OCR
Oxford Cambridge and RSA

H

Friday 13 November 2020 – Morning

GCSE (9–1) Physics B (Twenty First Century Science)

J259/03 Breadth in physics (Higher Tier)

Time allowed: 1 hour 45 minutes

You must have:
- a ru er (cm/mm)
- the Data Sheet for GCSE (9–1) Phys cs B (ns de th s document)

You can use:
- a sc ent f c or graph ca ca cu ator
- an HB penc

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) ______________________

Last name ______________________

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answers should be supported with working. Marks might be given for using a correct method even if your answer is wrong.

INFORMATION
- The total mark for this paper is **90**.
- The marks for each question are shown in brackets **[ ]**.
- This document has **28** pages.

ADVICE
- Read each question carefully before you start your answer.

Answer **all** the questions.

1 Amir investigates how insulation affects the rate of cooling.

He writes down his method.

1. Fill a metal tin with water at 80 °C.
2. Wait for 10 minutes.
3. Measure the new temperature and write it down.
4. Repeat the experiment for each of these types of insulation:

Experiment	Insulation
A	None
B	1 layer of aluminium foil
C	1 layer of bubble wrap
D	3 layers of bubble wrap
E	1 layer of bubble wrap **and** 1 layer of aluminium foil

(a) Predict which experiment will cool down the slowest. Explain your answer.

Experiment: ....

Explanation: ....

....

.... **[2]**

(b) Amir's teacher reads his method. The teacher says that the method is not detailed enough to make the experiment **reproducible**.

(i) Explain the meaning of the word **reproducible**.

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.... **[2]**

(ii) Give **one** piece of additional information that you would need to **reproduce** Amir's experiment.

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.... **[1]**

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2 A low-carbon source causes very little carbon dioxide to be given off into the atmosphere.

Some of the energy supplied to the UK comes from low carbon sources.

Fig. 2.1 shows how the percentage of UK energy supplied from low carbon sources has changed over time.

Fig. 2.1

(a) (i) Describe the trend in the percentage of UK energy supplied by **biofuels**.

....

.... **[1]**

(ii) Suggest **one** reason for this trend.

....

.... **[1]**

(b) Ali and Ling discuss the trends shown in the data.

Ali
I think that, in the future, we will get more energy from the wind than from nuclear power.

(i) Evaluate whether the evidence shown in **Fig. 2.1** supports Ali's statement.

....

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.... **[2]**

Ling
The data shows that in 2016, over 16% of energy was supplied by renewable energy sources.

(ii) State why Ling is **incorrect**.

....

.... **[1]**

(iii) Using **Fig. 2.1**, estimate the correct percentage of energy that was supplied by renewable energy sources in 2016.

Percentage = ... % **[1]**

3 Ultraviolet radiation can be used to disinfect water.

Fig. 3.1 shows an ultraviolet disinfection unit.

