AQA Physics GCSE Student literacy sheet

P1.9

Name .... Class .... Date ....

Energy stores and transfers

Specification references:

- P1.1.1 Energy stores and systems
- P1.2.1 Energy transfers in a system

Aims

This is an activity that has been designed to help you improve your literacy skills. In this activity you will learn more about the ideas of energy stores and energy transfers for a range of devices. You will practise answering questions that involve some of the key command words and scientific terms that you will encounter in the topic of energy stores, transfers, and conservation.

Learning outcomes

After completing this worksheet, you should be able to:

- know and understand what energy stores and energy transfers are
- describe a number of examples of energy stores and transfers
- explain what the principle of conservation of energy is
- apply ideas to energy stores and transfers for a variety of devices.

Setting the scene

Energy stores, energy transfers, and the principle of conservation of energy are central to our understanding of physics. In this activity you will consider the importance of these terms as well as why the Universe behaves the way that it does, based on the laws that govern energy transfers. It is worth remembering that the way that energy is being taught in schools is changing quite dramatically, with more talk about energy stores and energy transfers as opposed to 'types of energy' and energy being 'converted' from one type to another.

Task

Read the information about energy stores, energy transfers, and the conservation of energy and then answer the questions that follow.

Energy stores and transfers

Some ways of talking about energy are clearer and more helpful than others. It is helpful to talk about *energy stores*. A spring, or a rubber band, can store energy. You do work to stretch them (or to squash the spring), and you get back almost the same amount of energy when they relax. These are two of the best examples for grasping what 'potential energy' is all about. It is energy in a mechanical store. You can also feel energy being stored when magnets are pushed together or pulled apart.

The example that most textbooks give of potential energy is perhaps the most difficult to grasp. It is the gravitational energy of a lifted mass. Here the energy is said to be ‘in’ the lifted object – as for a spring it is said to be ‘in’ the spring. However, you could say that the energy is stored between the Earth and the lifted object (in the gravitational field).

Another kind of energy store is a mixture of fuel and oxygen. It is common to talk about just the fuel, for example, petrol, as the energy store, but remember that for this chemical energy store there must be oxygen too.

There are a limited number of energy stores

- ***chemical*** (e.g., fuel plus oxygen)
- ***kinetic*** (in a moving object)
- ***gravitational*** (due to the position of an object in a gravitational field)
- ***elastic*** (e.g., in a stretched or compressed spring)
- ***thermal*** (in a warm object)
- ***magnetic*** (in two separated magnets that are attracting, or repelling)
- ***electrostatic*** (in two separated electric charges that are attracting, or repelling)
- ***nuclear*** (released through radioactive decay, fission, or fusion)

Energy carriers (or pathways) and energy transfers

It is often helpful to think of energy being carried from one place to another. For example, light carries energy from the Sun to the Earth. Light itself is not ‘energy’. It is an electromagnetic wave, or a stream of photons. However, energy does travel *with* the light. The same is true of other electromagnetic waves, for example, radio waves and microwaves. In a microwave oven, microwaves carry energy from the microwave generator to the interior of the food. Other kinds of waves carry energy too, for example, mechanical waves in the sea.

Electric current in a circuit is another energy carrier. It is helpful to think about an electrical circuit as a way of moving energy from one place to another. The National Grid distributes energy from a number of power stations, via the wires and cables, to homes and factories.

It is often useful to think of matter that is moving as carrying energy, too. A strong wind delivers energy to a wind turbine. But, equally often, it is better to think of the moving mass as storing energy. A train has to be given energy to get it moving, and energy has to be taken from the train to stop it. The kinetic energy of the moving train has to be transferred to thermal energy in the brakes to bring the train to a stop.

Energy carriers (or pathways, or transfers)

- mechanical (when a force moves through a distance)
- electrical (when a charge moves through a potential difference)
- by heating (because of a temperature difference)
- by radiation (e.g., light, microwaves, sound)

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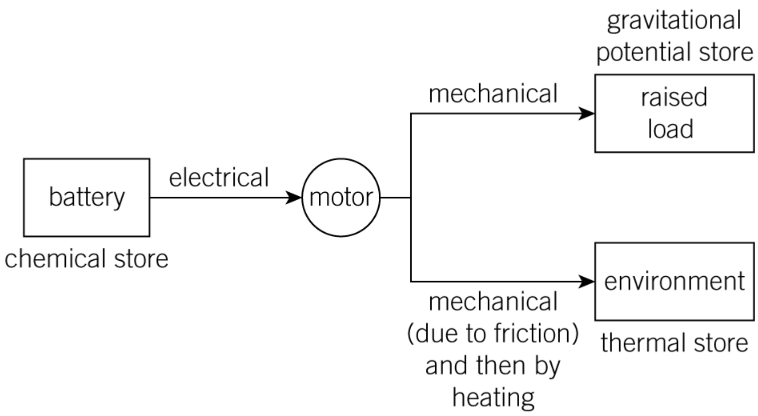
With all of these, we are interested in the rate at which energy is being transferred and not the amount stored anywhere.

