A

Surname ______________________

Other Names ______________________

Centre Number ______________________

Candidate Number ______________________

Candidate Signature ______________________

I declare this is my own work.

AS

PHYSICS

Paper 1

7407/1

Tuesday 12 May 2020 Morning

Time allowed: 1 hour 30 minutes

At the top of the page, write your surname and other names, your centre number, your candidate number and add your signature.

[Turn over]

J U N 2 0 7 4 0 7 1 0 1

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For this paper you must have:
- **a pencil and a ruler**
- **a scientific calculator**
- **a Data and Formulae Booklet.**

INSTRUCTIONS

- **Use black ink or black ball-point pen.**
- **Answer ALL questions.**
- **You must answer the questions in the spaces provided. Do NOT write on blank pages.**
- **If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).**
- **Do all rough work in this book. Cross through any work you do not want to be marked.**
- **Show all your working.**

INFORMATION

- **The marks for questions are shown in brackets.**
- **The maximum mark for this paper is 70.**
- **You are expected to use a scientific calculator where appropriate.**
- **A Data and Formulae Booklet is provided as a loose insert.**

DO NOT TURN OVER UNTIL TOLD TO DO SO

Answer ALL questions in the spaces provided.

0 1 One strong interaction that occurs when two high-energy protons collide is

$$p + p \rightarrow p + \pi^{+} + \pi^{-} + X$$

0 1 . 1 Determine the lepton number, strangeness and charge of particle X. [2 marks]

lepton number = ______________________

strangeness = ______________________

charge = ______________________

0 1 . 2 **Identify particle X. [1 mark]**

____

0 1 . 3 **A possible decay of a negative pion is**

$$\pi^- \rightarrow e^- + Y$$

What is particle Y?

Tick (✓) ONE box. [1 mark]

☐ $\bar{\nu}_e$

☐ ν_e

☐ π^0

☐ ${}^1_0 n$

[Turn over]

0 1 . 4 **Some subatomic particles are classified as hadrons. There are two classes of hadrons.**

Discuss the nature of hadrons.
Your answer should include:

- **the identifying properties of hadrons**
- **the structure of a hadron in each class**
- **a discussion of the stability of free hadrons.**

[6 marks]

[Turn over]

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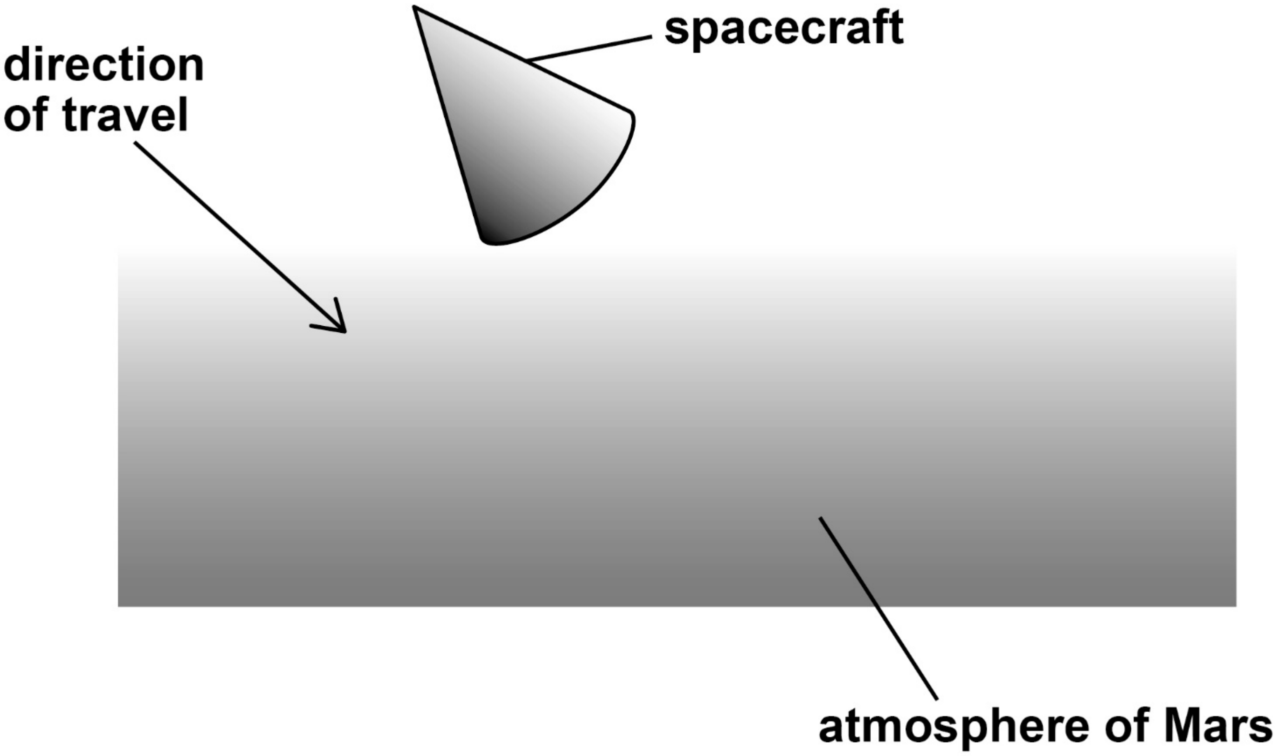
[Turn over]

