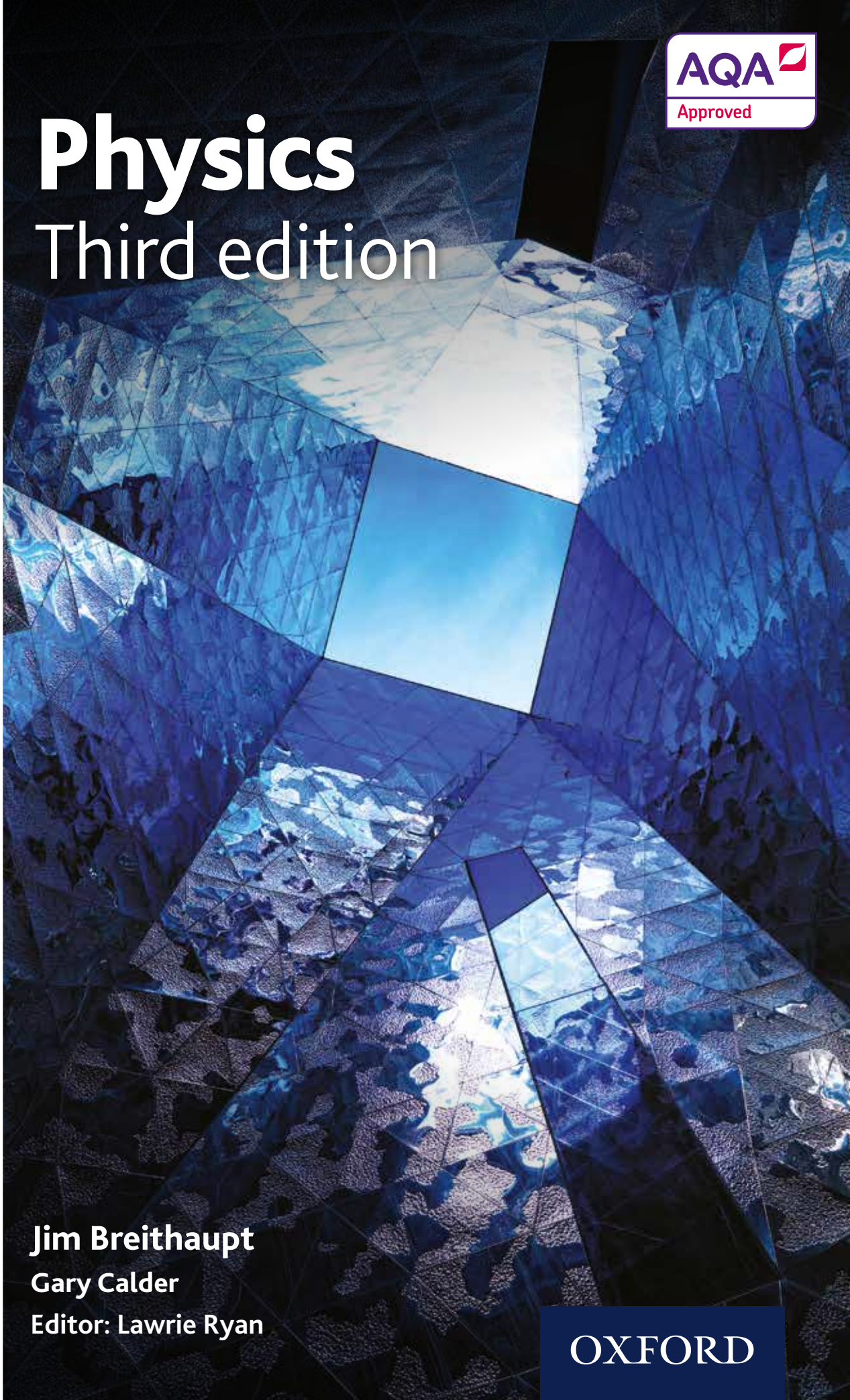
AQA

GCSE

Physics

Third edition



AQA Approved

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OXFORD

1 Energy and energy resources

Energy is needed to make objects move and to keep devices such as mobile phones working. Most of the energy you use is obtained by burning fuels, such as coal, oil, and gas.