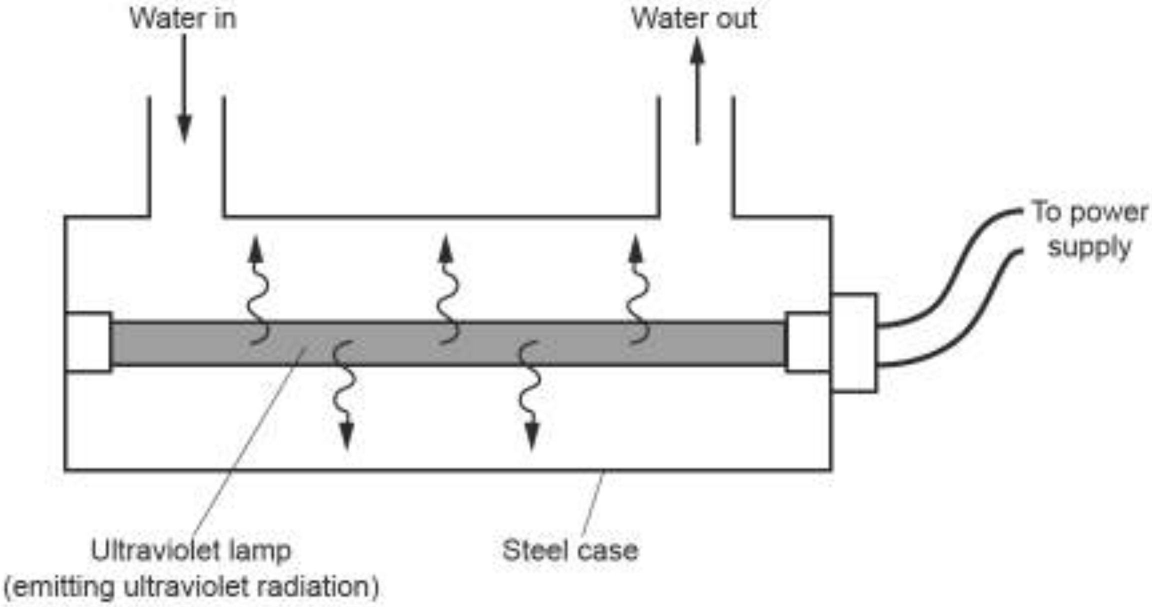

Fig. 3.1

(a) Ultraviolet radiation is emitted by the atoms in the ultraviolet lamp.

Describe how changes in atoms can generate ultraviolet radiation.

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.... **[2]**

(b) Ultraviolet disinfection works because ultraviolet radiation harms micro-organisms in the water.

(i) Explain why ultraviolet radiation is also harmful to living organisms, including humans.

....

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.... **[2]**

(ii) Suggest how the design of the disinfection unit in **Fig. 3.1** prevents it from harming humans.

....

.... **[1]**

(c) Alpha radiation is also harmful to living organisms.

Give **two** reasons why alpha radiation would not be suitable for disinfecting water.

1 ....

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2 ....

....
[2]

4 Planets outside our solar system have been discovered orbiting a star called Kepler-106.

Table 4.1 shows the properties of these planets. Assume that the planets move in **circular** orbits.

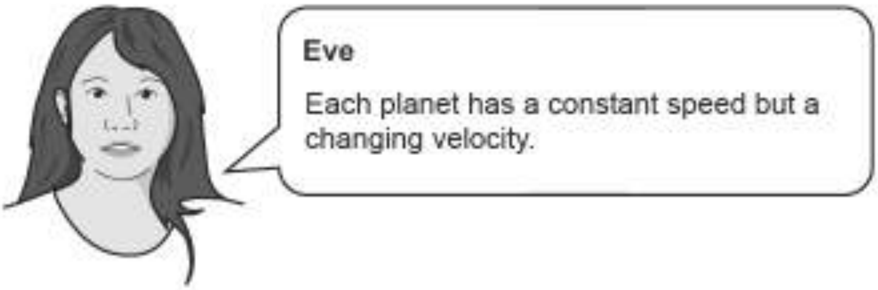
Planet	Radius of orbit (km)	Time to complete one orbit (s)	Speed (m/s)	Mass (kg)
1	9.87×10^6	5.36×10^5	116 000	2.73×10^{24}
2	1.66×10^7	1.18×10^6	89 000	6.26×10^{25}
3	3.59×10^7	3.80×10^6	59 000	3.87×10^{25}

Table 4.1

(a) Calculate the momentum of planet **1**.

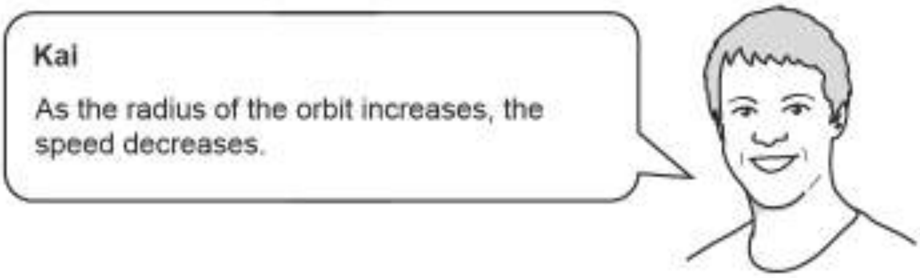
Momentum = ... kg m/s **[3]**

(b) Eve and Kai look at the information in **Table 4.1**.



