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27 Resistance and Power

Equations:

$$\text{voltage} = \text{current} \times \text{resistance}$$

$$V = IR$$

$$\text{power} = \text{current} \times \text{voltage}$$

$$P = IV$$

Example 1 – Calculate the power dissipated in a $6.0 \, \Omega$ resistor carrying $3.5 \, \text{A}$.

$$\text{Voltage} = IR = 3.5 \, \text{A} \times 6.0 \, \Omega = 21 \, \text{V}$$

$$\text{Power} = IV = 3.5 \, \text{A} \times 21 \, \text{V} = 73.5 \, \text{W} = 74 \, \text{W} \, (2 \, \text{sf})$$

Eliminating V , we have:

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

$$I^2 = P/R \quad \text{and} \quad R = P/I^2.$$

Example 2 – Calculate the resistance of a heater if it needs to carry $13 \, \text{A}$ when dissipating $3100 \, \text{W}$.

$$R = P/I^2, \text{ so } R = 3100/169 = 18 \, \Omega \, (2 \, \text{sf})$$

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 $240 \, \text{V}$ supply.

$$P = V^2/R = 240^2/200 = 290 \, \text{W} \, (2 \, \text{sf})$$

Example 4 – Calculate the resistance of a $50 \, \text{W}$ light bulb connected to a $12 \, \text{V}$ supply.

$$R = V^2/P = 12^2/50 = 2.9 \, \Omega \, (2 \, \text{sf})$$

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 $18\ \Omega$ resistor;
- (b) 32 A flows through a $2.0\ \Omega$ wire;
- (c) an $18\ \Omega$ resistor is connected to a 24 V supply;
- (d) a $2.0\ \Omega$ 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)	$300\ \Omega$	(b)
240 V	13 A	(c)	(d)
240 V	(e)	$25\ \Omega$	(f)
(g)	100 A	$3.0\ \Omega$	(h)
240 V	(i)	(j)	2 500 W
240 V	(k)	(l)	60 W
23 kV	(m)	(n)	23 MW
9.0 V	(o)	$22\ \text{k}\Omega$	(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 $4.5\ \Omega$ 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 $1.5\ \Omega$. 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 $2.5\ \Omega$?

- 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?