Power

6.1.1.4 · Physics · revision notes

Power is how quickly energy is transferred or work is done. You need to calculate power, energy and time with P = E ÷ t and P = W ÷ t, and explain what a greater power means. Questions are usually 2 to 4 marks, often joined to work done, gravitational potential energy or efficiency.

Key facts

- Power = rate of energy transfer = rate of doing work
- P = W ÷ t
- 1 W = 1 J/s
- E = P × t and t = E ÷ P
- P = E ÷ t
- Units: P in W, E and W in J, t in s
- 1 kW = 1000 W; 1 MW = 1 000 000 W

Notes

What power means

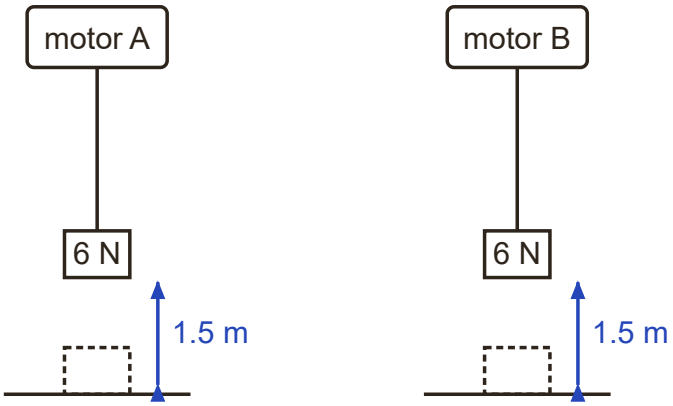
- **Power** is the rate at which energy is transferred, or the rate at which work is done.
- The unit of power is the **watt (W)**. An energy transfer of 1 joule per second is a power of 1 watt.
- 1 kilowatt (kW) = 1000 W; 1 megawatt (MW) = 1 000 000 W.
- Example: a 40 W lamp transfers 40 J of energy every second.

The equations

- P = E ÷ t and P = W ÷ t (both on the equations sheet).
- P = power (W), E = energy transferred (J), W = work done (J), t = time (s).
- Rearranged: E = P × t and t = E ÷ P.
- When a motor lifts a load at a steady speed, the useful work it does equals the gain in the load's gravitational potential energy (m g h).

Comparing powers

- Two motors lift the same weight through the same height. They do the same amount of work, but the one that does it in less time has the greater power.



work = 6 × 1.5 = 9 J
time = 3.0 s
power = 9 ÷ 3 = 3.0 W

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time = 9.0 s
power = 9 ÷ 9 = 1.0 W

Same work done, less time, so motor A has the greater power.

- A 3 kW kettle heats the same amount of water faster than a 2 kW kettle, because it transfers energy at a greater rate.
- A more powerful device does not always transfer more energy in total: that also depends on how long it is switched on.

How to answer each type of question

Calculate the power

2 marks | **Grade 4**

1. Write P = E ÷ t (or P = W ÷ t).
2. Check the energy is in J and the time is in s.
3. Substitute and give the unit W.

Example. An electric motor transfers 9000 J of energy in 30 s.
Calculate the power of the motor.

Model answer.

P = 9000 ÷ 30 (1)
P = 300 W (1)

Calculate the energy transferred (with unit conversions)

2 to 3 marks | Grade 5

1. Convert kW to W and minutes to s.
2. Rearrange: E = P × t.
3. Substitute and give the unit J.

Example. A 2.5 kW electric heater is switched on for 4.0 minutes.
Calculate the energy transferred by the heater.

Model answer.

P = 2500 W and t = 240 s (1)
E = 2500 × 240 (1)
E = 600 000 J (1)

Calculate power from the energy gained or work done

3 to 4 marks | Grade 7

1. Work out the energy transferred or the work done first, e.g. E_p = m g h.
2. Divide by the time in seconds.
3. Use the unrounded value from the first step.

Example. A crane lifts a load of mass 800 kg through a height of 12 m in 40 s.
gravitational field strength = 9.8 N/kg
Calculate the useful power output of the crane.

Model answer.

E_p = 800 × 9.8 × 12 (1)
E_p = 94 080 J (1)
P = 94 080 ÷ 40 (1)
P = 2352 W (about 2400 W) (1)

Explain which device has the greater power

2 marks | Grade 5

1. Compare the energy transferred (or work done) by each device.
2. Compare the times taken.
3. Link to power: the same energy in less time means a greater power.

Example. Motor A and motor B each lift a weight of 5.0 N through a height of 2.0 m. Motor A takes 4.0 s and motor B takes 10 s.
Explain which motor has the greater power.

Model answer. Both motors do the same amount of work (10 J) (1). Motor A does it in less time, so it transfers energy at a greater rate and has the greater power (1).

Don’t lose marks

- Leaving the time in minutes or hours instead of seconds.
- Not converting kW (or MW) to W.
- Defining power as 'energy' or 'how strong something is'. Power is the rate of energy transfer.
- Mixing up W for the watt (the unit) with W for work done (in the equation).

More tips

Memory tricks

- Power = how fast; energy = how much.
- Triangle: E on top, P and t underneath. Cover the one you want.
- Sense check: household devices range from a few watts (a phone charger) to about 3 kW (a kettle).
- If you keep the power in kW and the time in seconds, the energy comes out in kJ.

Exam technique

- For a definition, use the word 'rate': 'power is the rate of energy transfer'.
- In compare questions, mention both the energy (or work done) and the time.
- Give the final unit: W, or kW if the question asks for it.

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 transferred per second.

Grade 4 — **Define power**
Power is the rate at which energy is transferred, or the rate at which work is done.

Grade 4 — **Calculate power from energy and time**
Divide the energy transferred (J) by the time taken (s).

Grade 5 — **Compare the power of two machines**
If two motors do the same work, the one that takes less time has the greater power.

Grade 5 — **Convert kW, kJ and minutes first**
Change kilowatts to watts, kilojoules to joules and minutes to seconds before you substitute.

Grade 5 — **Rearrange to find energy or time**
E = P × t and t = E ÷ P.

Grade 7 — **Combine power with work done or energy**
Find the work done or gravitational potential energy gained first, then divide by the time.

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