(i) Explain why Eve is correct.

[2]



(ii) Suggest why Kai is correct.

[2]

5 Sarah and Jack experiment with two hand-held radios.

(a) The radio waves have a frequency of 446 MHz and speed of 3.0×10^8 m/s.

(i) Explain why Sarah and Jack cannot see the radio waves.

....

....

.... [2]

(ii) Calculate the wavelength of the radio waves.

Use the equation: wavelength = wave speed ÷ frequency

Give your answer to **2** significant figures.

Wavelength = ... m [4]

(b) Describe how electrical circuits in the radios can produce radio waves.

....

.... [1]

6 Jane is learning to drive.

(a) In a driving lesson, Jane's car is moving at 25 mph when she is asked to stop.

The car comes to a stop in a total time of 2.5 s.

Calculate the deceleration of the car as it stops.

Use the approximation: 1 mph ≈ 0.5 m / s

Deceleration = ... m/s^2 **[4]**

(b) In the driving test, Jane's car is moving at a speed of 16 m / s when she is asked to complete an emergency stop.

The car comes to a stop in a total time of 2.2 s.

Estimate the force acting on the car during the emergency stop.

Use your own estimate of the mass of the car to complete the calculation.

Force = ... N **[4]**

7 Ben wants to compare the density of three different foods.

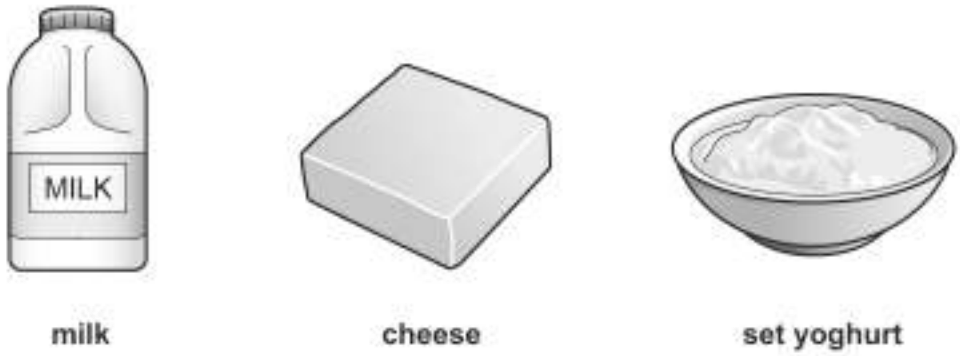


Fig. 7.1

(a) Describe how to accurately determine the density of milk.

You should include in your answer how accurate measurements can be obtained from the apparatus used.

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.... **[3]**

(b) **Fig. 7.2** shows the dimensions of a block of cheese.

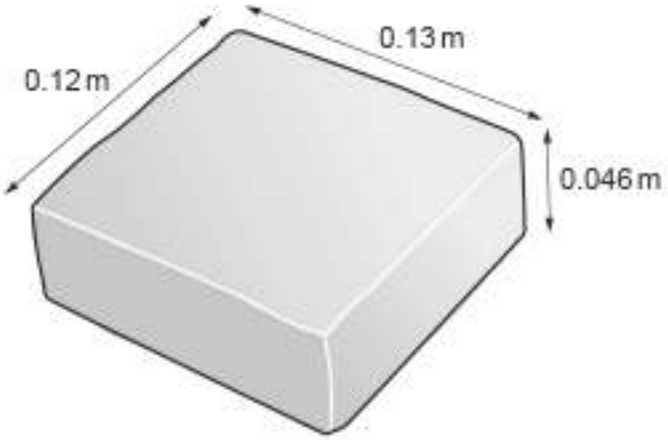

Fig. 7.2

Calculate the volume of the block of cheese, in m^3.

Give your answer in **standard form** and to **3** significant figures.

Volume = ... m^3 **[2]**

(c) The yoghurt in **Fig. 7.1** is not runny, so it can't be poured like milk.

