

# 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 ( $P = I^2 R$ ). 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
- $P = V I$ : power (W) = pd (V) × current (A)
- $P = I^2 R$ : power (W) = current<sup>2</sup> (A<sup>2</sup>) × resistance (Ω)
- $I = P \div V$  and  $V = P \div I$
- 1 kW = 1000 W

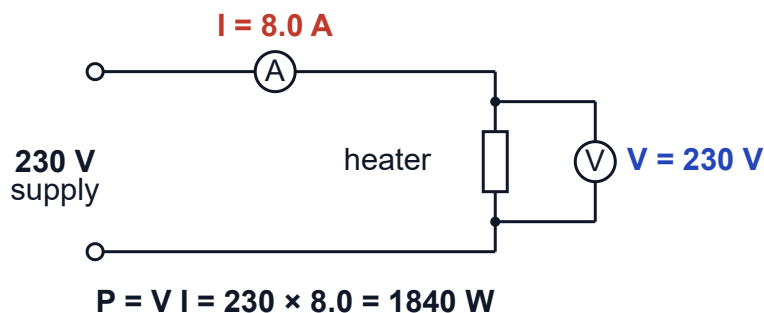
### Notes

#### 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:  $I = P \div V$  and  $V = P \div I$ .
- Example: a heater on the 230 V mains with a current of 8.0 A has a power of  $230 \times 8.0 = 1840$  W.



Power from the meter readings:  $P = V \times I$ .

## **$P = I^2 R$**

- power = (current)<sup>2</sup> × resistance:  **$P = I^2 R$**  (P in W, I in A, R in  $\Omega$ ).
- 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  $\Omega$ ,  $P = 3.0^2 \times 5.0 = 9.0 \times 5.0 = 45$  W.

### 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)

### 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  $P = VI$ : 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

- $P = VI$  and  $P = I^2 R$  must both be learned: neither is on the equation sheet.
- 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 $P = VI$

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

### Grade 5

#### Rearrange $P = VI$

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

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