0 2 A spacecraft entering the atmosphere of Mars must decelerate to land undamaged on the surface.

FIGURE 1



0 2 . 1 **FIGURE 1 shows the spacecraft of total mass $610\ \mathrm{kg}$ entering the atmosphere at a speed of $5.5\ \mathrm{km\ s^{-1}}$.**

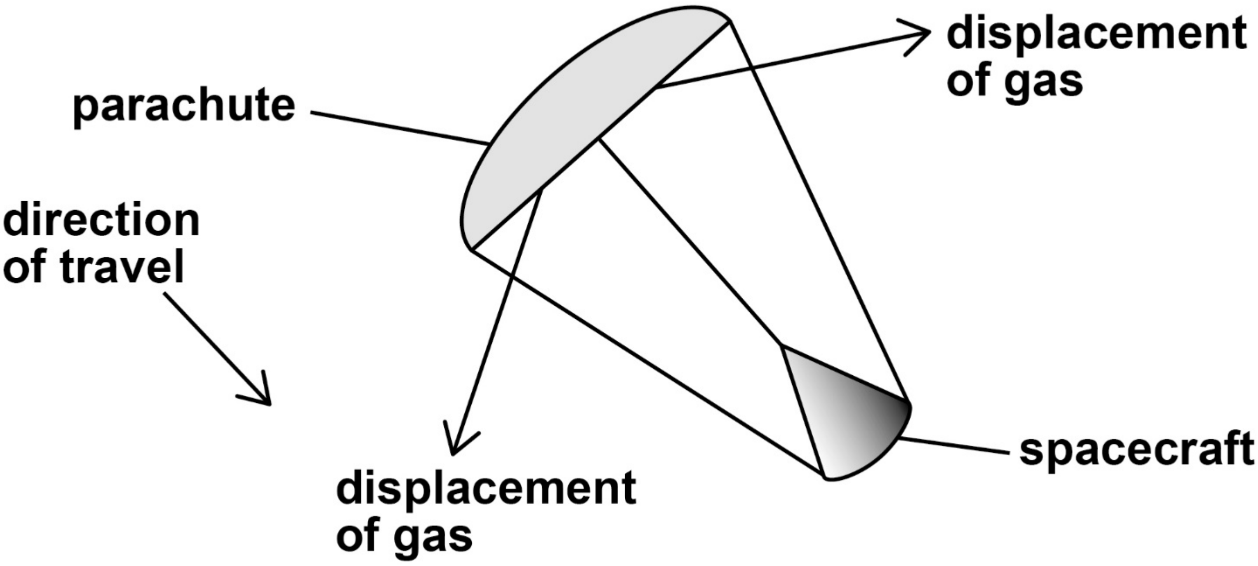
Calculate the kinetic energy of the spacecraft as it enters the atmosphere.
Give your answer to an appropriate number of significant figures. [3 marks]

kinetic energy = ______________________ J

0 2 . 2 A parachute opens during the spacecraft's descent through the atmosphere.

FIGURE 2 shows the parachute–spacecraft system, with the open parachute displacing the atmospheric gas. This causes the system to decelerate.