It is also too soft to hold its shape like a block of cheese.

Suggest **one** method to measure the volume of a sample of the yoghurt.

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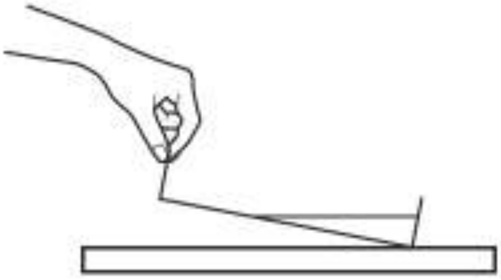
.... **[2]**

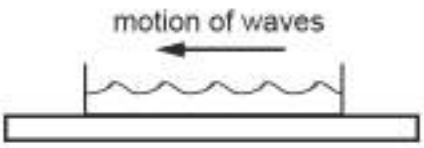
8 Amaya is investigating waves using a tray of water.

She makes waves by dropping one end of the tray so that waves travel up and down the length of the tray.

The diagram shows her method.



Amaya lifts one end of the tray.



Amaya drops the tray. Waves travel along the surface of the water.

It takes less than 1 second for the waves to travel the length of the tray.

(a) (i) Describe how to accurately determine the **speed** of the waves.

You should include in your answer how accurate measurements can be obtained from the apparatus used.

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.... [3]

(ii) Amaya finds that she gets a different result every time she repeats the measurements.

She thinks this is because her method makes slightly different waves every time.

Suggest how Amaya can make her method more **repeatable**.

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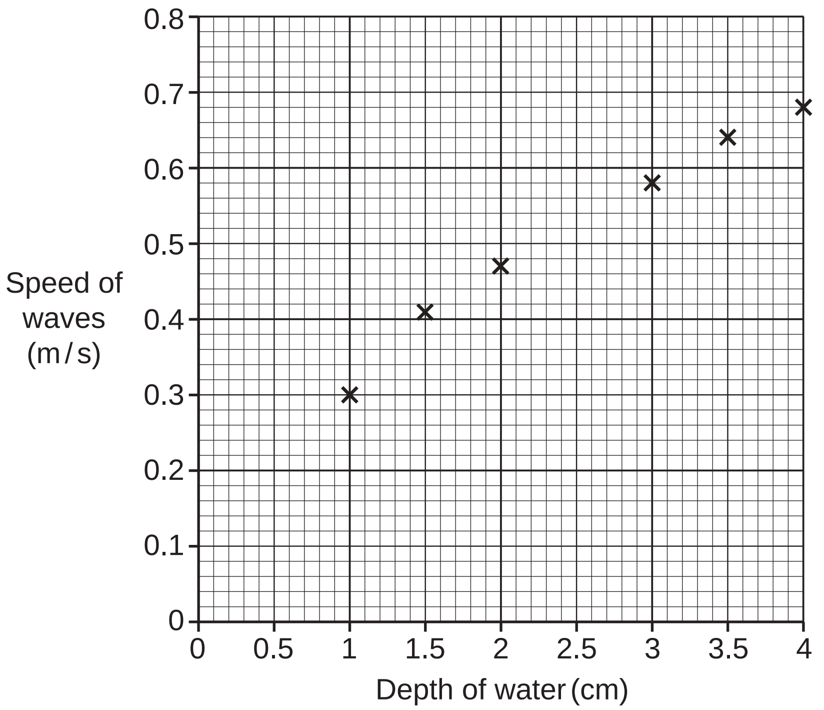
.... [1]

(b) Amaya investigates how the speed of the waves depends on the depth of the water.

The table and graph show her results.

Depth of water (cm)	**Speed of waves (m/s)**
1.0	0.30
1.5	0.41
2.0	0.47
2.5	0.53
3.0	0.58
3.5	0.64
4.0	0.68



(i) Plot the missing point on the graph. **[1]**

(ii) Describe **two** key features of the pattern shown by the data.

....

....

.... **[2]**

(iii) Estimate the speed of waves in a depth of water of 0.5 cm.

Show your working on the graph.