The ability to access energy at the flick of a switch makes life much easier. People in developing countries often can't access energy as easily as we can, while people in developed countries are burning too much fuel and are endangering our planet by making the atmosphere warmer.

In this section you will learn about measuring and using energy. You will also learn how wind turbines and other energy resources that don't burn fuel could enable everyone to have access to energy.

Key questions

- How is energy stored and transferred?
- How can we calculate the energy needed to heat an object?
- What is meant by thermal conductivity?
- How can we compare different renewable energy resources?

Making connections

- Electricity generated in power stations provides us with energy at the flick of a switch. The energy we use from them reaches us from distant power stations via the National Grid, which is a vast network of cables and transformers. You will learn about electricity in **P4 Electric circuits** and **P5 Electricity in the home**, and about transformers in **P15 Electromagnetism**.
- Nuclear power stations provide electricity without burning fossil fuels. Instead, they use energy from uranium to generate electricity. A nuclear power station can generate enough electricity for hundreds of thousands of homes. You will learn more about nuclear reactors in **P7 Radioactivity**.

I already know...	I will learn...
Energy is a quantity that can be measured and calculated.	How to work out the energy stored in a moving object or in an object when it is lifted or stretched.
The total energy before and after a change has the same value.	How energy is stored and transferred and what happens to it after it is used.
Energy transfers can be compared in terms of usefulness.	How to compare machines and appliances in terms of their efficiency.
Energy transfer by heating can be reduced by using insulating materials.	How energy is transferred by heating through conduction.
Energy is transferred by radiation.	How energy transfer by radiation is causing the Earth to become warmer.
The energy needed to heat an object depends on its mass and the material it is made of.	How to work out the energy needed to heat an object.
A renewable resource will not run out because it is a natural process.	How to compare different renewable and non-renewable energy resources.
Burning fossil fuels releases carbon dioxide gas, which is a greenhouse gas, into the atmosphere.	How the environment is affected by the use of different energy resources.

Required Practicals

Practical		Topic
1	Determining the specific heat capacity of a metal	P2.4
2	Testing sheets of materials as insulators	P2.1

P 1 Conservation and dissipation of energy

1.1 Changes in energy stores

Learning objectives

After this topic, you should know:

- the ways in which energy can be stored
- how energy can be transferred
- the changes in energy stores that happen when an object falls
- the energy transfers that happen when a falling object hits the ground without bouncing back.

On the move

Cars, buses, planes, and ships all use fuels as chemical energy stores. They carry their own fuel. Electric trains use energy transferred from fuel in power stations. Electricity transfers energy from the power station to the train.

Figure 1 *The French Train à Grande Vitesse electric train can reach speeds of more than 500 km/hour*

Energy can be stored in different ways and is transferred by heating, waves, an electric current, or when a force moves an object. Here are some examples:

- Chemical energy stores include fuels, foods, or the chemicals found in batteries. The energy is transferred during chemical reactions.
- Kinetic energy stores describe the energy an object has because it is moving.
- Gravitational potential energy stores are used to describe the energy stored in an object because of its position, such as an object above the ground.
- Elastic potential energy stores describe the energy stored in a springy object when you stretch or squash it.
- Thermal energy stores describe the energy a substance has because of its temperature.

Energy can be transferred from one store to another. In a torch, the torch's battery pushes a current through the bulb. This makes the torch bulb emit light, and also get hot.

When an electric kettle is used to boil water, the current in the kettle's heating element transfers energy to the thermal energy store of the water and the kettle.

When an object is thrown into the air, the object slows down as it goes up. Here, energy is transferred from the object's kinetic energy store to its gravitational potential energy store.

You can show the energy transfers by using a flow diagram:

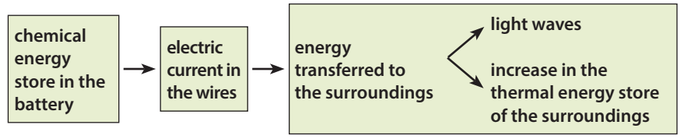

Figure 2 *Changes in energy stores in a torch lamp*

Energy transfers

When an object starts to fall freely, it speeds up as it falls. The force of gravity acting on the object causes energy to be transferred from its gravitational potential energy store to its kinetic energy store.