FIGURE 2



Explain, with reference to Newton's laws of motion, why displacing the atmospheric gas causes a force on the system AND why this force causes the system to decelerate.
[4 marks]

___

___

0 2 . 3 As the parachute–spacecraft system decelerates, it falls through a vertical distance of $49\,\mathrm{m}$ and loses $2.2 \times 10^{5}\,\mathrm{J}$ of kinetic energy.
During this time, $3.3 \times 10^{5}\,\mathrm{J}$ of energy is transferred from the system to the atmosphere.
The total mass of the system is $610\,\mathrm{kg}$.

Calculate the acceleration due to gravity as it falls through this distance. [3 marks]

acceleration due to gravity =

______________________ $\mathrm{m\,s^{-2}}$

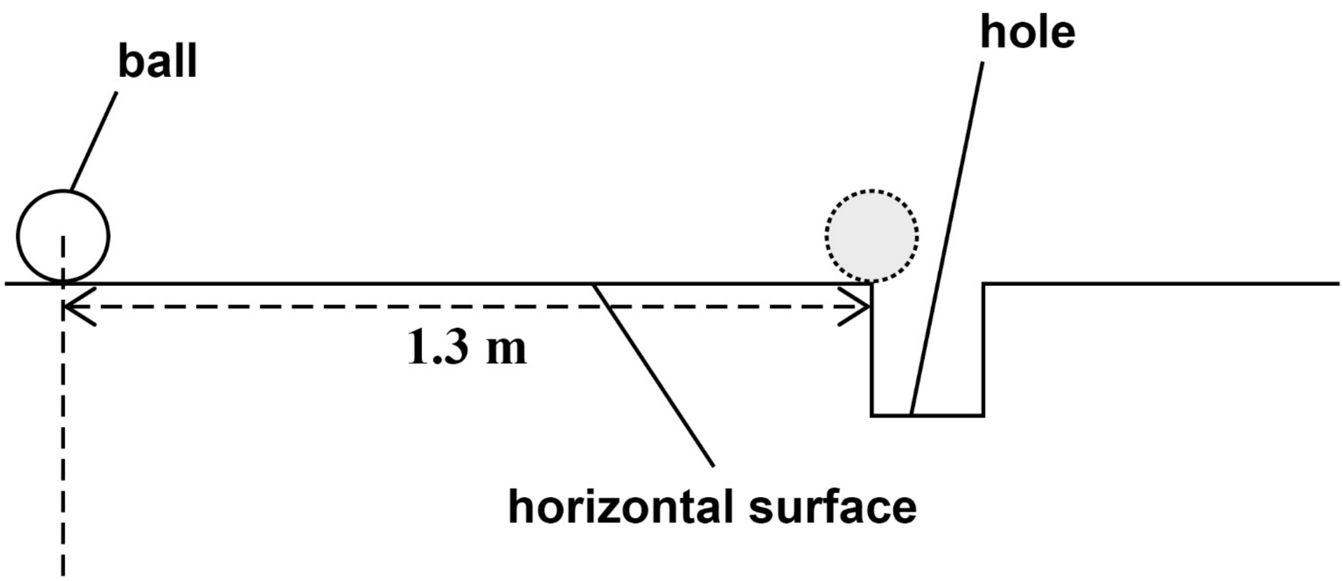
0 2 . 4 **Dust from the surface of Mars can enter the atmosphere. This increases the density of the atmosphere significantly.**

Deduce how an increase in dust content will affect the deceleration of the system.
[3 marks]

0 3 . 1 **FIGURE 3 shows a golf ball at rest on a horizontal surface $1.3\ \mathrm{m}$ from a hole.**

The diagram is not drawn accurately.

FIGURE 3



A golfer hits the ball so that it moves horizontally with an initial velocity of $1.8\ \mathrm{m\,s^{-1}}$. The ball experiences a constant deceleration of $1.2\ \mathrm{m\,s^{-2}}$ as it travels to the hole.

