1 Wooden trucks on a toy railway have permanent magnets that hold the train together.

The magnets are arranged so that an N-pole touches an S-pole between each truck, as shown in Figure 15.

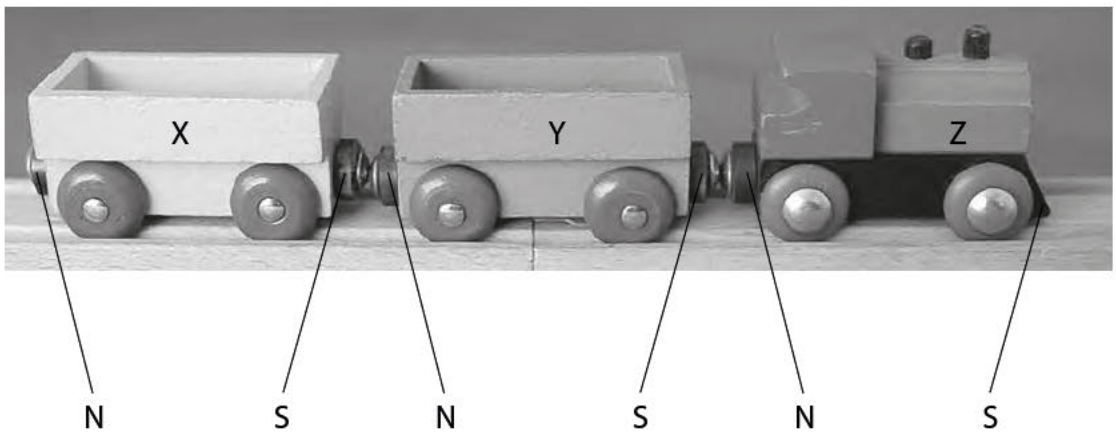


Figure 15

(a) Truck Y is removed from the train, turned through 180° and is then replaced between truck X and Z.

How does this affect the train?

(1)

☒ **A** Y attracts both X and Z as before

☒ **B** Y still attracts X but now repels Z

☒ **C** Y still attracts Z but now repels X

☒ **D** Y now repels both X and Z

(b) The structure of a truck, seen from above, is shown in Figure 16.

The permanent magnets cause a magnetic field both inside and outside the truck.

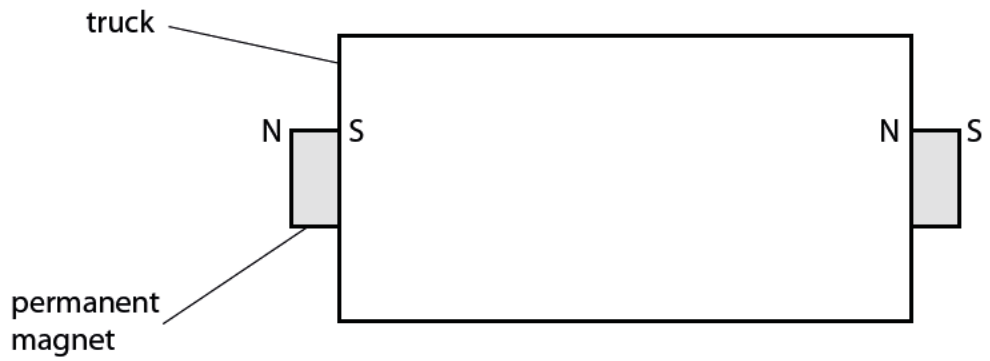
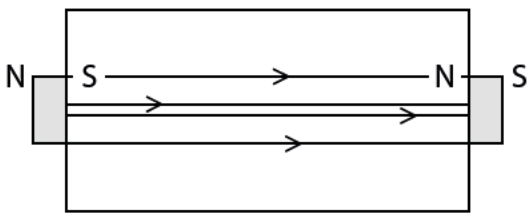


Figure 16

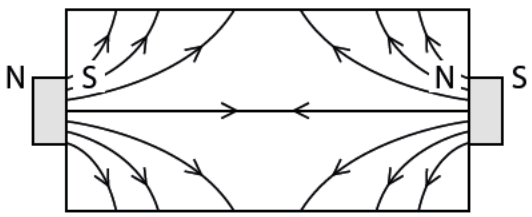
Which of these correctly shows the field inside the truck?

