| **Surname:** | **First Name:** |
|---|---|

| **Current School:** |
|---|

Shrewsbury School

# SHREWSBURY SCHOOL

## SIXTH FORM ENTRANCE EXAMINATION 2024 ENTRY

# PHYSICS

**(1 Hour)**

### Instructions to candidates:

Please answer all questions. Calculators may be used.

Questions 1-30 are multiple choice: **record your answers in the grid provided.**

**Be sure to leave about 20 minutes for section B**: these should be answered in the spaces provided in the booklet.

Assume g = 9.8 m/s$^2$ unless otherwise stated.

# Useful Equations

| Word equation | Symbol equation |
|---|---|
| weight = mass × gravitational field strength ($g$) | $W = m\,g$ |
| work done = force × distance (along the line of action of the force) | $W = F\,s$ |
| force applied to a spring = spring constant × extension | $F = k\,e$ |
| moment of a force = force × distance (normal to direction of force) | $M = F\,d$ |
| pressure = $\frac{\text{force normal to a surface}}{\text{area of that surface}}$ | $p = \frac{F}{A}$ |
| distance travelled = speed × time | $s = v\,t$ |
| acceleration = $\frac{\text{change in velocity}}{\text{time taken}}$ | $a = \frac{\Delta v}{t}$ |
| resultant force = mass × acceleration | $F = m\,a$ |
| momentum = mass × velocity | $p = m\,v$ |
| kinetic energy = 0.5 × mass × (speed)$^2$ | $E_k = \frac{1}{2}m\,v^2$ |
| gravitational potential energy = mass × gravitational field strength ($g$) × height | $E_p = m\,g\,h$ |
| power = $\frac{\text{energy transferred}}{\text{time}}$ | $P = \frac{E}{t}$ |
| power = $\frac{\text{work done}}{\text{time}}$ | $P = \frac{W}{t}$ |
| efficiency = $\frac{\text{useful output energy transfer}}{\text{total input energy transfer}}$ | |
| efficiency = $\frac{\text{useful power output}}{\text{total power input}}$ | |
| wave speed = frequency × wavelength | $v = f\,\lambda$ |
| charge flow = current × time | $Q = I\,t$ |
| potential difference = current × resistance | $V = I\,R$ |
| power = potential difference × current | $P = V\,I$ |
| power = (current)$^2$ × resistance | $P = I^2\,R$ |
| energy transferred = power × time | $E = P\,t$ |
| energy transferred = charge flow × potential difference | $E = Q\,V$ |
| density = $\frac{\text{mass}}{\text{volume}}$ | $\rho = \frac{m}{V}$ |

Name: .....

**Circle your answers for Section A:**

| | | | | |
|---|---|---|---|---|
| **Q.1** | A | B | C | D |
| **Q.2** | A | B | C | D |
| **Q.3** | A | B | C | D |
| **Q.4** | A | B | C | D |
| **Q.5** | A | B | C | D |
| **Q.6** | A | B | C | D |
| **Q.7** | A | B | C | D |
| **Q.8** | A | B | C | D |
| **Q.9** | A | B | C | D |
| **Q.10** | A | B | C | D |
| **Q.11** | A | B | C | D |
| **Q.12** | A | B | C | D |
| **Q.13** | A | B | C | D |
| **Q.14** | A | B | C | D |
| **Q.15** | A | B | C | D |
| **Q.16** | A | B | C | D |
| **Q.17** | A | B | C | D |
| **Q.18** | A | B | C | D |
| **Q.19** | A | B | C | D |
| **Q.20** | A | B | C | D |
| **Q.21** | A | B | C | D |
| **Q.22** | A | B | C | D |
| **Q.23** | A | B | C | D |
| **Q.24** | A | B | C | D |
| **Q.25** | A | B | C | D |
| **Q.26** | A | B | C | D |
| **Q.27** | A | B | C | D |
| **Q.28** | A | B | C | D |
| **Q.29** | A | B | C | D |
| **Q.30** | A | B | C | D |

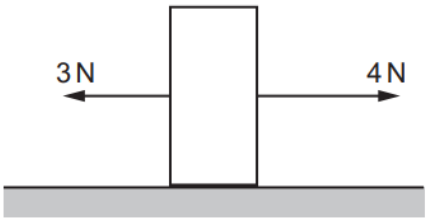
## Section A - 30 marks: Attempt all questions.