Calculate the velocity of the ball when it reaches the edge of the hole. [2 marks]

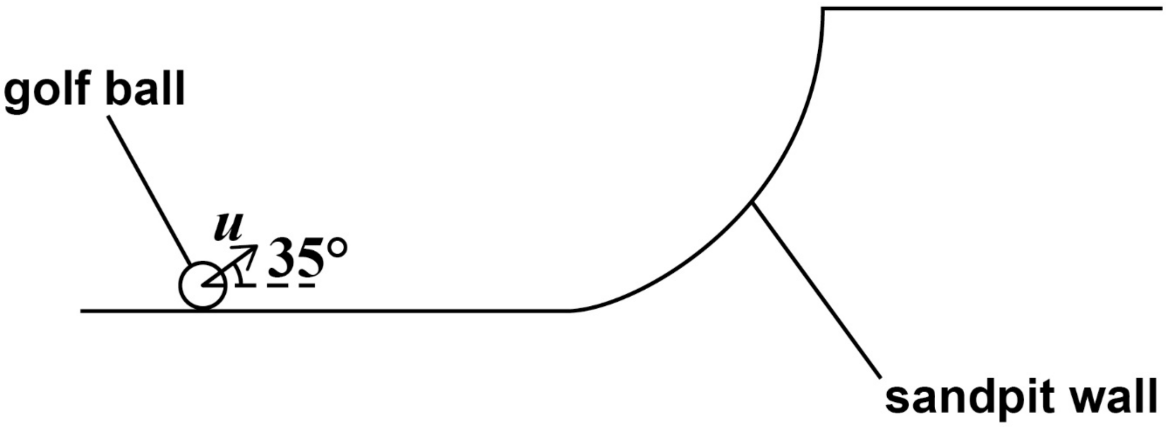
velocity = ______________________ $m\,s^{-1}$

[Turn over]

0 3 . 2 **Later, the golf ball lands in a sandpit. The golfer hits the ball, giving it an initial velocity u at $35°$ to the horizontal, as shown in FIGURE 4. The horizontal component of u is $8.8\ \mathrm{m\,s^{-1}}$.**

The diagram is not drawn accurately.

FIGURE 4



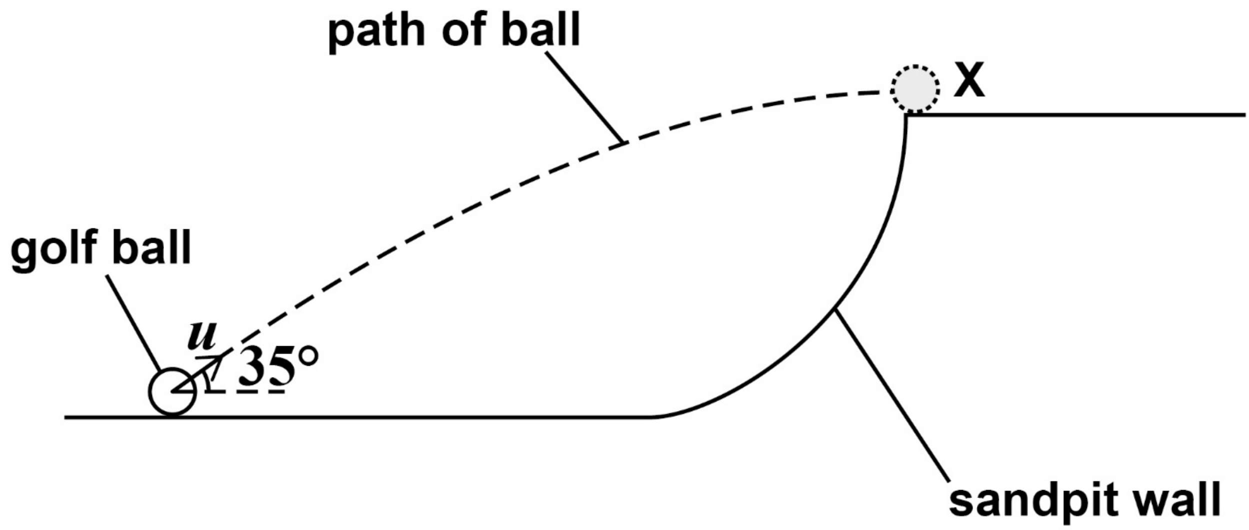
Show that the vertical component of u is approximately $6\ \mathrm{m\,s^{-1}}$. [1 mark]

[Turn over]

0 3 . 3 The ball is travelling horizontally as it reaches X, as shown in FIGURE 5.