(1)

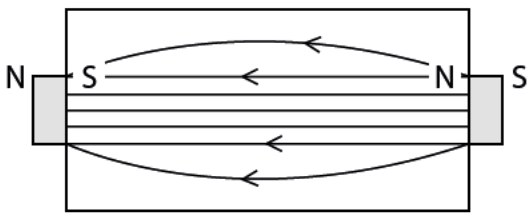
☒ **A**



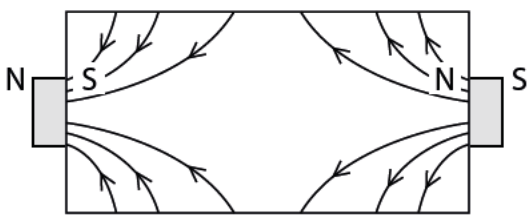
☒ **B**



☒ **C**



☒ **D**



(c) A student investigates the forces between the trucks in the toy railway.

She places another truck, **W**, next to truck **X**.

She pulls truck **Z** in the direction shown by the arrow.

The whole train travels at a constant speed as shown in Figure 17.

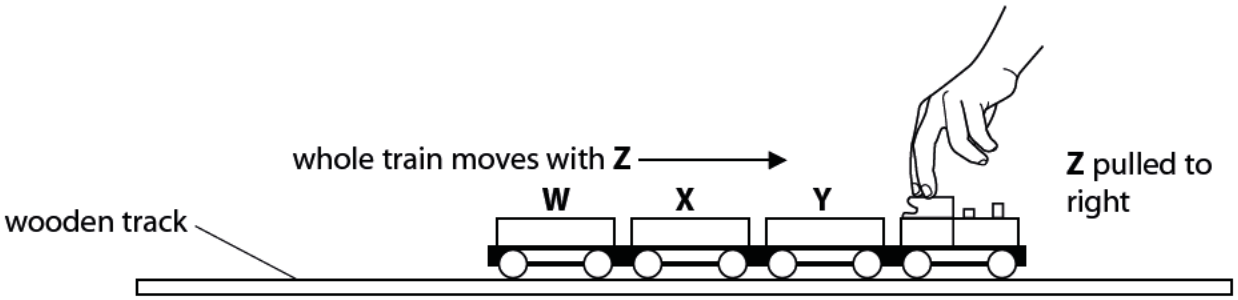


Figure 17

The student repeats this method of adding trucks and pulling the train each time.

When there are seven trucks in total, the train comes apart between **Y** and **Z** when tested as shown in Figure 18.

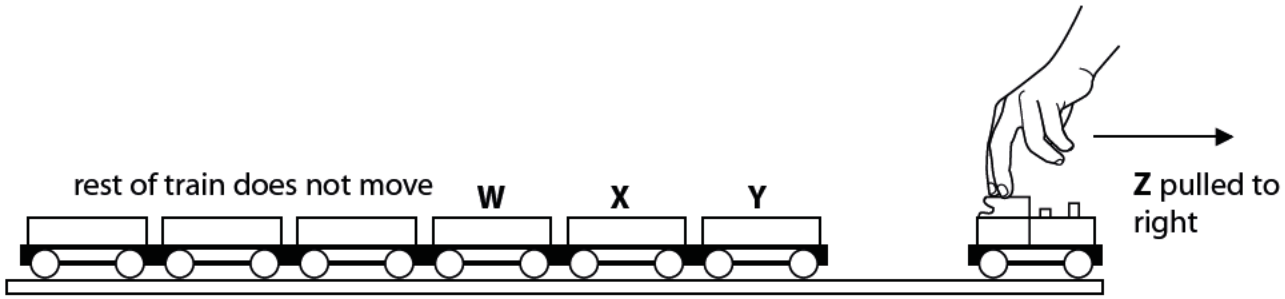


Figure 18

(i) Explain why the train acts in this way by considering the forces involved.