1 On Mars, the acceleration of free fall $g$ is $3.7\,m/s^2$.

What is the weight of a 2.0 kg mass on Mars?

**A** 0.54 N **B** 1.9 N **C** 7.4 N **D** 20 N

2 The diagram shows a solid object on a flat surface, with two forces acting on the object.




What is the resultant force on the object?

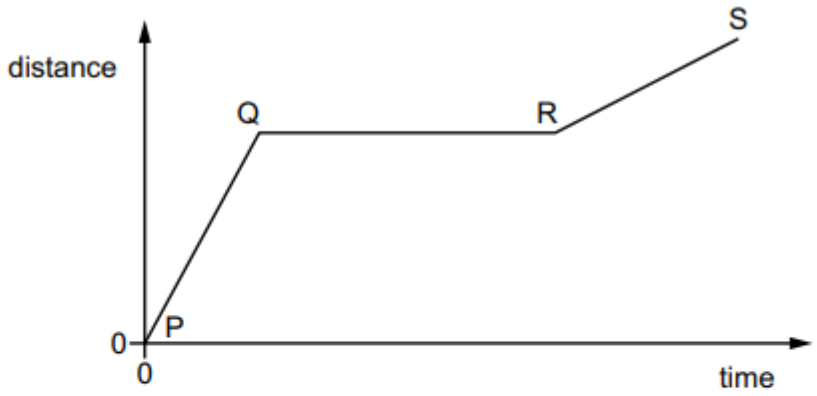
**A** 1 N to the left

**B** 1 N to the right

**C** 7 N to the left

**D** 7 N to the right

3 The graph shows how the distance travelled by a vehicle changes with time.

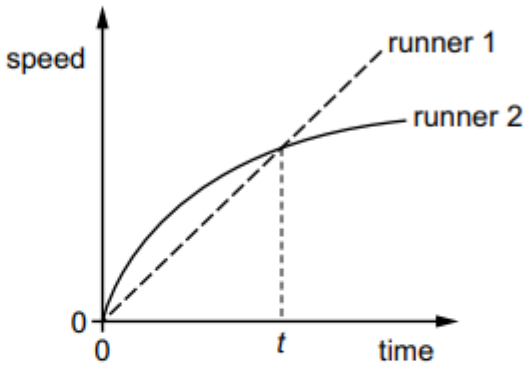



Which row describes the speed of the vehicle in each section of the graph?

| | P to Q | Q to R | R to S |
|---|---|---|---|
| **A** | constant | zero | constant |
| **B** | constant | zero | decreasing |
| **C** | increasing | constant | decreasing |
| **D** | increasing | zero | constant |

4 Two runners take part in a race.

The graph shows how the speed of each runner changes with time.




What does the graph show about the runners at time *t*?

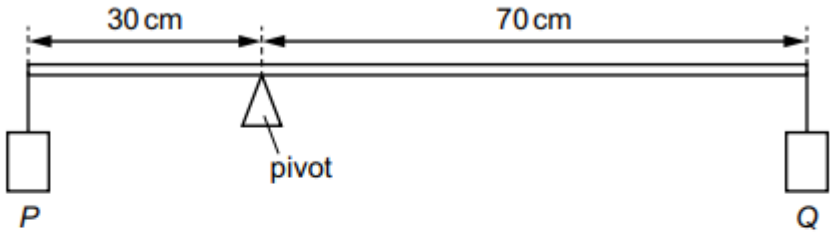
**A** Both runners are moving at the same speed.

**B** Runner 1 has zero acceleration.

**C** Runner 1 runs ahead of runner 2.

**D** Runner 2 is slowing down.

5 A beam on a pivot supports a load *P* at one end and a load *Q* at the other end.
The weight of the beam can be ignored.




The beam is balanced.

Which row gives possible values for *P* and for *Q*?

| | *P*/N | *Q*/N |
|---|---|---|
| **A** | 21 | 7 |
| **B** | 21 | 9 |
| **C** | 30 | 10 |
| **D** | 30 | 70 |

6 A student uses her thumb to push a drawing pin (thumb tack) into a notice board.

The pin goes into the board but does not penetrate her thumb.

Which statement explains this?