You can use flow diagram representations to strengthen the distinction between energy stores and energy carriers, for example:



There are some very important scientific ideas in this way of looking at things. Among them are:

- that energy tends, in most cases, to be transferred from a more concentrated store to more dispersed stores; and that this makes it less useful for doing anything further
- that the energy often ends up warming the environment.

Questions

1 a List the eight types of energy store.

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b List the four energy carriers or energy transfer pathways.

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2 For each of the following processes, state the initial energy store, the final energy stores and the energy carriers.

a A battery-operated toy crane lifts a mass and places it on a shelf.

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....

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b A butane gas heater is used to warm a pot of water on a camp stove.

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c A nuclear power station is used to provide energy for the Christmas lights in a city.

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3 a State the principle of conservation of energy.

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b Energy is always wasted in any energy transfer. Describe what happens to this energy.

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4 a Explain why light is no longer stated as an energy store.

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b Explain the importance of the sentence: 'With all of these [energy carriers], we are interested in the rate at which the energy is being transferred and not the amount stored anywhere.'

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Energy transfers

Specification references:

- Maths skills 1a, 1b, 2a, 2h, 3a, 3b, 3c, 3d

Aims

In this worksheet you will learn how to calculate kinetic energy, gravitational, and elastic potential energy. You will also rearrange equations to calculate unknowns and carry out calculations involving indices.

Learning outcomes

After completing this worksheet, you should be able to:

- calculate the amount of energy associated with a moving object
- calculate the amount of elastic potential energy stored in a stretched spring
- calculate the amount of gravitational potential energy gained by an object raised above the ground.

Worked example

An Olympic archer applies a force of 100 N in pulling back her bow by 0.5 m. How much energy is stored in the bow? The arrow she shoots has a mass of 0.05 kg. What is its maximum speed if there are no losses due to friction?

Firstly you need to determine the work done in stretching the elastic string for the bow, which equals force (F) × distance (d). So:

Elastic PE = 100 × 0.5 = 50 Joules

We assume that all of the elastic potential energy is converted to kinetic energy of the arrow so $E_P = E_k$.

You know that the kinetic energy of a moving object can be calculated using the equation:

$$E_k = \frac{1}{2} mv^2$$

Rearranging the equation to give v on its own you get:

$$v^2 = \frac{E_k}{\frac{1}{2}m}$$

or $$v = \sqrt{\frac{E_k}{\frac{1}{2}m}}$$

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You know that kinetic energy $E_k = 50$ J and mass $m = 0.01$ kg, and want to know speed v; its units will be m/s.

Substituting the values you know into the equation

$$v = \sqrt{\frac{50}{0.5} \times 0.01}$$

$v = 100$ m/s

The arrow flies at a speed of 100 m/s.

Questions

1 Calculate the kinetic energy of the following objects.

a A car that travels at a speed of 20 m/s and has a mass of 1200 kg.

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.... (*1 mark*)

b A pupil with a mass of 55 kg swinging back on a chair and falling off at a speed of 0.6 m/s.

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.... (*1 mark*)

c The earth with a mass of 5.97×10^{24} kg moving at a velocity of 461 m/s.

....

.... (*1 mark*)

d A tennis ball travelling at a speed of 46 m/s with a mass of 58 g.

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.... (*1 mark*)

e A plane at a speed of 255 m/s with a mass of 2.15×10^5 kg.

....

.... (*1 mark*)

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2 Calculate the velocity of:

a A bus travelling through town, with a mass of 5040 kg and kinetic energy of 493 900 J.

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.... (*1 mark*)

b A lift travelling up to the top floor of the Empire State building with a mass of 4200 kg and a kinetic energy of 4116 J.

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.... (*1 mark*)

c A bird flying towards its nest with a mass of 0.25 kg and a kinetic energy of 40.5 J.

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.... (*1 mark*)

d A hot air balloon with a kinetic energy of 76 550 J and a mass of 1890 kg.

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.... (*1 mark*)

3 Calculate the mass of:

a An automatic door closing at 0.2 m/s with a kinetic energy of 1.6 J.

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.... (*1 mark*)

b A wind turbine blade with a kinetic energy of 1 MJ turning at 6 m/s.