(2)

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(ii) Devise an experiment to investigate the horizontal force needed to separate the trucks from the engine.

(3)

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(iii) Explain why a larger force is needed to separate the trucks from the engine if the force is applied at an angle to the horizontal.

(2)

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(Total for Question 6 = 9 marks)

2 (a) A straight piece of wire is 0.713 m long.

It is placed at right angles to a uniform magnetic field of 0.47 T.

The force on the wire is 0.089 N.

Calculate the current in the wire.

Use an equation from the formula sheet. Give your answer to an appropriate number of significant figures.

(2)

current = ... A

(b) A student investigates the relationship between the magnetic flux density and the electromagnetic force on a current-carrying wire.

The student has the equipment shown in Figure 19.

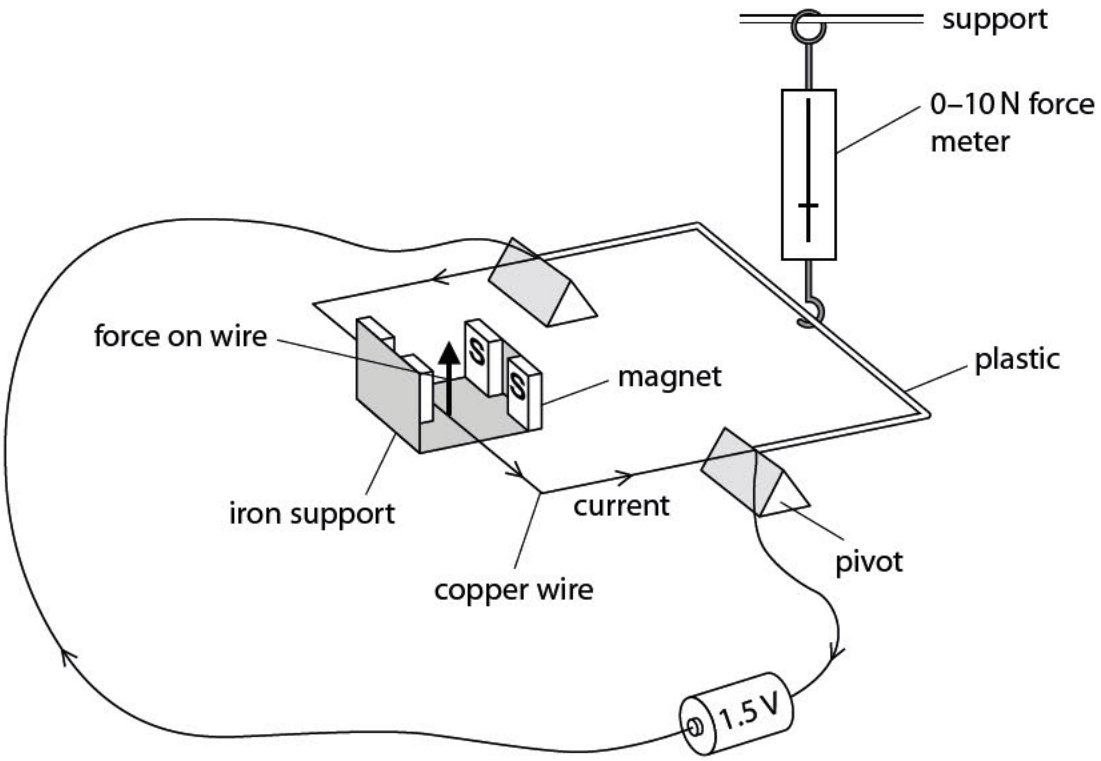

Figure 19

The student varies the number of magnets and measures the force on the wire using the force meter.

The results are shown in Figure 20.

number of pairs of magnets	reading on force meter (N)
1	0.0
2	0.0
3	0.1

Figure 20

The student decides that his equipment is not sufficiently sensitive.

Give **three** ways the student should develop his investigation to improve the quality of his results.

(3)

1 .....

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2 .....