**A** The force exerted by the pin on her thumb is greater than the force exerted by the pin on the notice board.

**B** The force exerted by the pin on the notice board is greater than the force exerted by the pin on her thumb.

**C** The pressure of the pin on her thumb is greater than the pressure of the pin on the notice board.

**D** The pressure of the pin on the notice board is greater than the pressure of the pin on her thumb.

7 A book has a mass of 400 g.

The surface of the book in contact with a table has dimensions 0.10 m × 0.20 m.

The gravitational field strength $g$ is 10 N / kg.

What is the pressure exerted on the table due to the book?

**A** $0.08\,N/m^2$ **B** $8.0\,N/m^2$ **C** $20\,N/m^2$ **D** $200\,N/m^2$

8 A child is standing on the platform of a station, watching the trains.

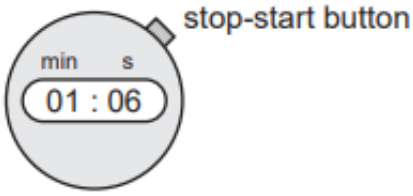
A train travelling at 30 m / s takes 3 s to pass the child.

What is the length of the train?

**A** 10 m **B** 30 m **C** 90 m **D** 270 m

9 The diagram shows a stopwatch, originally set at 00:00.

When a car was first seen, the stop-start button was pressed. When the car passed the observer, the stopwatch showed 01:06.




How long did the car take to reach the observer?

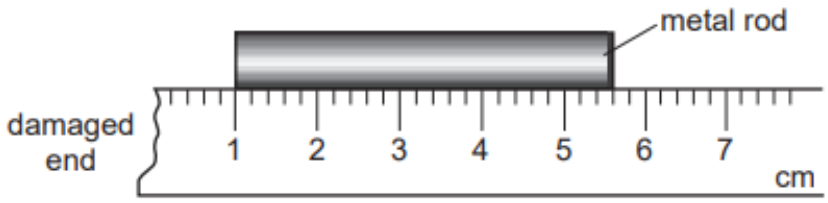
**A** 1.06 seconds

**B** 6 seconds

**C** 66 seconds

**D** 106 seconds

10 A girl uses a rule to measure the length of a metal rod. Because the end of the rule is damaged, she places one end of the rod at the 1 cm mark as shown.

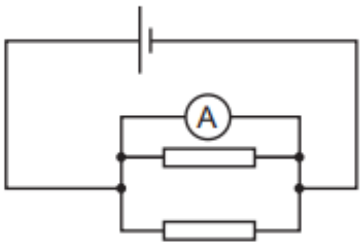



How long is the metal rod?

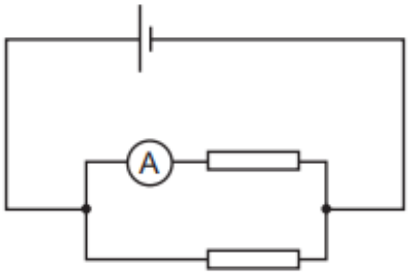
**A** 43 mm **B** 46 mm **C** 53 mm **D** 56 mm

11 In which circuit does the ammeter read the total current through both resistors?

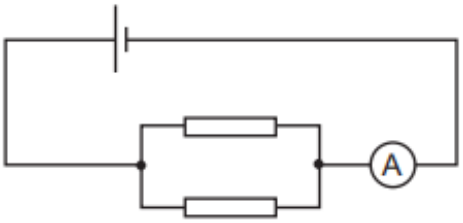
A



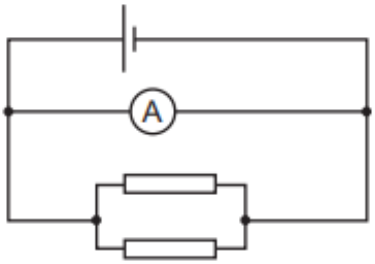

B



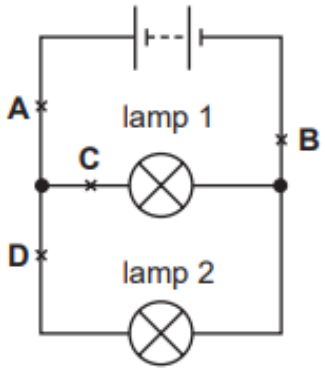

C




D

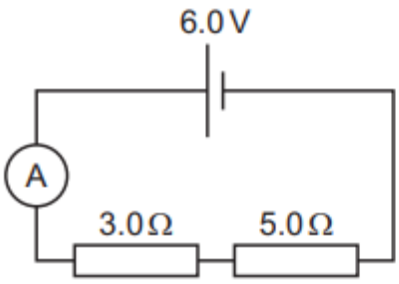



12 The diagram shows a circuit, with four possible positions to place a switch.




At which labelled point should a switch be placed so that lamp 1 remains on all the time and lamp 2 can be switched on and off?

