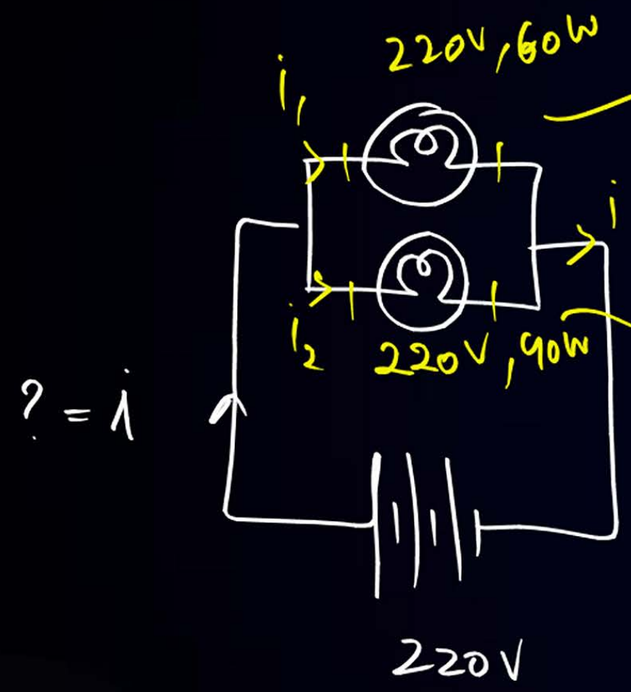
$R_2 > R_1$

$\uparrow P \propto \frac{1}{R} \downarrow$

When V = Constant

Question

A 60 W and a 40 W bulb is connected (in parallel) across a battery of 220 V, find the amount of current flowing in the circuit.



$P = Vi_1$

$60 = 220 \times i_1 \Rightarrow i_1 = \frac{60}{220}$ A

$P = Vi_2$

$40 = 220 \times i_2 \Rightarrow i_2 = \frac{40}{220}$ A

$i = i_1 + i_2$

$= \frac{60}{220} + \frac{40}{220}$

$= \frac{100}{220} = \frac{5}{11}$

$= \frac{5}{11}$ A ✓

Question

M.W.

A bulb having power rating as 60 W, 220 V is connected across 110 V, how much power will be expended by the bulb?

COMMERCIAL UNIT OF ENERGY

Energy

- SI unit ⇒ Joule
- CGS unit ⇒ ergs
- Practical unit of Heat ⇒ Calorie (Cal.)
- Commercial unit of Energy ⇒ kWh (Kilowatt hour)

$E = P \times t$

Joule = Watt × Seconds

E = Kilowatt hour

$P \times T$

$1\ kwh = 3.6 \times 10^6\ J$

Question

An electric refrigerator rated 400 W operates 8 hour/day. What is the cost of the energy to operate it for 30 days at Rs 3.00 per kWh?

$P = 400\ W$

$t = \frac{8\ h}{1\ day} \times 30\ day = 240\ h$

$E = P \times t = \frac{400}{1000} \times 240\ h = 96\ kwh$

$1\ kwh \longrightarrow ₹\ 3$

$96\ kwh \longrightarrow 96 \times 3 = ₹\ 288$


Thank You