The diagram is not drawn accurately.

FIGURE 5



Assume that weight is the only force acting on the ball when it is in the air.

Calculate the time for the ball to travel to X.
[2 marks]

time = ____________________________ s

0 3 . 4 **Calculate the vertical distance of X above the initial position of the ball. [2 marks]**

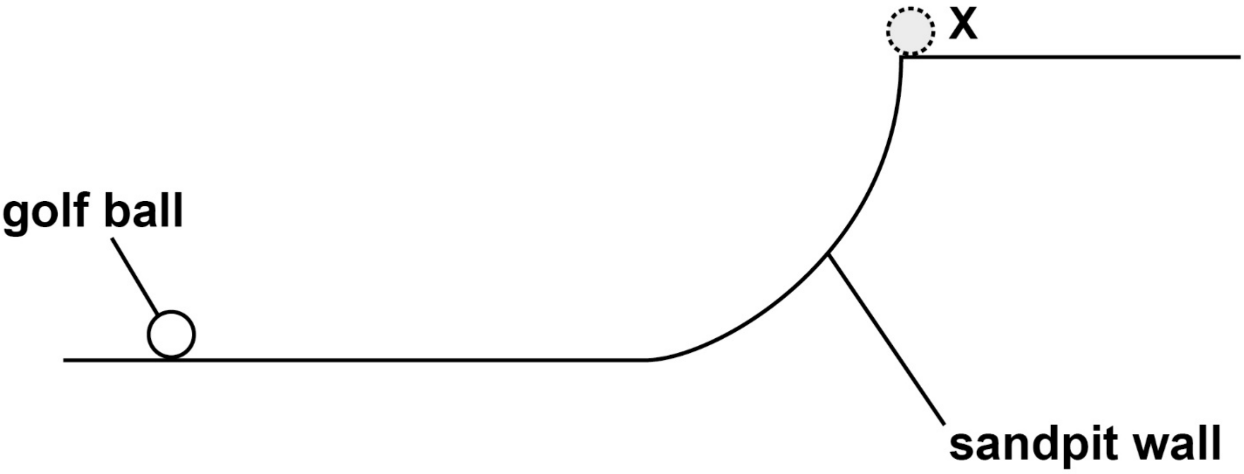
vertical distance = ______________________ m

[Turn over]

The golfer returns the ball to its original position in the sandpit. He wants the ball to land at X but this time with a SMALLER horizontal velocity than in FIGURE 5.

The diagram is not drawn accurately.

FIGURE 6



0 3 . 5 Sketch on FIGURE 6 a possible trajectory for the ball. [1 mark]

0 3 . 6 **Explain your reason for selecting this trajectory. [2 marks]**

[Turn over]

10

0 4 A sample of pure boron contains only isotope X and isotope Y.
A nucleus of X has more mass than a nucleus of Y.

0 4 . 1 The sample is ionised, producing ions each with a charge of $+1.6 \times 10^{-19}$ C.
The specific charge of an ion of X is 8.7×10^{6} C kg^{-1}.

Calculate the mass of an ion of X. [1 mark]

mass of ion = ______________________ kg

0 4 . 2 **Determine the number of nucleons in a nucleus of X.**

mass of a nucleon = 1.7×10^{-27} **kg**

[2 marks]

number of nucleons = ______________________

[Turn over]

0 4 . 3 **Compare the nuclear compositions of X and Y.**
[2 marks]

04.4 **Ions of Y have the same charge as ions of X.**

State and explain how the specific charge of an ion of X compares with that of an ion of Y.
[2 marks]

[Turn over]

0 4 . 5 **TABLE 1 contains data about two completely ionised samples of pure boron.
Each sample contains only isotopes X and Y.**

TABLE 1

Sample number	Number of ions in sample	Mass of sample / kg	Charge on each ion / C
1	3.50×10^{16}	6.31×10^{-10}	$+1.60 \times 10^{-19}$
2	3.50×10^{7}	6.20×10^{-19}	$+1.60 \times 10^{-19}$

Deduce which sample, 1 or 2, contains a greater percentage of isotope Y. [3 marks]

[Turn over]

10

0 5 **A cell has an emf of $1.5\ \mathrm{V}$ and an internal resistance of $0.65\ \Omega$.**
The cell is connected to a resistor R.