13 The circuit diagram shows a cell connected to an ammeter and two resistors.




What is the current in the circuit?

**A** 0.75 A **B** 1.3 A **C** 12 A **D** 48 A

14 The current in a lamp connected on its own to the mains supply is 0.60 A.

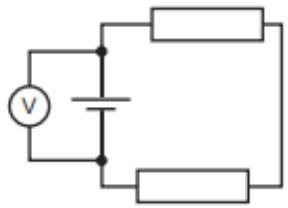
A table decoration has three of these lamps connected in parallel.

Which rating of fuse is suitable to protect this circuit?

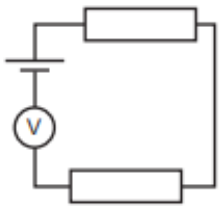
**A** 0.2 A **B** 0.6 A **C** 1.0 A **D** 5.0 A

15 Which circuit shows how a voltmeter is connected to measure the potential difference across the cell?

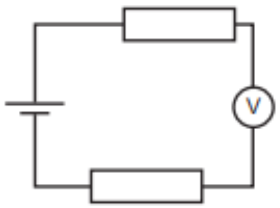
**A**



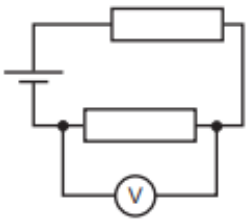

**B**




**C**




**D**




16 A plane mirror is on a wall.

Which is a correct description of the image formed by the mirror?

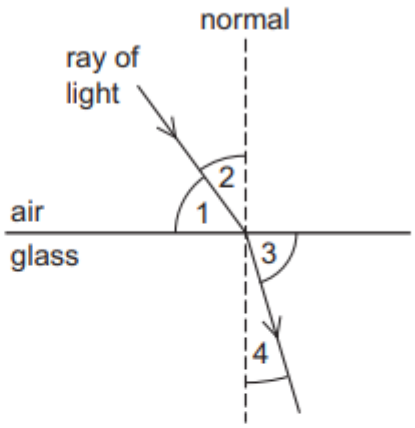
**A** the right way up and smaller than the object

**B** the right way up and the same size as the object

**C** upside down and smaller than the object

**D** upside down and the same size as the object

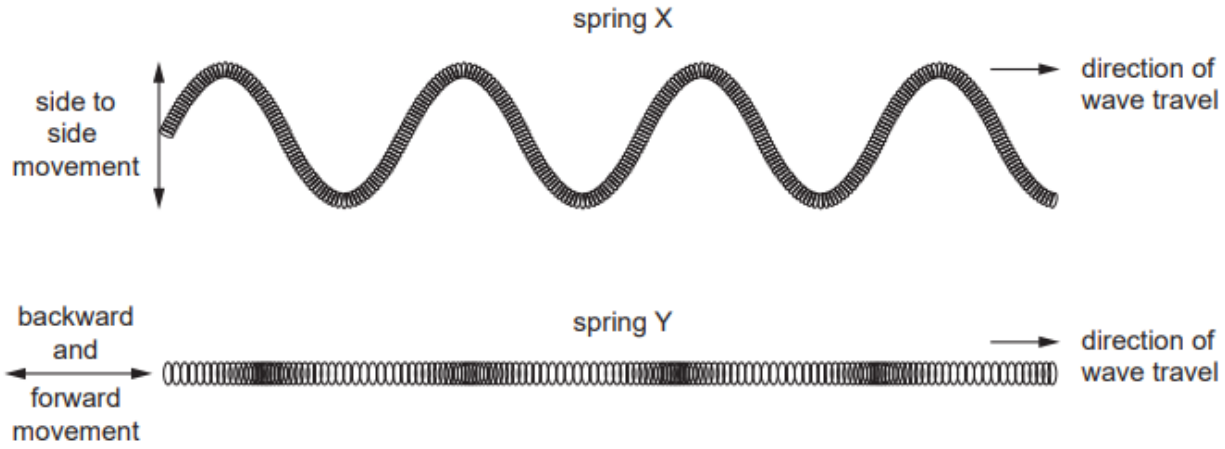
17 The diagram shows a ray of light entering a block of glass.