Look at Figure 3. It shows an object that hits the floor with a thud. All of the energy in its kinetic energy store is transferred by heating to the thermal energy store of the object and the floor, and by sound waves moving away from the point of impact. The amount of energy transferred by sound waves is much smaller than the amount of energy transferred by heating.

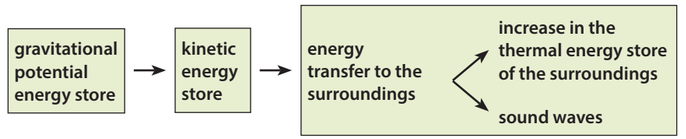

Figure 4 *An energy transfer diagram for an object when it falls and when it hits the ground*

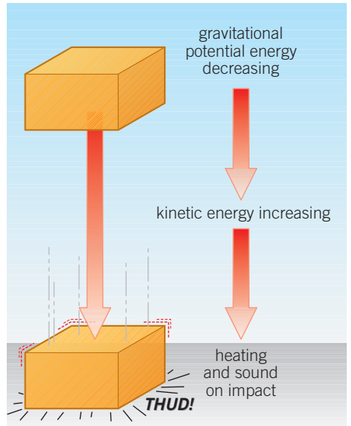

Figure 3 *An energetic drop. On impact, energy is transferred to the thermal energy store of the surroundings by heating and by sound waves*

1 Describe the changes to energy stores that take place when:
- **a** a ball falls in air [2 marks]
- **b** an electric heater is switched on. [2 marks]

2 **a** List two different objects you could use to light a room if you have a power cut. For each object, describe the energy transfers and changes to energy stores that occur when it lights up the room. [4 marks]
- **b** Which of the two objects in **a** is:
  - **i** easier to obtain energy from? [1 mark]
  - **ii** easier to use? [1 mark]

3 Describe the changes in energy stores of an electric train as it:
- **a** moves up a hill at constant speed [2 marks]
- **b** approaches a station and brakes to a halt. [2 marks]

4 Describe the changes in energy stores that take place when food is heated in a microwave oven. [2 marks]

Key points

- Energy can be stored in a variety of different energy stores.
- Energy is transferred by heating, by waves, by an electric current, or by a force when it moves an object.
- When an object falls and gains speed, its store of gravitational potential energy decreases and its kinetic energy store increases.
- When a falling object hits the ground without bouncing back, its kinetic energy store decreases. Some or all of its energy is transferred to the surroundings – the thermal energy store of the surroundings increases, and energy is also transferred by sound waves.

P1.2 Conservation of energy

Learning objectives

After this topic, you should know:

- what conservation of energy is
- why conservation of energy is a very important idea
- what a closed system is
- how to describe the changes to energy stores in a closed system.

Figure 1 *Energy transfers on a roller coaster*

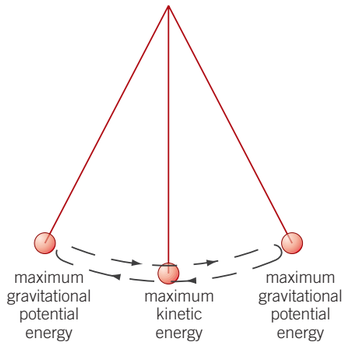

Figure 2 *A pendulum in motion. As the pendulum swings down and towards the centre, its gravitational potential energy store decreases as its kinetic energy store increases. As the pendulum moves upwards and away from the centre, its gravitational potential energy store increases as its kinetic energy store decreases*

At the funfair

Funfairs are very exciting places because changes to stores of energy happen quickly. As a roller coaster climbs an incline, its gravitational potential energy store increases. This energy is then transferred to other energy stores as the roller coaster races downwards.

As the roller coaster descends, its gravitational potential energy store decreases. Most of this energy is transferred to its kinetic energy store, which therefore increases. However, some energy is transferred to the thermal energy store of the surroundings by air resistance and friction, and some energy is transferred by sound waves.

Investigating pendulums

When changes to energy stores happen, does the total amount of energy stay the same? You can investigate this question with a simple pendulum.

Figure 2 shows a pendulum bob swinging from side to side.

