Down to Earth

1 A pilot begins to land an aircraft.

(a) The height of the aircraft decreases from 200 m above the ground to 100 m.

(i) What happens to the gravitational potential energy of the aircraft?

Put a cross (☒) in the box next to your answer.

(1)

☐ **A** it becomes zero

☐ **B** it decreases

☐ **C** it does not change

☐ **D** it increases

(ii) The velocity of the aircraft remains constant.

What happens to the kinetic energy of the aircraft?

Put a cross (☒) in the box next to your answer.

(1)

☐ **A** it becomes zero

☐ **B** it decreases

☐ **C** it does not change

☐ **D** it increases

(b) The aircraft lands with its wheels on the runway as shown.

The aircraft is moving forwards.

(i) Draw an arrow on the diagram to show the direction of the momentum of the aircraft.

(1)

(ii) The velocity of the aircraft when it lands is 75 m/s.

The mass of the aircraft is 130 000 kg.

Calculate the momentum of the aircraft.

(2)

momentum = ... kg m/s

(iii) The aircraft comes to a stop.

State the momentum change of the aircraft from when it lands to when it stops.

(1)

change in momentum = ... kg m/s

(c) When the aircraft lands, the momentum of each passenger also changes.

(i) Explain why it is more comfortable for a passenger if the aircraft takes a longer time to slow down.

(2)

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(ii) Suggest why some aircraft need a very long runway to land safely.

(2)

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(Total for Question 4 = 10 marks)

The swing

2 A child is stationary on a swing.

(a) The child is given a push by his brother to start him swinging.
His brother applies a steady force of 84 N over a distance of 0.25 m.

(i) Calculate the work done by this force.

(2)

work done = ... J

(ii) State how much energy is transferred by this force.

(1)

energy transferred = ... J

(iii) After several more pushes, the child has a kinetic energy of 71 J.

The mass of the child is 27 kg.

Show that the velocity of the child at this point is about 2.3 m/s.

(2)

(iv) Which one of these quantities changes in both size and direction while he is swinging?

Put a cross (☒) in the box next to your answer.

(1)

☐ **A** his gravitational potential energy

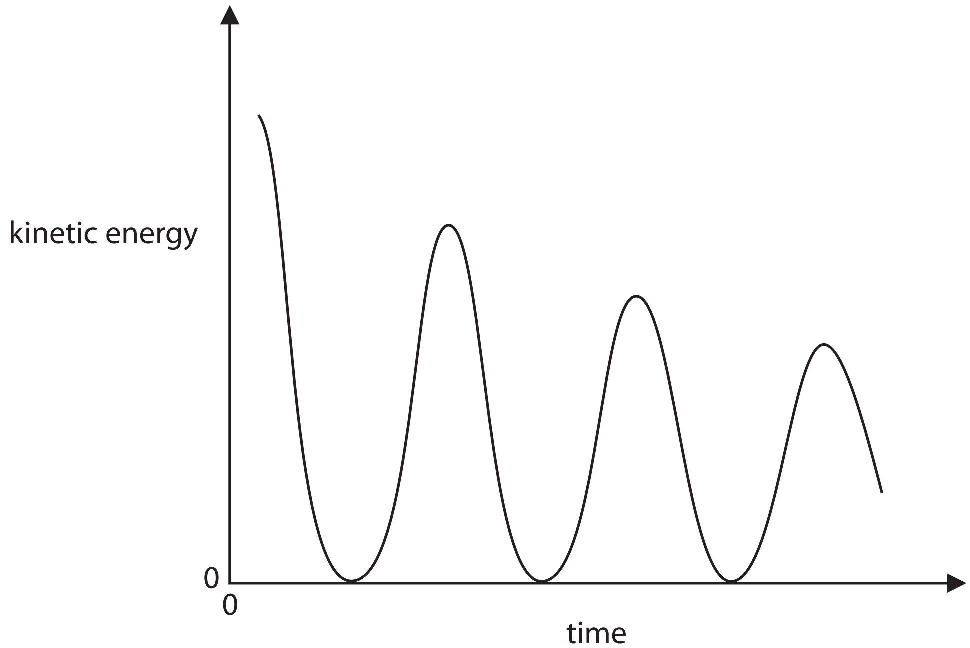
☐ **B** his momentum

☐ **C** the force of gravity acting on him

☐ **D** his kinetic energy

*(b) The brother then stops pushing the child.