Which numbered angles are the angles of incidence and of refraction?

| | angle of incidence | angle of refraction |
|---|---|---|
| **A** | 1 | 3 |
| **B** | 1 | 4 |
| **C** | 2 | 3 |
| **D** | 2 | 4 |

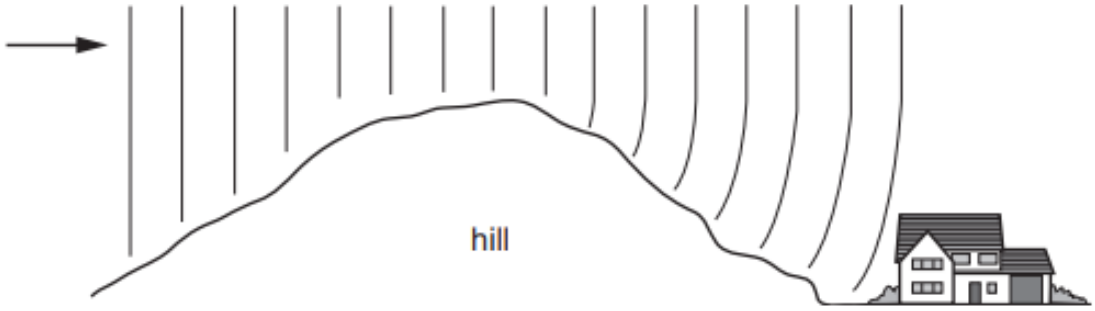
18 Waves are sent along two long springs X and Y as shown.




How should the wave motions in X and Y be described?

| | spring X | spring Y |
|---|---|---|
| **A** | longitudinal | longitudinal |
| **B** | longitudinal | transverse |
| **C** | transverse | longitudinal |
| **D** | transverse | transverse |

19 Radio waves are received at a house at the bottom of a hill.




The waves reach the house because the hill has caused them to be

**A** diffracted.

**B** radiated.

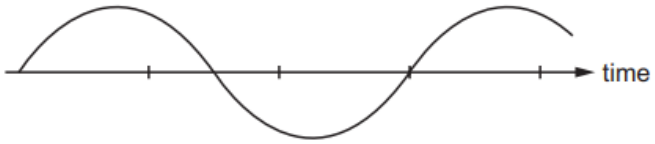
**C** reflected.

**D** refracted.

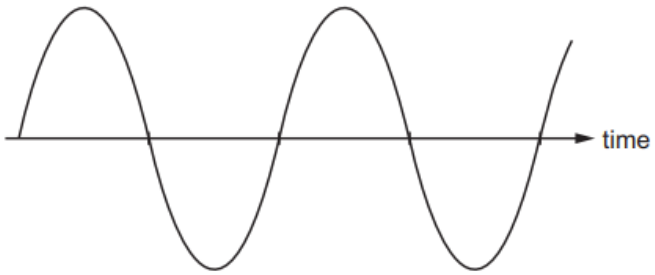
20 The diagrams represent the waves produced by four sources of sound. The scales are the same for all the diagrams.

Which sound has the highest frequency?

**A**

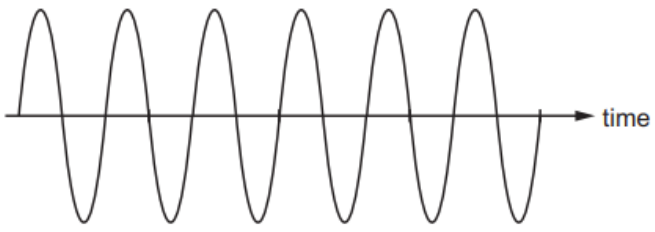



**B**




**C**


**D**



21 The nuclide notation of the isotope strontium-90 is $^{90}_{38}Sr$.

Which statement is correct?