Speed = ... m/s **[2]**

9 Nuclear power stations use uranium-235 as a fuel.

Energy is released from uranium-235 when it undergoes nuclear fission.

Fig. 9.1 shows what happens in nuclear fission.

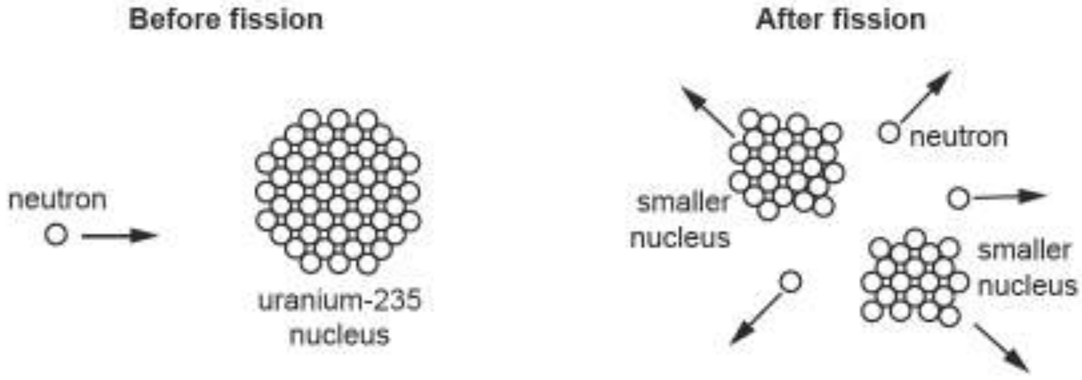


Fig. 9.1

(a) Describe how the energy released during nuclear fission is transferred.

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.... **[2]**

(b) **Fig. 9.2** below shows a simplified view of a nuclear reactor.

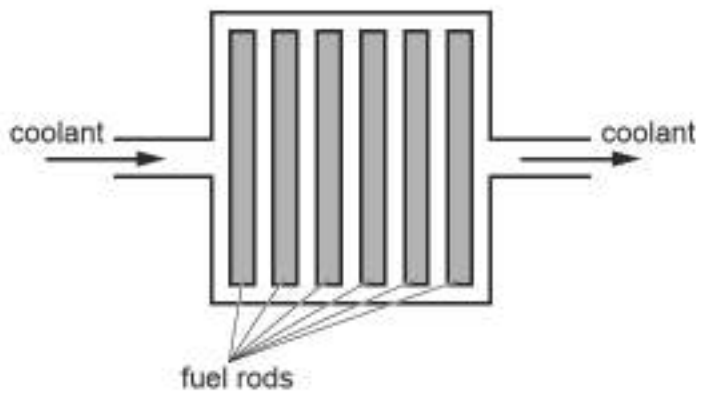

Fig. 9.2

(i) Nuclear fission takes place in the fuel rods. The fuel rods contain uranium.

To release a useful amount of energy, there must be a chain reaction. If only one fuel rod is used, there will not be a chain reaction.

Explain why many fuel rods are needed to cause a chain reaction.

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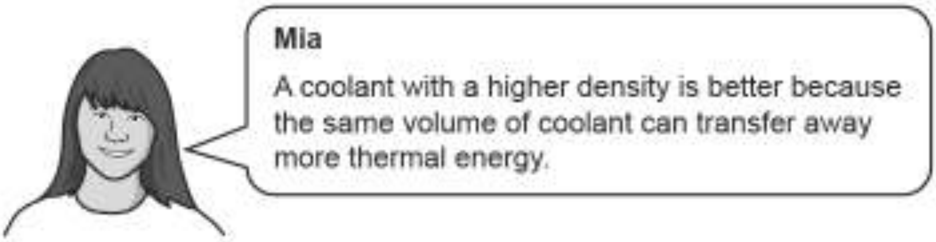
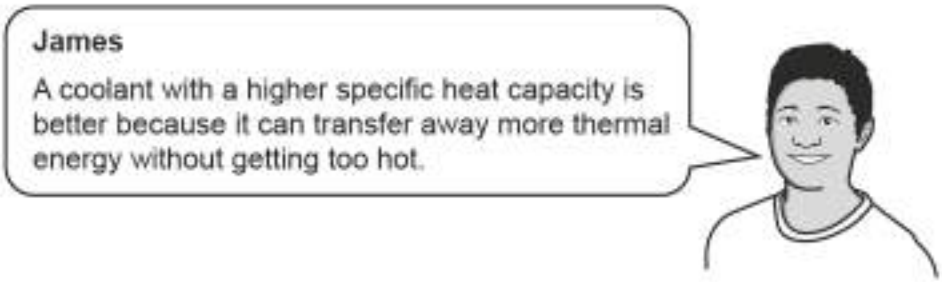
.... **[2]**