The graph shows how the kinetic energy of the child varies over the next few swings.



Explain the energy changes during this time.

(6)

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(Total for Question 5 = 12 marks)

3 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.

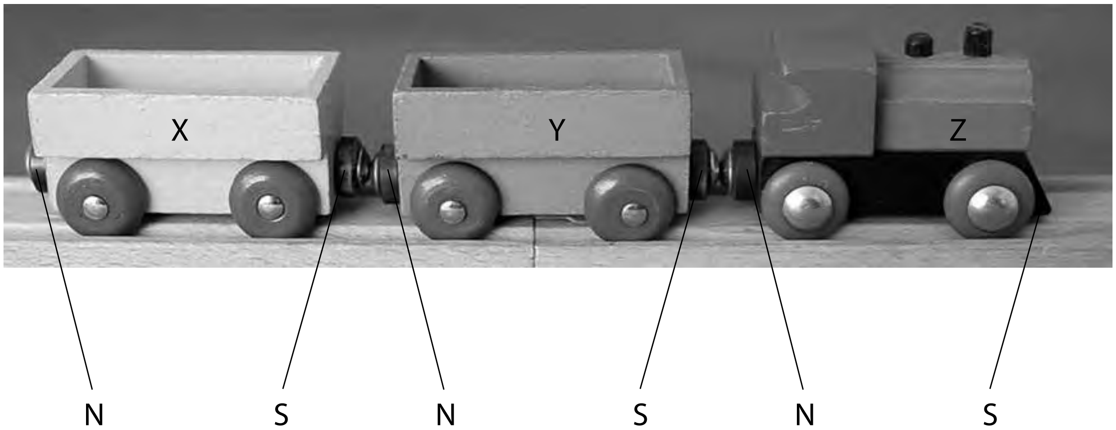


Figure 15

(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.

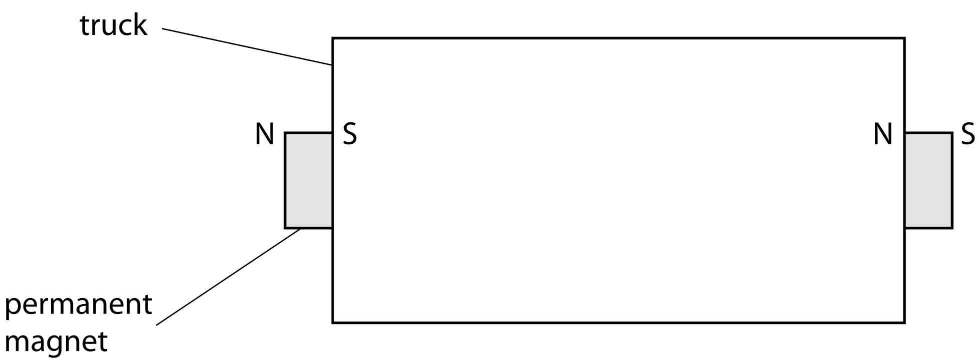
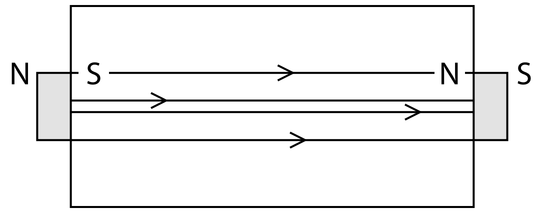


Figure 16

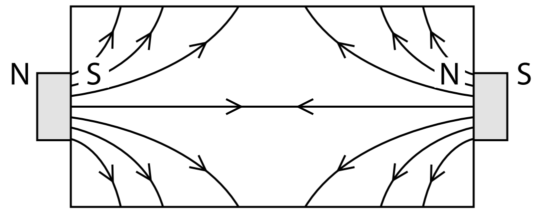
Which of these correctly shows the field inside the truck?