As it moves towards the middle, energy is transferred by the force of gravity from its gravitational potential energy store to its kinetic energy store. So its gravitational potential energy store decreases and its kinetic energy store increases.

As it moves away from the middle, its kinetic energy stores decreases and its gravitational potential energy store increases. If the air resistance on the bob is very small the bob will reach the same height on each side.

- Describe the changes to energy stores that take place in the bob when it goes from one side at maximum height to the other side at maximum height.
- Explain why it is difficult to mark the exact height the pendulum bob rises to. Suggest how you could make your judgement of height more accurate.

Conservation of energy

The pendulum in Figure 2 would probably keep on swinging for ever if it was in a vacuum because there would be no air resistance acting on it, and so no energy would be transferred from any of its energy stores. There would be no net change to the energy stored in the system. Because of this, it would be an example of a closed system.

A system is an object or a group of objects. Scientists have done lots of tests and have concluded that the total energy of a closed system is always the same before and after energy transfers to other energy stores within the closed system.

This important result is known as the principle of conservation of energy. It says that:

energy cannot be created or destroyed.

Energy can be stored in various ways. For example:

- when a rubber band is stretched, its elastic potential energy store increases
- when an object is lifted, its gravitational potential energy store is increased.

Bungee jumping

What energy transfers happen to a bungee jumper after jumping off the platform?

- When the rope is slack, energy is transferred from the gravitational potential energy store to the kinetic energy store as the jumper accelerates towards the ground due to the force of gravity.
- When the rope tightens, it slows the bungee jumper's fall. This is because the force of the rope reduces the speed of the jumper. The jumper's kinetic energy store decreases and the rope's elastic potential energy store increases as the rope stretches. Eventually the jumper comes to a stop – the energy that was originally in the kinetic energy store of the jumper has all been transferred into the elastic potential energy store of the rope.

After reaching the bottom, the rope recoils and pulls the jumper back up. As the jumper rises, the energy in the elastic potential energy store of the rope decreases and the bungee jumper's kinetic energy store increases until the rope becomes slack. After the rope becomes slack, and at the top of the ascent, the bungee jumper's kinetic energy store decreases to zero. The bungee jumper's gravitational potential energy store increases throughout the ascent.

The bungee jumper doesn't return to the original height. This is because some energy was transferred to the thermal energy store of the surroundings by heating as the rope stretched and then shortened again.

1 When a roller coaster gets to the bottom of a descent, describe the energy transfers and changes to energy stores that happen if:
- **a** the brakes are applied to stop it [4 marks]
- **b** it goes up and over a second hill. [5 marks]

2 **a** A ball dropped onto a trampoline returns to almost the same height after it bounces. Describe the energy transfers and changes to the energy stores of the ball from the point of release to the top of its bounce. [5 marks]
- **b** Describe the energy stores of the ball at the point of release compared with its energy stores at the top of its bounce. [1 mark]
- **c** Describe how you would use the test in **a** to see which of three trampolines is the bounciest. [5 marks]

3 One exciting fairground ride acts like a giant catapult. The capsule in which you are strapped is fired high into the sky by the rubber bands of the catapult. Explain the changes to the energy stores that take place in the ride as you move upwards. [4 marks]

Study tip

Never use the terms 'movement energy' or 'motion energy' – only 'kinetic energy'.

Bungee jumping

You can try out the ideas about energy transfers during a bungee jump using the experiment shown in Figure 3.

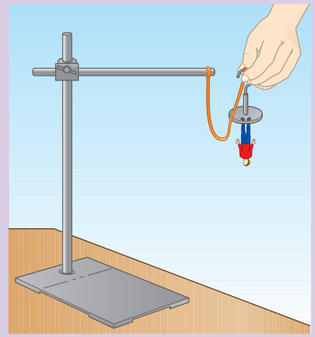

Figure 3 *Testing a bungee jump*

Safety: Make sure the stand is secure. Protect feet and bench from falling objects.

Key points

- Energy cannot be created or destroyed.
- Conservation of energy applies to all energy changes.
- A closed system is an isolated system in which no energy transfers take place out of or into the energy stores of the system.
- Energy can be transferred between energy stores within a closed system. The total energy of the system is always the same, before and after, any such transfers.