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.... (*1 mark*)

c An aeroplane travelling at 75 m/s with a kinetic energy of 843 kJ.

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.... (*1 mark*)

d A canoe moving down the river with a kinetic energy of 5 J and a speed of 0.5 m/s.

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.... (*1 mark*)

e A child riding a bike at a speed of 0.6 m/s with a total kinetic energy of 12.4 J. If the mass of the child is 30 kg, what is the mass of the bike?

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....

.... (*2 marks*)

4 A car moves at a constant velocity of 30 m/s and has 3.6×10^5 J of kinetic energy. The driver applies the brakes and the car stops in 95 m.

a Calculate the force needed to stop the vehicle.

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.... (*2 marks*)

b Calculate the mass of the vehicle.

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....

.... (*2 marks*)

5 A pendulum of mass 200 g is pulled horizontally sideways by 30 cm. The length of the pendulum string is 50 cm.

a Calculate the potential energy of the pendulum in this position. Assume g = 9.8 N/kg

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.... (*2 marks*)

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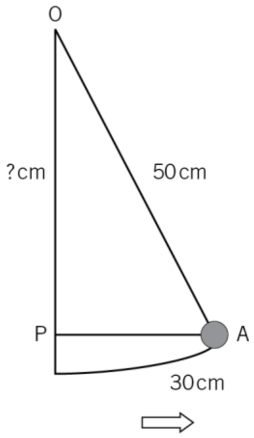

b Calculate the maximum velocity that the pendulum falls with from this position.

....

.... (*2 marks*)

Electricity

Specification references:

- P2.1 Current, potential difference, and resistance
- MS 1a, 2a, 3a, 3b, 3c, 3d, 4a

Aims

In this worksheet you will learn how to calculate resistance in series and parallel circuits. You will rearrange formulae to find unknowns and calculate resistance, potential difference, and current.

Learning outcomes

After completing this worksheet, you should be able to:

- calculate resistance, potential difference, and current in series circuits, potential difference, and current
- rearrange the equations to find unknowns and calculate potential difference
- recognise that components in parallel always have a lower resistance than in series and be able to explain why.

Worked example

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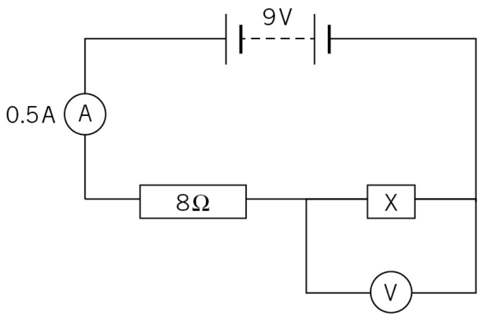

a Calculate the potential difference across the 8 Ω resistor.

b Calculate the voltage over resistor X and its resistance.

Step 1:

a The resistor of 8 Ω has 0.5 A going to it, so use the following equations:

$V = I \times R$

$I = 0.5$ A

$R = 8\ \Omega$

$V = 0.5 \times 8 = 4$ V

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Step 2:

b There are 9 volts being supplied to the circuit so the potential difference over X is what remains after the 4 volts are used over the 8 Ω component:

9 – 4 = 5 volts are dropped over X

Step 3:

X receives 5 volts and 0.5 amps

V = I × R so rearranging to give $R = \frac{V}{I}$

$R = \frac{5}{0.5} = 10\ \Omega$

Alternatively, Total $R = \frac{\text{Total } V}{\text{Total I}} = \frac{9}{0.5} = 18$

Total resistance in series $R_{total} = R_1 + R_2$

$R_{total} = 8 + X$

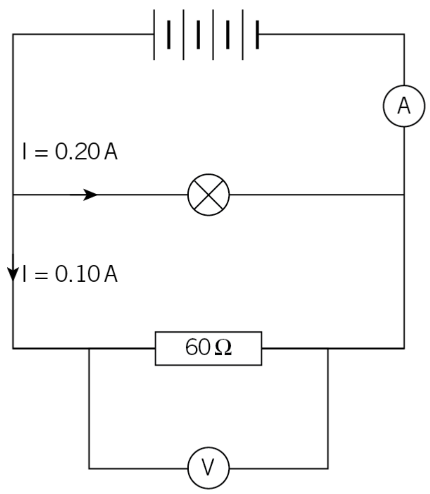
18 = 8 + X

18 – 8 = X

So resistance over X = 10 Ω

Questions

1 A circuit was set up as shown in the diagram.



Each cell provides a potential difference of 1.5 volts.

a What is the total potential difference provided by the four cells in the circuit?