(ii) Coolant is continually pumped through the reactor. The purpose of the coolant is to remove thermal energy from the reactor.

The table shows two coolants that can be used in nuclear reactors.

Coolant	Approximate specific heat capacity (J/kg °C)	Density (kg/m^3)
A	150	11 000
B	1300	860





Both students are correct that these factors improve the coolant.

Suggest which coolant would be the most suitable to use in a nuclear reactor.

Use data in the table and calculations to support your answer.

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.... **[2]**

10 Sundip is a scientist in the UK, and studies the waves produced by Earthquakes to understand more about the inside of the Earth.

The table shows some properties of the two main types of wave produced by earthquakes.

Name of wave	Type of wave	Travels through solids	Travels through liquids
P-wave	Longitudinal	Yes	Yes
S-wave	Transverse	Yes	No

(a) Compare the vibration of particles in P-waves and S-waves.

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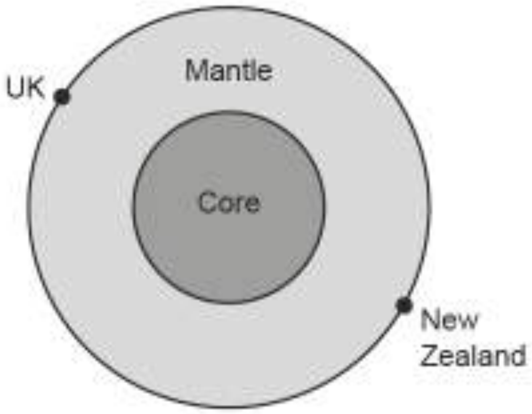
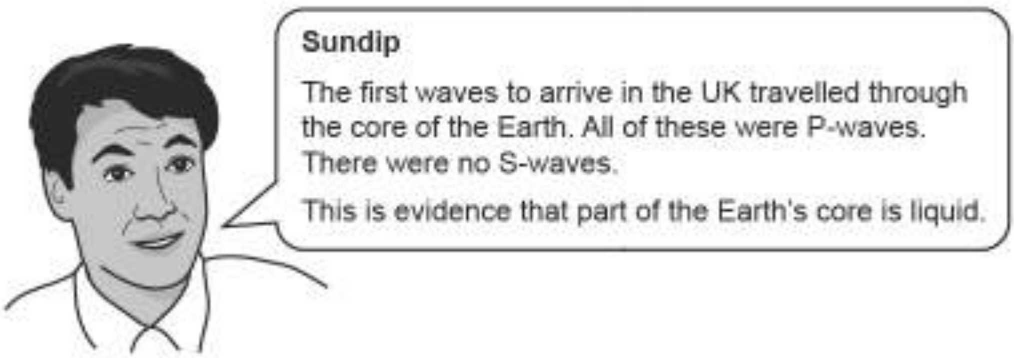
.... **[2]**

(b) There is an earthquake in New Zealand, almost on the opposite side of the Earth to the UK.



Sundip studies waves produced by this earthquake.



(i) Explain why Sundip is correct.

Use the information in the table to support your answer.

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.... **[2]**

(ii) Sundip detected some S-waves in the UK later, but these did **not** travel through the centre of the Earth.

Suggest how these S-waves reached Sundip's detector in the UK.

You may draw a diagram to support your answer.

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.... **[2]**

11 Alex is a trapeze artist with the circus.

He hangs from a metal ring which is attached to two **elastic** ropes, as shown in **Fig. 11.1**.