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3 .....

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(c) Figures 21 and 22 show different voltages that can be applied across a wire.

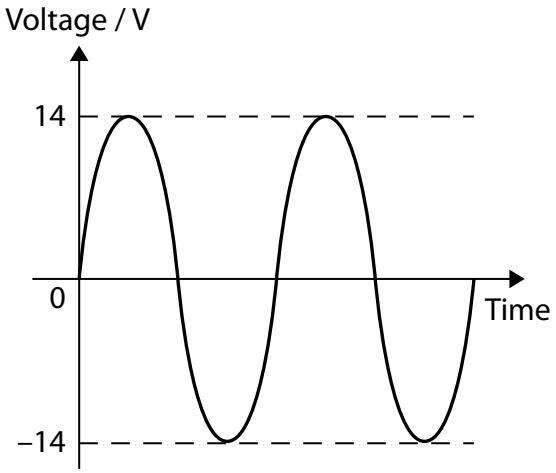

Figure 21

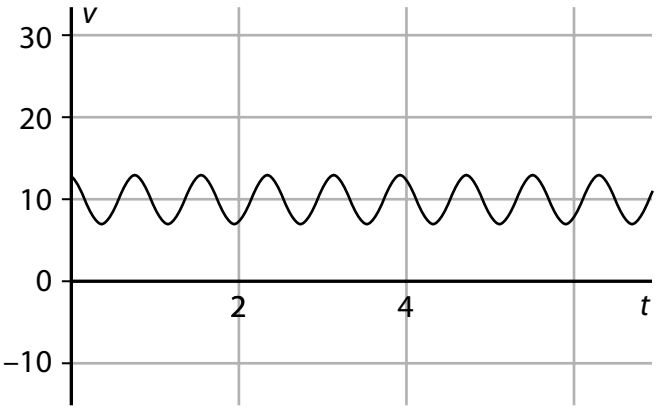

Figure 22

Explain which of the voltages in Figures 21 and 22 cause an a.c. current in the wire.

(2)

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(d) A power transmission wire hangs so that it is at right angles to the Earth's magnetic field.

Although this magnetic field is constant, the cable experiences a changing force.

Explain why the force experienced by the cable changes.

(4)

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(Total for Question 7 = 11 marks)

3 (a) A man monitors
He uses a device which calculates the cost of electrical energy used.
He connects his 2.9 kW electric kettle to the 230 V mains supply.

(i) Calculate the current in the kettle element.

(3)

current = ... A

(ii) The device shows that in one week the total cost of the electrical energy used by the kettle is 97 p.
1kW h of electrical energy costs 17 p.

Calculate the length of time for which the kettle has been switched on during the week.

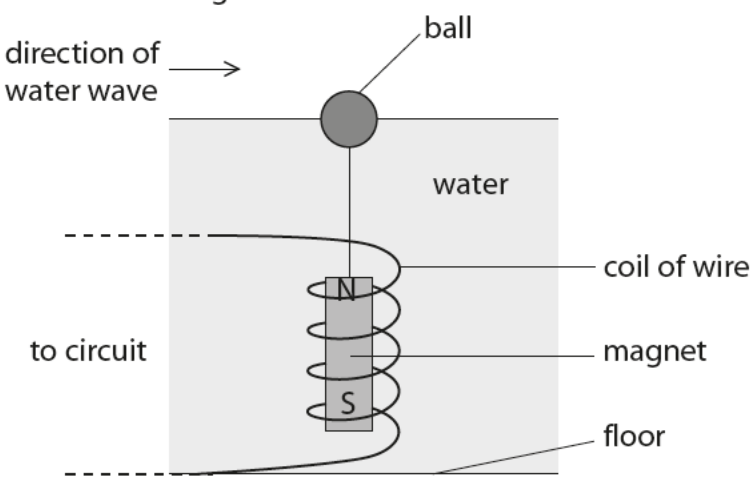
(3)

