

Effects of Electric Current

heat from resistance, magnetism from motion, and current induced back again

The heating effect

- a current passing through a resistance produces heat, because the moving charges collide with the atoms of the conductor
- Joule's law: the heat produced is $H = I^2 R t$, proportional to the square of the current, the resistance and the time
- since the current is squared, doubling it produces four times the heat, which is the most useful thing to know here
- the heating effect is wanted in an electric heater, iron, geyser and filament lamp, where the element has a high resistance
- it is unwanted in motors and transformers, where it wastes energy and has to be carried away
- a fuse uses the effect deliberately: a thin wire of low melting point that melts and breaks the circuit if the current grows too large

Heat, power and energy *

Joule's law of heating

$$H = I^2 R t$$

electrical power, three equivalent forms

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

energy used in time t

$$E = Pt$$

the commercial unit of energy

$$1 \text{ kWh} = 3.6 \times 10^6 \text{ J}$$

Ohm's law, underlying all of these

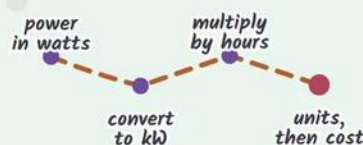
$$V = IR$$

which form of the power formula to use depends on what the question gives. If the voltage across a device is fixed, V^2/R is the one to reach for, and a lower resistance then draws more power

Cost of running an appliance

Q. A 1500 W heater runs for 4 hours a day for 30 days. Find the energy used in kWh and the cost at ₹5 per unit.

- convert the power to kilowatts: $1500 \text{ W} = 1.5 \text{ kW}$
- the total time is 4 hours a day for 30 days, that is 120 hours
- energy in kilowatt hours is power in kW times time in hours: 1.5×120
- so the energy used is 180 kWh, and one kWh is one unit
- the cost is 180×5
- therefore the cost is ₹900, and note that the whole calculation stays in kW and hours, with no conversion to joules needed



the four steps of any electricity bill question in order: the only conversion needed is watts to kilowatts, and the time must already be in hours before the multiplication

Answer 180 kWh, costing ₹900

