Unit 1
Particles, Quantum Phenomena and Electricity

5.2 More about resistance

AS25

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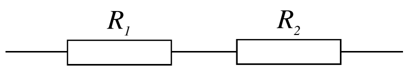
Adding resistors in series and parallel

(i) In series

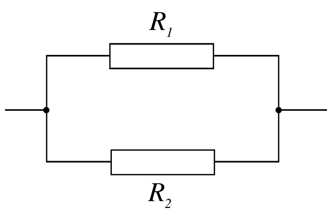
When resistors are connected in a series circuit, the current must flow through each one of them so the total resistance of the circuit is just the sum of the individual resistances.



The total resistance is given by $R_T = R_1 + R_2$

(ii) in parallel

When resistors are connected in parallel, each added resistor offers an extra path along which the current can flow, so the overall resistance is decreased. The total resistance is always smaller than the smallest resistor in the combination.



The total resistance is given by

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$$

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Power dissipated as heat in a resistor

- The resistance of a component is caused by collisions between the electrons and the positive ions of the conducting material. These repeated collisions transfer energy and cause the ions to vibrate more violently. This random vibration is what we know as heat.
- Since the p.d. across a component is the number of joules of energy each coulomb delivers to it, and the current is the number of coulombs flowing through it every second, we can find the number of joules delivered per second, (that is, the power delivered), from the equation:

$$\text{power supplied,} \quad P = IV$$

- Combining this equation with the equation relating p.d., current and resistance, $V = IR$, we can express this power in two other ways:

$$P = I^2R \quad \text{and} \quad P = \frac{V^2}{R}$$

The power dissipated as heat in a component of constant resistance, (in other words, at constant temperature), is usually expressed using the form:

$$\text{rate of heat transfer} = I^2R$$

The total heat transferred or dissipated is then just power $\times$ time, or

$$\text{Energy transfer} = IVt = I^2Rt = \frac{V^2}{R}t$$