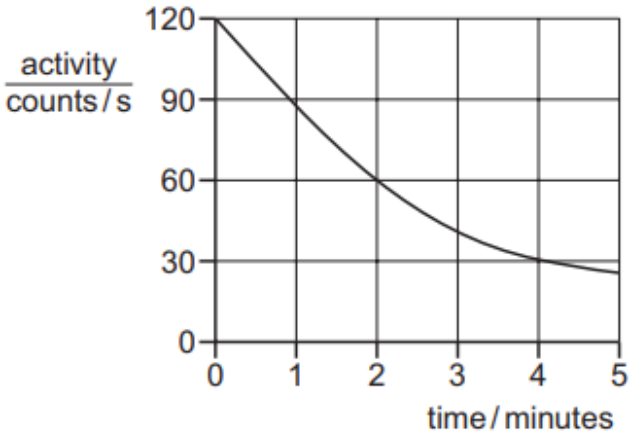
**A** A nucleus of strontium-90 has 38 neutrons.

**B** A nucleus of strontium-90 has 52 neutrons.

**C** A nucleus of strontium-90 has 90 electrons.

**D** A nucleus of strontium-90 has 90 neutrons.

22 The graph shows the activity of a radioactive source over a period of time.




What is the half-life of the source?

**A** 1.0 minute **B** 2.0 minutes **C** 2.5 minutes **D** 4.0 minutes

23 Which statement about α-particles and β-particles is correct?

**A** α-particles are less ionising than β-particles.

**B** α-particles are more penetrating than β-particles.

**C** α-particles have greater mass than β-particles.

**D** α-particles have the same charge as β-particles.

24 Atom X loses an electron to form an ion.

Atom Y gains an electron to form an ion.

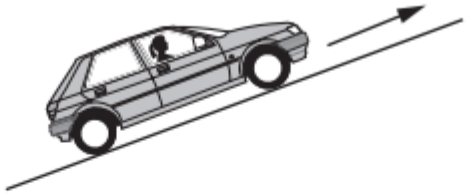
Which row in the table is correct?

| | charge on the ion of atom X | charge on the ion of atom Y |
|---|---|---|
| **A** | positive | positive |
| **B** | positive | negative |
| **C** | negative | positive |
| **D** | negative | negative |

25 Which line in the table gives the numbers of protons and neutrons in the nuclide $^{7}_{3}\text{Li}$?

| | protons | neutrons |
|---|---|---|
| **A** | 3 | 4 |
| **B** | 3 | 7 |
| **C** | 4 | 3 |
| **D** | 7 | 3 |

26 A car accelerates along a road as it rises uphill.

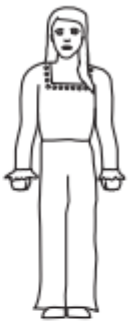


Which energy changes are taking place?

| | energy of motion (kinetic energy) | energy of position (gravitational potential energy) |
|---|---|---|
| **A** | decreasing | decreasing |
| **B** | decreasing | increasing |
| **C** | increasing | decreasing |
| **D** | increasing | increasing |

27 A boy and a girl run up a hill in the same time.

boy weighs 600 N



girl weighs 500 N

The boy weighs more than the girl.

Which statement is true about the power produced?

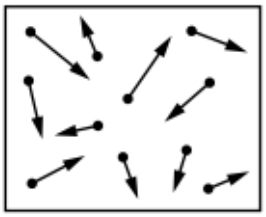
**A** The boy produces more power.

**B** The girl produces more power.

**C** They both produce the same power.

**D** It is impossible to tell who produces more power.

28 The diagram represents particles of a gas inside a closed container of constant volume.



The gas is heated.

What happens to the particles of the gas?

