Power and energy devices

Teacher review edition. Ask your teacher if anything is unclear.

How can we test whether a device design has improved?

What you will learn

- Calculate power and energy.
- Calculate electrical power using voltage and current.
- Set clear design criteria and use fair tests to improve a device.

What is power?

Power
Energy transferred each second. Measured in watts (W); 1 W = 1 J per second.

$$\text{power} = \frac{\text{energy transferred}}{\text{time taken}}$$

- Power is measured in watts (W). One W = one joule transferred each second.
- Average power = energy transferred ÷ time taken.
- A motor transfers 180 J in 30 s: average power = 180 ÷ 30 = 6 W.

Power and energy are different

Energy is an amount. Power is the amount transferred each second.

$$\text{energy transferred} = \text{power} \times \text{time}$$

- Energy = power × time.
- A 6 W motor running for 50 s transfers 6 × 50 = 300 J.
- A higher-power device transfers energy faster, but its running time also affects total energy use.
- A 10 W device running for 10 s and a 5 W device running for 20 s each transfer 100 J.

Electrical power

Electrical power
The rate of electrical energy transfer. Calculate it by multiplying voltage by current.

electrical power = potential difference × current

- Use volts and amps to obtain power in watts.
- For a lamp at 3 V and 0.4 A: power = 3 × 0.4 = 1.2 W.
- The lamp transfers 1.2 J of electrical energy each second.

Start a design with a clear job

Design criterion
A measurable requirement that tells you whether a design does its job.

- Example: lift a 50 g load through 20 cm in less than 10 s.
- Agree limits such as materials, battery supply and load before building.
- Include safety as well as performance.

Improve a design using test results

1. Set a measurable goal
↓
2. Build a prototype
↓
3. Test and evaluate
↓
4. Improve and test again

Use the test results to choose an improvement. Repeat the cycle when needed; do not assume a change works until it is tested.

Build and test a prototype

Prototype
A model built to test a design idea.

- Sketch the design and label the parts before building.
- Show the energy pathway: battery → motor → lifted load.

- Test against your criteria. Record the load, height and time.
- Repeat trials to check reliability. Record failures too: slipping string, friction or weak connections may explain them.

Change one thing and test again

> **Improvement**
> A change that makes a design work better, supported by the results of a new test.

Change one feature so you can tell whether it helps.

- Try a different pulley or a stronger support.
- Keep load, lifting height and supply conditions the same.
- Repeat the same test for both versions.
- If several things change at once, you cannot tell which caused an improvement.

Evaluate the result

> **Evaluation**
> Comparing test results with what a design was meant to achieve.

- Use measurements to check each design criterion.
- Consider speed, energy use, reliability and safety together.
- A faster device might also use more energy or fail more often.
- Record a sketch, the results and a reason for the next improvement.

Worked examples

A motor transfers 180 J in 30 s. Find its average power. Then find the energy it transfers in 50 s if it keeps the same power.

Work through it

1. Power = energy ÷ time = 180 ÷ 30 = 6 W.
2. Energy = power × time.
3. In 50 s, energy = 6 × 50 = 300 J.

$$\text{power} = \frac{180}{30} = 6 \text{ W}$$

$$\text{energy} = 6 \times 50 = 300 \text{ J}$$

Common mistakes

Common mistake: Giving energy in watts and power in joules.

Remember: Energy is measured in joules; power is measured in watts, or joules per second.

Common mistake: Claiming a design is better because it worked once.

Remember: Repeat comparable tests and check all the agreed design criteria, including safety and reliability.

Answering questions

- Write down energy and time with their units before choosing power = energy ÷ time or energy = power × time.
- When evaluating a design change, quote a result and explain how it relates to a specific design criterion.

Try an investigation

Design a low-voltage device to lift a small load. Agree the load and height with your teacher. Sketch, build and test it, keeping moving parts clear of fingers. Change one feature and repeat the same test. Use the results to explain whether the change helped.

Plan, record and review

- Question and prediction: What are you testing, and what do you think will happen? Give a reason.
- Change, measure, keep the same: What will you deliberately change? What will you measure, and in what units? What stays the same to make it a fair test? For an observation, say what you will record consistently instead.
- Record and look for a pattern: Use a table with headings and units. Look for a pattern or a result that does not fit.
- Conclude from evidence: Answer your question using a result or observation. Say if the evidence is unclear.
- Improve the investigation: What would you repeat or change, and how would that make the evidence better?

Do practical work with your teacher and follow the laboratory safety instructions.