0 5 . 1 **State what is meant by an emf of $1.5\ \mathrm{V}$.**
[2 marks]

0 5 . 2 **The current in the circuit is 0.31 A.**

Show that the total power output of the cell is approximately 0.47 W. [1 mark]

[Turn over]

0 5 . 3 **Calculate the energy dissipated per second in resistor R. [2 marks]**

energy dissipated per second =

______________________ J s^{-1}

0 5 . 4 **The cell stores 14 kJ of energy when it is fully charged. The cell's emf and internal resistance are constant as the cell is discharged.**

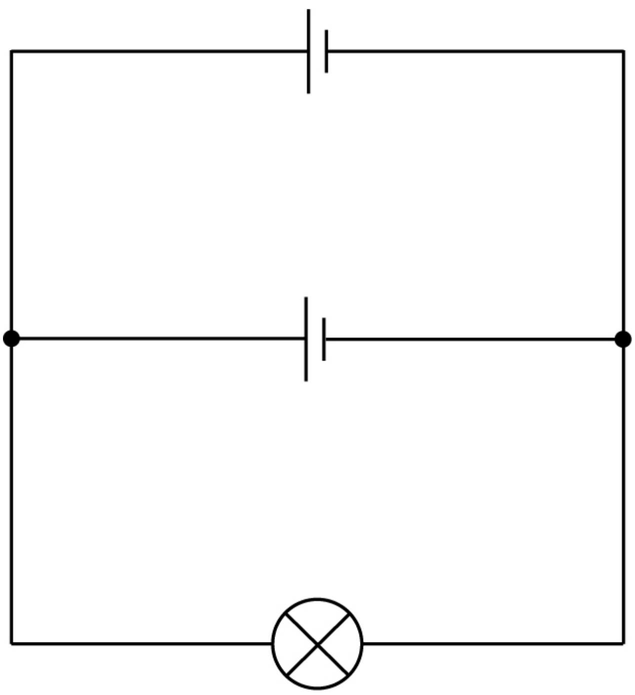
Calculate the maximum time during which the fully-charged cell can deliver energy to resistor R. [2 marks]

maximum time = ______________________ s

[Turn over]

05.5 **A student uses two cells, each of emf $1.5\ \mathrm{V}$ and internal resistance $0.65\ \Omega$, to operate a lamp. The circuit is shown in FIGURE 7.**

FIGURE 7



The lamp is rated at 1.3 V, 0.80 W.

Deduce whether this circuit provides the lamp with 0.80 W of power at a potential difference (pd) of 1.3 V.
Assume that the resistance of the lamp is constant. [4 marks]

[Turn over]

05.6 **The lamp operates at normal brightness across a pd range of 1.3 V to 1.5 V.**

State and explain how more of these cells can be added to the circuit to make the lamp light at normal brightness for a longer time.
No further calculations are required.
[3 marks]

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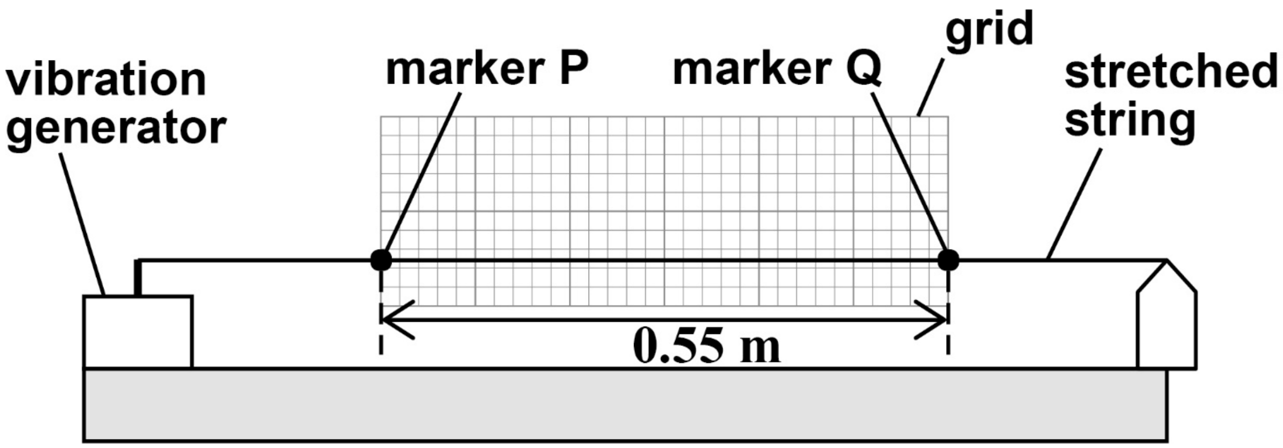
[Turn over]