The metal ring is in equilibrium.

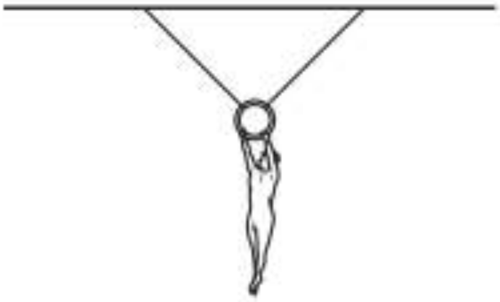


Fig. 11.1

(a) Define equilibrium.

....

.... **[1]**

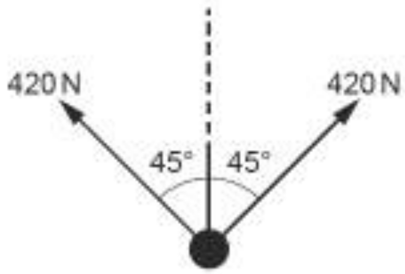
(b) **Fig. 11.2** shows two of the forces acting on the metal ring. These two forces are tension forces caused by the two elastic ropes pulling on the metal ring.

(i) Draw an arrow on **Fig. 11.2** to show the third force acting on the metal ring.

Label the arrow with the name of the force.

You do **not** need to draw the arrow to scale.

Fig. 11.2



[2]

(ii) What will happen to the metal ring and the elastic ropes at the moment that Alex lets go?

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.... **[1]**

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12 Kareem is completing a project on stars.

He finds out this information about three stars.

Star	**A**	**B**	**C**
Temperature (°C)	6000	3000	12 000
Relative diameter	1	900	40
Relative brightness	1	42 000	28 000
Colour	Yellow	Red	Blue

(a) The colour of a star depends on the wavelengths of light that it emits.

Explain why the three stars have different colours.

Use data from the table to support your answer.

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.... **[2]**

(b) **(i)** Star **B** is expected to explode in the next few thousand years.
When it explodes, it will emit huge amounts of visible light radiation.

Calculate, in **years**, the time it will take for the visible light radiation to reach the Earth.

The distance from Earth to star **B** is about 6×10^{18} m.

The speed of visible light in space is 3.0×10^{8} m/s.

1 year = 3.2×10^{7} s.

Time = ...years **[3]**

(ii) The explosion will also emit radiation from other regions of the electromagnetic spectrum.

Scientists predict that all this radiation will reach the Earth at the same time.

Explain why.

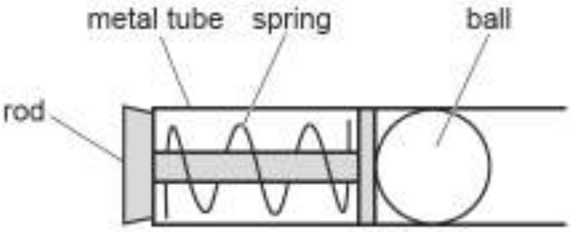
....

.... **[1]**

13 Li is building a pinball machine.

In a pinball machine, a spring is used to push out a small metal ball at high speed.

Fig. 13.1 shows the mechanism that fires the ball.



To fire the ball, the rod is pulled back. When it is released, the ball moves off at a high speed.

