27 Resistance and Power

Equations:

$$\text{voltage} = \text{current} \times \text{resistance} \qquad V = IR$$
$$\text{power} = \text{current} \times \text{voltage} \qquad P = IV$$

Example 1 – Calculate the power dissipated in a $6.0\ \Omega$ resistor carrying 3.5 A.
Voltage $= IR = 3.5\text{ A} \times 6.0\ \Omega = 21$ V
Power $= IV = 3.5\text{ A} \times 21\text{ V} = 73.5\text{ W} = 74$ W (2 sf)

Eliminating V, we have:

$$P = I \times V = I \times (IR) = I^2R: \quad \text{rearranging gives}$$
$$I^2 = P/R \quad \text{and} \quad R = P/I^2.$$

Example 2 – Calculate the resistance of a heater if it needs to carry 13 A when dissipating $3\,100$ W.
$R = P/I^2$, so $R = 3100/169 = 18\ \Omega$ (2 sf)

Eliminating I, we have:

$$P = I \times V = (V/R) \times V = V^2/R: \quad \text{rearranging gives}$$
$$V^2 = PR \quad \text{and} \quad R = V^2/P.$$

Example 3 – Calculate the power dissipated when a $200\ \Omega$ resistor is connected to a 240 V supply.
$P = V^2/R = 240^2/200 = 290$ W (2 sf)

Example 4 – Calculate the resistance of a 50 W light bulb connected to a 12 V supply.
$R = 12^2/50 = 2.9\ \Omega$ (2 sf)

27.1 Use a two stage method, as in example 1, where you need to first calculate the unknown voltages or the unknown currents: Calculate the power when

(a) 3.2 A flows through an 18 Ω resistor;

(b) 32 A flows through a 2.0 Ω wire;

(c) an 18 Ω resistor is connected to a 24 V supply;

(d) a 2.0 Ω wire is put across the terminals of a 240 V supply.

27.2 Complete the table, where each row is a separate situation.

Voltage	Current	Resistance	Power
9.0 V	(a)	300 Ω	(b)
240 V	13 A	(c)	(d)
240 V	(e)	25 Ω	(f)
(g)	100 A	3.0 Ω	(h)
240 V	(i)	(j)	2 500 W
240 V	(k)	(l)	60 W
23 kV	(m)	(n)	23 MW
9.0 V	(o)	22 kΩ	(p)
(q)	30 mA	(r)	0.75 W

27.3 What voltage is needed if 3.0 W of power is going to be dissipated in a 4.5 Ω resistor?

27.4 Some of the power coming into houses is wasted by the wires carrying the current due to their resistance.

(a) For a particular house, the wire which supplies it has a resistance of 1.5 Ω. If the current is 83 A, what is the power wastage in the supply wire?

(b) For a different house, the rules say that no more than 6.0 V may be 'dropped' across the supply wire. What power wastage does this correspond to if the wire has a resistance of 2.5 Ω?

27.5 What is the resistance of a 1.2 kW light bulb operating on a voltage of 115 V?

27.6 Old lamp dimmers were variable resistors wired in series with the light bulb. Suppose you put a $25\ \Omega$ resistor in series with a lamp such that the voltage across the lamp is only half of the 230 V supply voltage. What is the power dissipated by the resistor?

27.7 The National Grid operates at voltages of up to 400 kV. A generator has an output power of 68 MW at 400 kV. If the wire supplying customers has a resistance of $6.5\ \Omega$, calculate

(a) the current in the wire;

(b) the voltage 'dropped' along the wire, and;

(c) the power 'wasted' in the wire.

27.8 A resistor carries a current of 2.0 A.

(a) If its resistance is $50\ \Omega$, what is the power developed in it?

(b) If its resistance is $48\ \Omega$, what is the power developed in it?

27.9 What is the resistance of a resistor which develops $1\,000$ watts of power when 10 amps flows through it?

27.10 In the UK, mains voltage is 230 V.

(a) Calculate the power of a hair dryer element which is designed to operate from the mains and has an element of resistance $57.6\ \Omega$.

(b) What electric power is used by a light bulb which has a filament resistance of $1\,440\ \Omega$ and works on mains voltage?