time = ...hours

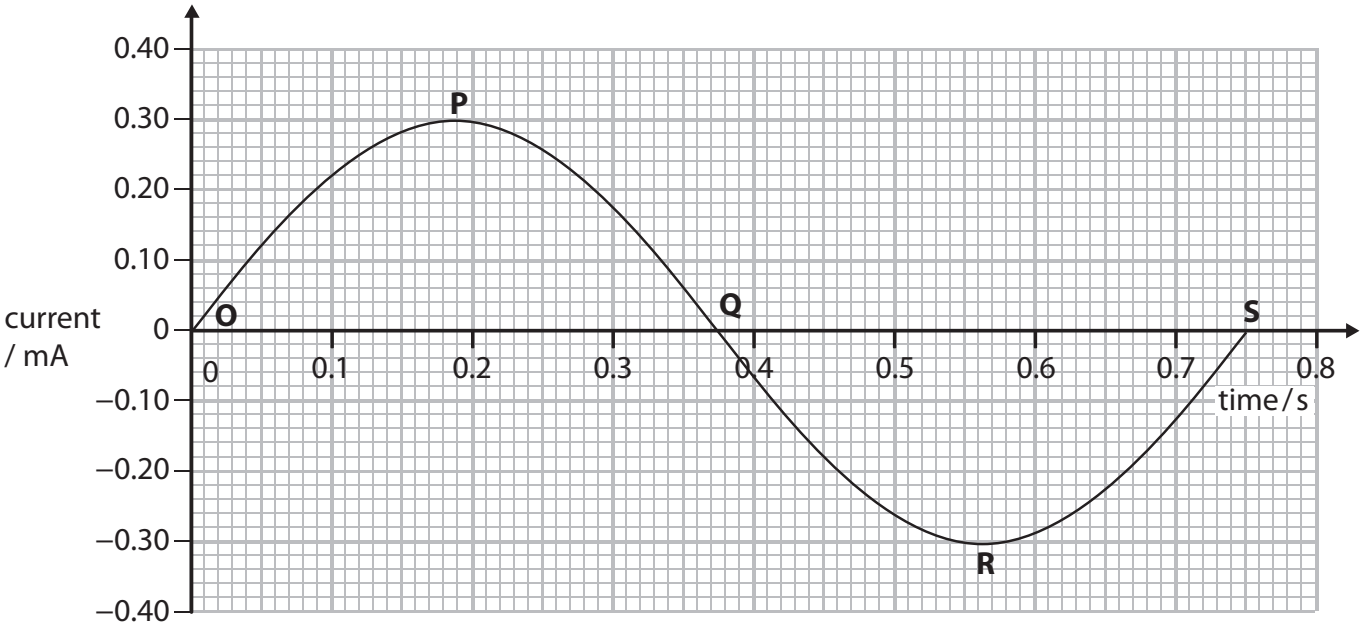
*(b) The diagram shows a model used to generate electricity from water waves in a tank.

A ball floats on the surface of the water in the tank.
A coil of wire is fixed to the floor of the tank.
A magnet is suspended from the ball inside the coil.

When a wave is sent along the surface of the water the ball moves up and down.



The graph shows the current induced in the coil.



Explain how this current is induced in the coil in the model.
You should refer to the model and to the labelled points on the graph in your answer.

(6)

(Total for Question 6 = 12 marks)

Generating electricity

4 The photograph shows a small generator.

When the handle is turned the current produced lights a lamp.

(a) (i) Complete the sentence by putting a cross (☒) in the box next to your answer.

The current produced

(1)

- ☒ **A** usually comes from a battery
- ☒ **B** always has the same frequency
- ☒ **C** is always the same size
- ☒ **D** is usually alternating in direction

(ii) State the unit in which electric current is usually measured.

(1)

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(b) (i) Describe what happens inside the generator to produce the current.

(3)

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(ii) State **one** way in which the size of the current could be increased.

(1)

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*(c) The National Grid is supplied with electricity from large-scale electrical generators.

These generators may be driven using different energy sources.

Compare the use of a non-renewable energy source with the use of a renewable energy source to produce electricity for the National Grid.

(6)

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(Total for Question 5 = 12 marks)