**A** They expand.

**B** They get closer together.

**C** They hit the container walls with less force.

**D** They move faster.

29 Which source of energy is renewable?

**A** coal

**B** natural gas

**C** oil

**D** wind

30 In which substances is convection a method of thermal energy transfer?

**A** air and water only

**B** air only

**C** air, water and wood

**D** water only

## Section B 20 marks. Attempt all questions.

1. Figure 1 shows the speed-time graph of part of a short journey made by a cyclist.

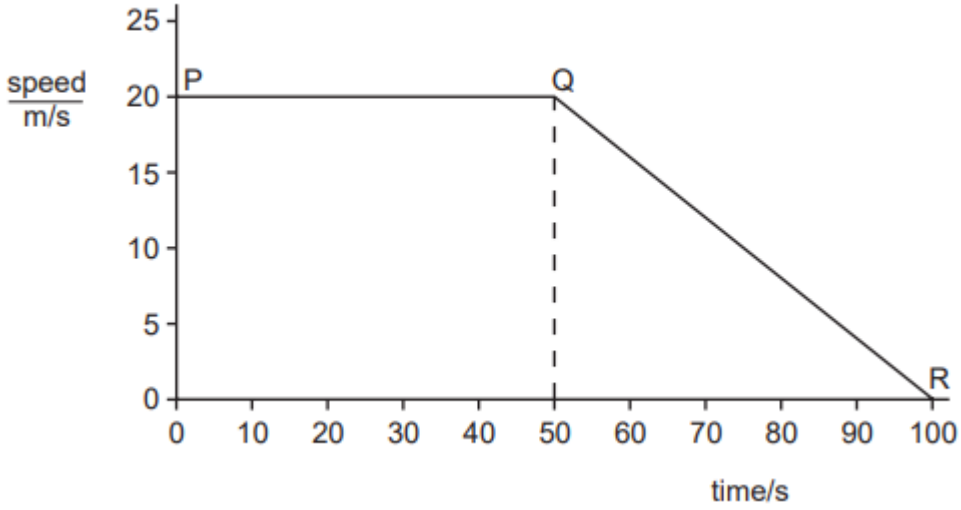



*Figure 1*

a. Which part of the graph shows when the cyclist is travelling at a constant speed?

(1)

b. State what is happening during the rest of the journey shown in Figure 1.

(1)

c (i) Calculate the distance travelled during the first 50 seconds.

Distance travelled = ..... m

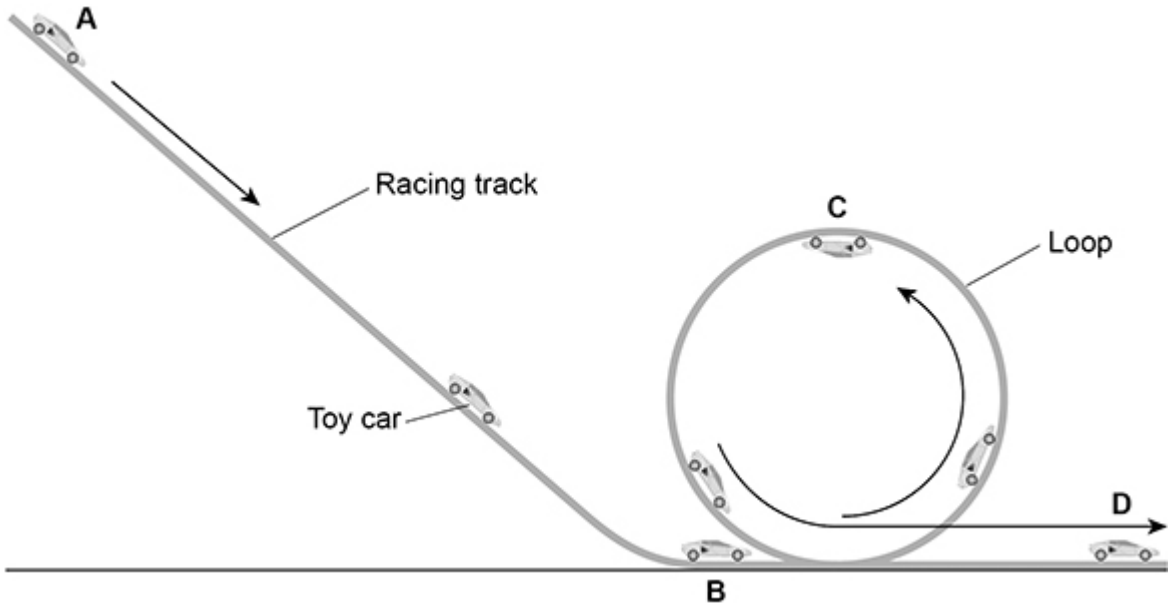
(2)

c (ii) Calculate the average speed during the 100 s journey.

Average speed = …….. m/s
(2)

**Total for question 1 = 6 marks**

2 The figure below shows a toy car in different positions on a racing track.




(a) The toy car and racing track can be modelled as a closed system.

Why can the toy car and racing track be considered ‘a closed system’?

