Power

4.2.4.1 · Electricity · revision notes

How the power of a device depends on the potential difference across it and the current through it (P = V I), or on the current and its resistance (P = I² R). Expect 2 to 4 mark calculations, often with rearranging, a square root or a unit conversion.

Key facts

- Power = rate of energy transfer; unit: watt (W) = J/s
- P = I^2 R: power (W) = current^2 (A^2) × resistance (Ω)
- Grade 7+ only I = √(P ÷ R) and R = P ÷ I^2
- P = V I: power (W) = pd (V) × current (A)
- I = P ÷ V and V = P ÷ I
- 1 kW = 1000 W

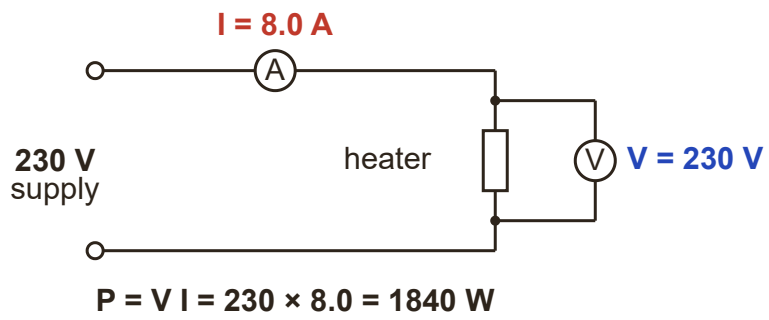
Notes

What power means

- Power is the **rate** at which energy is transferred: the energy transferred each second.
- Power is measured in **watts (W)**. 1 W is 1 joule of energy transferred per second. 1 kW = 1000 W.
- The power of a device depends on the pd across it and the current through it. A bigger pd or a bigger current means more energy is transferred each second.

P = V I

- power = potential difference × current: **P = V I** (P in W, V in V, I in A).
- Rearranged: I = P ÷ V and V = P ÷ I.
- Example: a heater on the 230 V mains with a current of 8.0 A has a power of 230 × 8.0 = 1840 W.



Power from the meter readings: P = V × I.

$P = I^2 R$

- power = (current)^2 × resistance: **$P = I^2 R$** (P in W, I in A, R in Ω).
- Use it when you know the current and the resistance but not the pd, e.g. for the energy transferred by heating in a cable.
- Square the current first: for I = 3.0 A and R = 5.0 Ω, $P = 3.0^2 \times 5.0 = 9.0 \times 5.0 = 45$ W.
- Doubling the current makes the power four times bigger (for the same resistance). Grade 7+ only
- To find the current: $I = \sqrt{(P \div R)}$. To find the resistance: $R = P \div I^2$. Grade 7+ only

How the equations link Grade 8+ only

- $P = I^2 R$ comes from $P = V I$ with $V = I R$ put in its place: $P = (I R) \times I = I^2 R$.
- So if you know any two of V, I and R, you can find the third with $V = I R$ and then the power with either equation.

How to answer each type of question

Calculate power using P = V I

2 marks **Grade 4**

1. Write $P = V I$.
2. Substitute the pd in volts and the current in amps.
3. Give the answer in watts.

Example. A hairdryer is connected to the 230 V mains supply. The current through it is 5.0 A. Calculate the power of the hairdryer.

Model answer.

$P = 230 \times 5.0$ (1)

$P = 1150$ W (1)

Calculate the current from a power rating

3 marks **Grade 5**

1. Convert kW to W.
2. Rearrange to $I = P \div V$.
3. Substitute and give the answer in amps.

Example. A kettle has a power rating of 2.3 kW. It is connected to the 230 V mains supply. Calculate the current through the kettle.

Model answer.

$P = 2.3 \times 1000 = 2300$ W (1)

$I = P \div V = 2300 \div 230$ (1)

$I = 10$ A (1)

Calculate power using $P = I^2 R$

2 marks | Grade 6

1. Write $P = I^2 R$.
2. Square the current, then multiply by the resistance.
3. Give the answer in watts.

Example. The current through a resistor of resistance 20 Ω is 0.50 A.
Calculate the power transferred by the resistor.

Model answer.

$P = 0.50^2 \times 20$ (1)

$P = 0.25 \times 20 = 5.0$ W (1)

Find the current using $P = I^2 R$

3 marks | Grade 8

1. Rearrange to $I^2 = P \div R$.
2. Calculate I^2 and write it down.
3. Take the square root to find I, and give the unit.

Example. A heating element has a resistance of 48 Ω. The power of the heating element is 1200 W.
Calculate the current through the heating element.

Model answer.

$I^2 = P \div R = 1200 \div 48$ (1)

$I^2 = 25$ (1)

$I = \sqrt{25} = 5.0$ A (1)

Don’t lose marks

- Forgetting to square the current in $P = I^2 R$, or squaring $I \times R$ instead of just I.
- Leaving the power in kW when using $P = V I$: convert to W first.
- Forgetting to take the square root at the end when finding I from $P = I^2 R$.
- Choosing the wrong equation. Pick the one that uses the two quantities you are given.

More tips

Memory tricks

- Formula triangle for P = V I: P on top, V and I underneath.
- A rhyme for the second equation: 'Twinkle, twinkle, little star, power equals I squared R.'
- Sense check: kettles and heaters are a few kilowatts, so on the 230 V mains their current is about 10 A.

Exam technique

- Practise choosing between P = V I and P = I^2 R using the quantities given.
- Write down the equation before substituting. This often earns the first mark.
- Show intermediate values, such as I^2 = 25, so the method marks are clear.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3

State the unit of power

Power is measured in watts (W); 1 W is 1 joule per second.

Grade 4

Explain what power means

Power is the rate of energy transfer: the energy transferred each second.

Grade 4

Calculate power using P = V I

Multiply the pd in volts by the current in amps to get the power in watts.

Grade 5

Rearrange P = V I

Use I = P ÷ V, e.g. to find the current an appliance takes from the mains.

Grade 6

Calculate power using P = I² R

Square the current first, then multiply by the resistance.

Grade 7

Find current or resistance from P = I² R

Use I = √(P ÷ R) or R = P ÷ I².

Grade 8

Combine power equations with V = I R

Link P = V I, P = I² R and V = I R in multi-step problems.

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