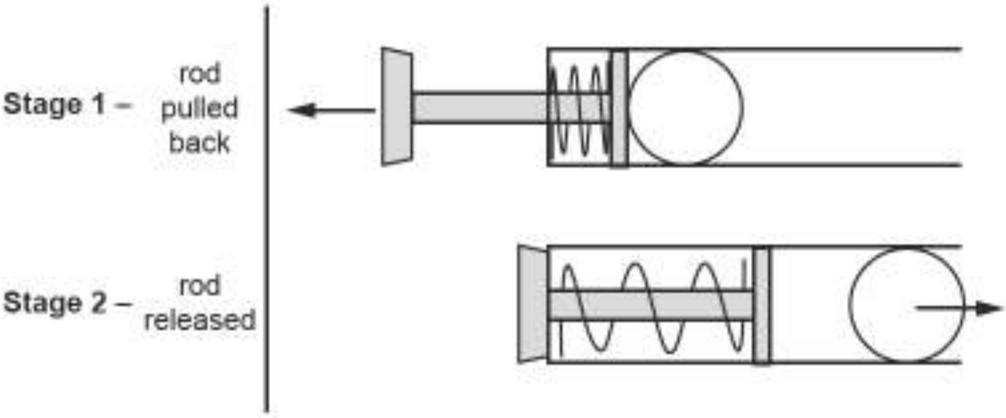
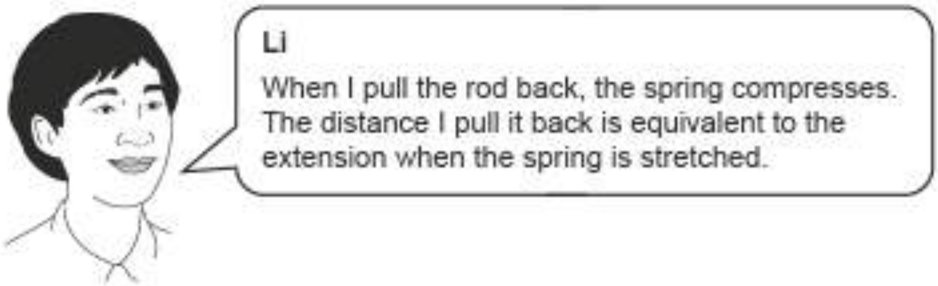


Fig. 13.1

(a) To test the mechanism, Li pulls the rod back by 5.0 cm.

The energy stored in the spring is 0.28 J.



Calculate the spring constant of the spring.

Use the data sheet.

Spring constant = ... N/m **[4]**

(b) In a second test, Li pulls the rod back a different distance.

The energy stored in the compressed spring now is 0.32 J. The mass of the ball is 0.040 kg.

Calculate the speed of the ball as it loses contact with the spring.

Assume that all energy stored in the compressed spring is transferred into kinetic energy of the moving ball.

Speed = ... m/s **[3]**

(c) **(i)** Write down the equation linking distance moved, force and work done.

....

.... **[1]**

(ii) In a third and final test, the kinetic energy of the ball when it leaves the spring is 0.25 J.

The same ball is used as the second test, with mass of 0.040 kg.

The ball moves 0.80 m up the slope of the pinball machine until it stops.

It rises a total vertical height of 0.50 m.

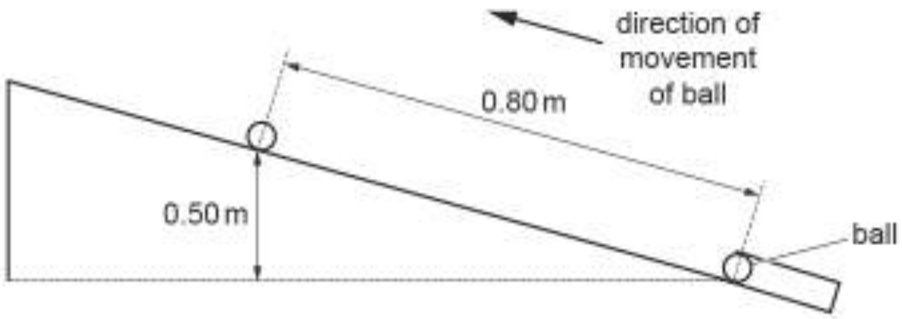


Fig. 13.2

Li explains the energy transfers as the ball moves up the slope in **Fig. 13.2**.

Li

Some of the kinetic energy has been transferred to a gravitational store. The rest of the kinetic energy has been transferred to a thermal store.

The energy transferred to the thermal store is equal to the work done by friction as the ball moves up the slope.

Calculate the average force of friction that acts on the ball as it moves up the slope.

Use Li's ideas about energy transfers.

Use your answer to **(c)(i)**.

Use the equation:
gravitational potential energy = mass × gravitational field strength × height.

Gravitational field strength = 10 N/kg.

Force of friction = ... N **[4]**

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).