.... (*1 mark*)

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b What potential difference is dropped over the 60 Ω resistor?

.... (*1 mark*)

c What is the current reading on the ammeter A?

.... (*1 mark*)

d What is the resistance of the bulb?

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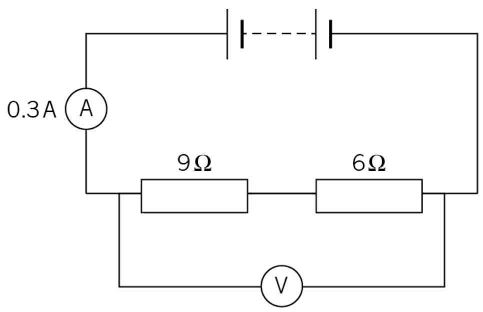
.... (*2 marks*)

2



a Calculate the total resistance in this series circuit.

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.... (*1 mark*)

b Calculate the potential difference in the circuit.

....

.... (*1 mark*)

3 The resistance of a 24 W, 12 V filament lamp depends on the current flowing through the lamp. For currents up to 0.8 A, the resistance has a constant value of 2.5 Ω.

Use the equation that relates potential difference to resistance and current to calculate the potential difference across the lamp when a current of 0.8 A flows through the lamp.

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.... (*1 mark*)

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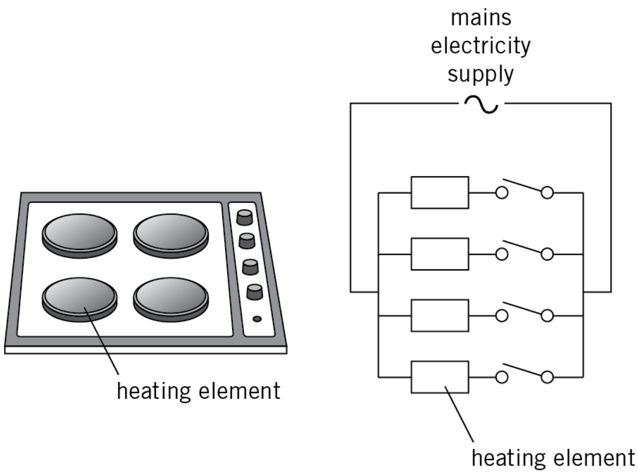
4 When all four heating elements are switched on at full power, the hob draws a current of 36 A from the 230 V mains electricity supply.



Calculate the resistance of one heating element when the hob is switched on at full power. Give your answer to 2 significant figures.

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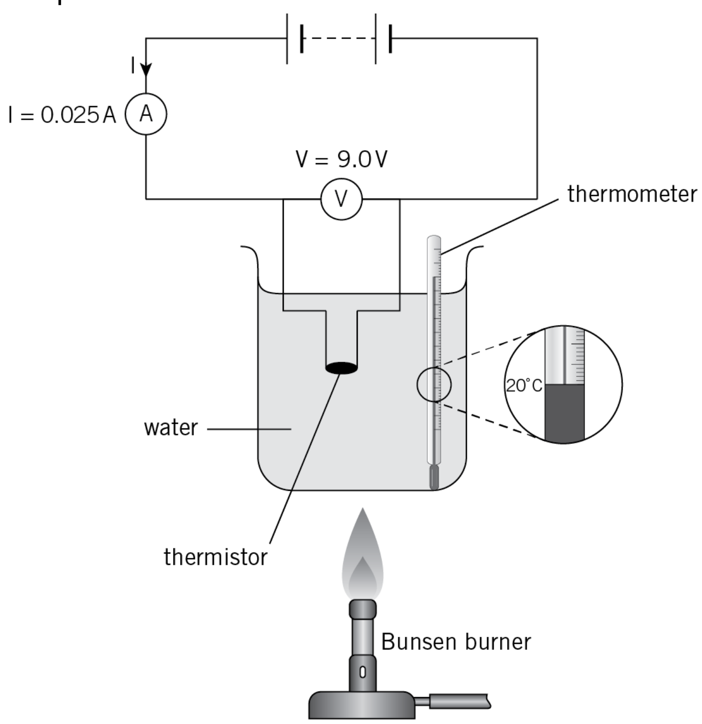
.... (*3 marks*)

5 An experiment to investigate how the resistance of a thermistor varies with temperature is shown below



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a What is the resistance of the thermistor shown in this diagram?

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.... (*3 marks*)

b As the temperature of the water increases, the resistance of the thermistor decreases. Draw a sketch graph of current vs. temperature for this thermistor. (*2 marks*)