(1)

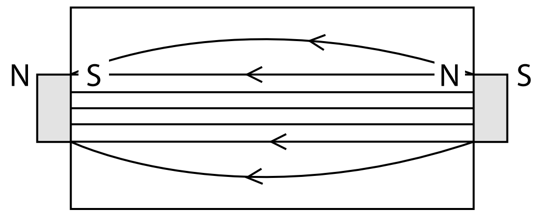
☒ **A**



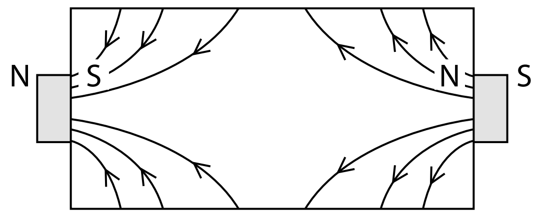
☒ **B**



☒ **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.

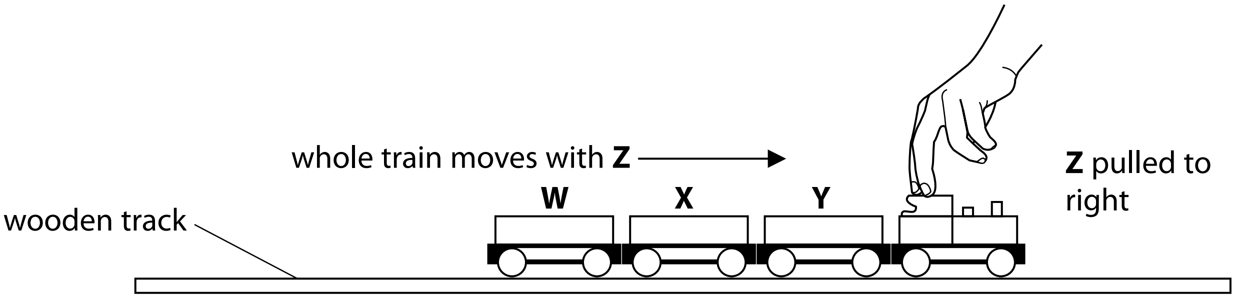


Figure 17

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.

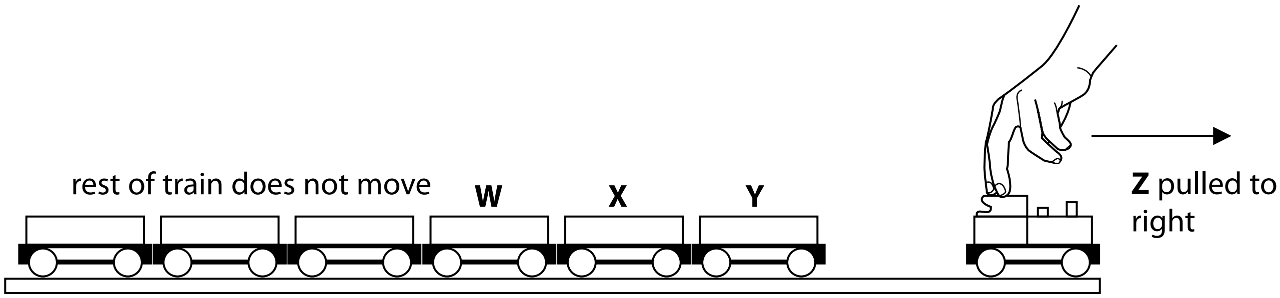


Figure 18

(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)