Tick (✓) **one** box.

| | |
|---|---|
| The racing track and the car both have gravitational potential energy. | ☐ |
| The racing track and the car are always in contact with each other. | ☐ |
| The total energy of the racing track and the car is constant. | ☐ |

(1)

(b) The car is released from rest at position **A** and accelerates due to gravity down the track to position **B**.

mass of toy car = 0.040 kg

vertical height between position **A** and position **B** = 90 cm

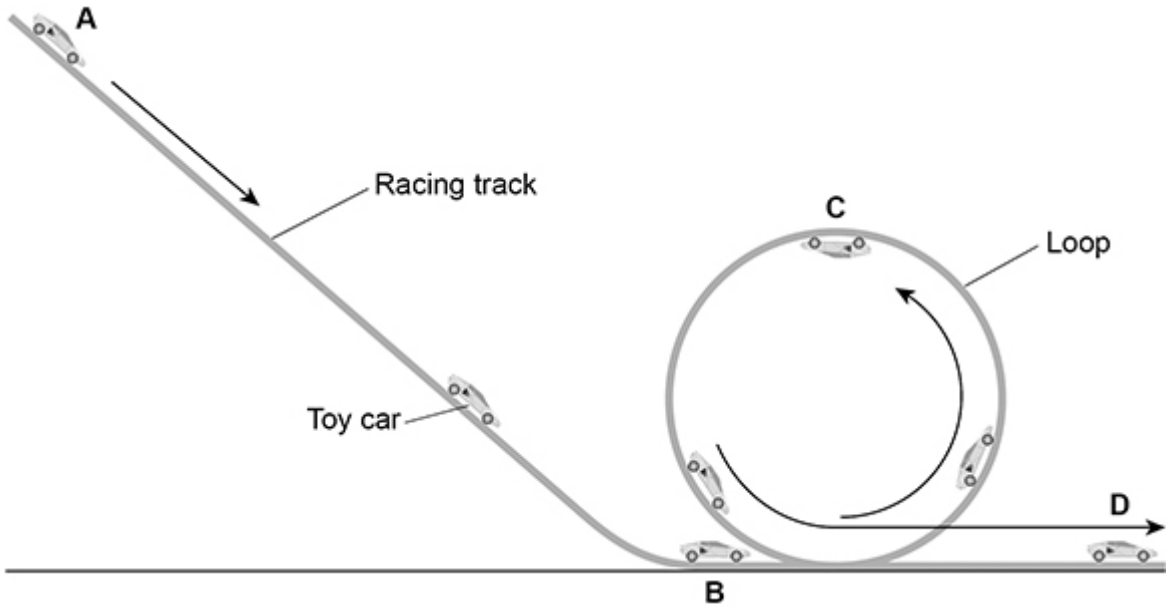
gravitational field strength = 9.8 N/kg

Calculate the maximum possible speed of the toy car when it reaches position **B**.

Speed = _____ m/s

**(5)**

The figure above is repeated below.




(c) At position **C** the car's gravitational potential energy is 0.20 J greater than at position **B**.

How much kinetic energy does the car need at position **B** to complete the loop of the track?

Give a reason for your answer.

Tick (✓) **one** box.

| | |
|---|---|
| Less than 0.20 J | ☐ |
| Exactly 0.20 J | ☐ |
| More than 0.20 J | ☐ |

Reason _____

_____

_____

**(2)**

**Total for question 2 = 8 marks**

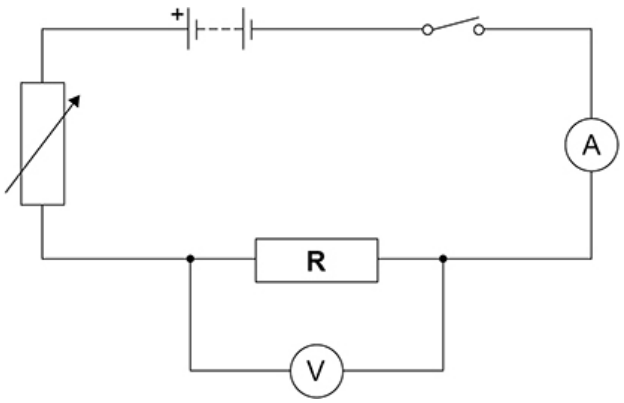
3

Student **A** investigated how the current in resistor **R** at constant temperature varied with the potential difference across the resistor.

Student **A** recorded both positive and negative values of current.

**Figure 1** shows the circuit Student **A** used.

**Figure 1**




(a) Describe a method that Student **A** could use for this investigation.

**(6)**

Total for question 3 = 6 marks