0 6 FIGURE 8 shows the apparatus a student uses to investigate stationary waves in a stretched string.

Two small pieces of adhesive tape are fixed to the string as markers P and Q. Markers P and Q are $0.55\ \mathrm{m}$ apart and an equal distance from the ends of the string. A graph paper grid is placed behind the string between P and Q.

The diagram is not drawn accurately.

FIGURE 8



0 6 . 1 **The string is made to vibrate at the second harmonic.**

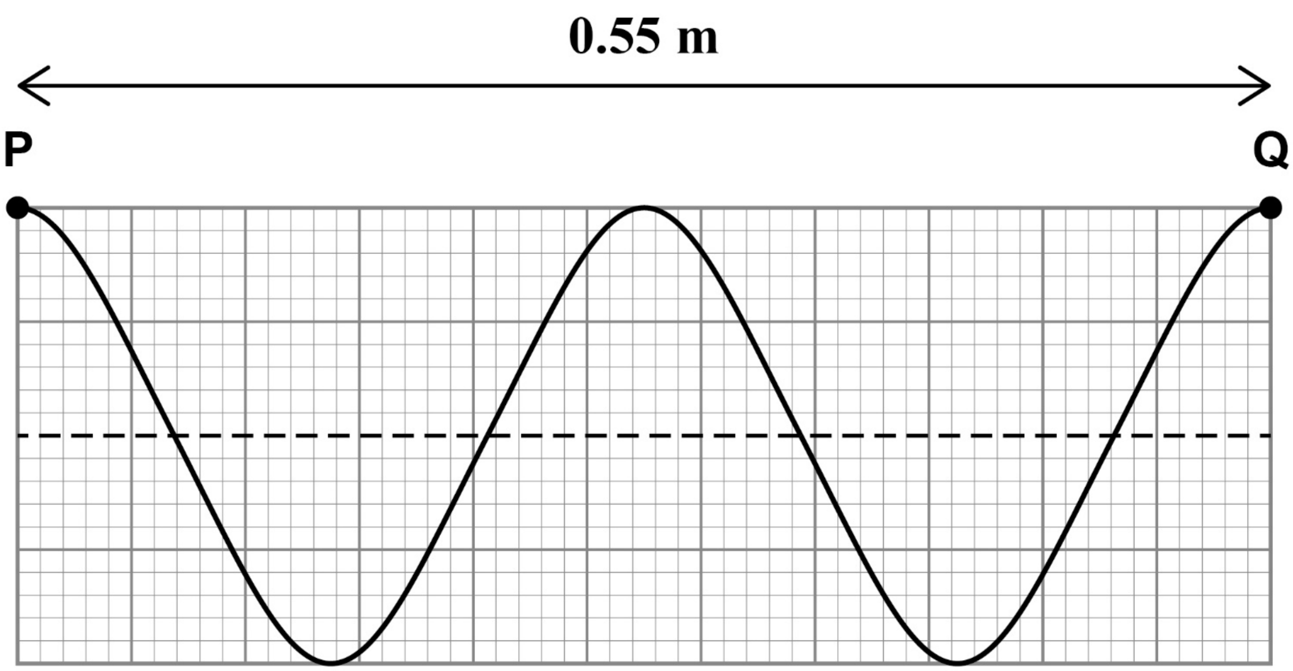
Compare the motion of P with that of Q.
[2 marks]

[Turn over]

0 6 . 2 The frequency of the vibration generator is increased, and a higher harmonic of the stationary wave is formed.

FIGURE 9 shows the string between P and Q at an instant in time. The dashed horizontal line indicates the position of the string at rest when the vibration generator is switched off.

FIGURE 9



The frequency of the vibration generator is 250 Hz.

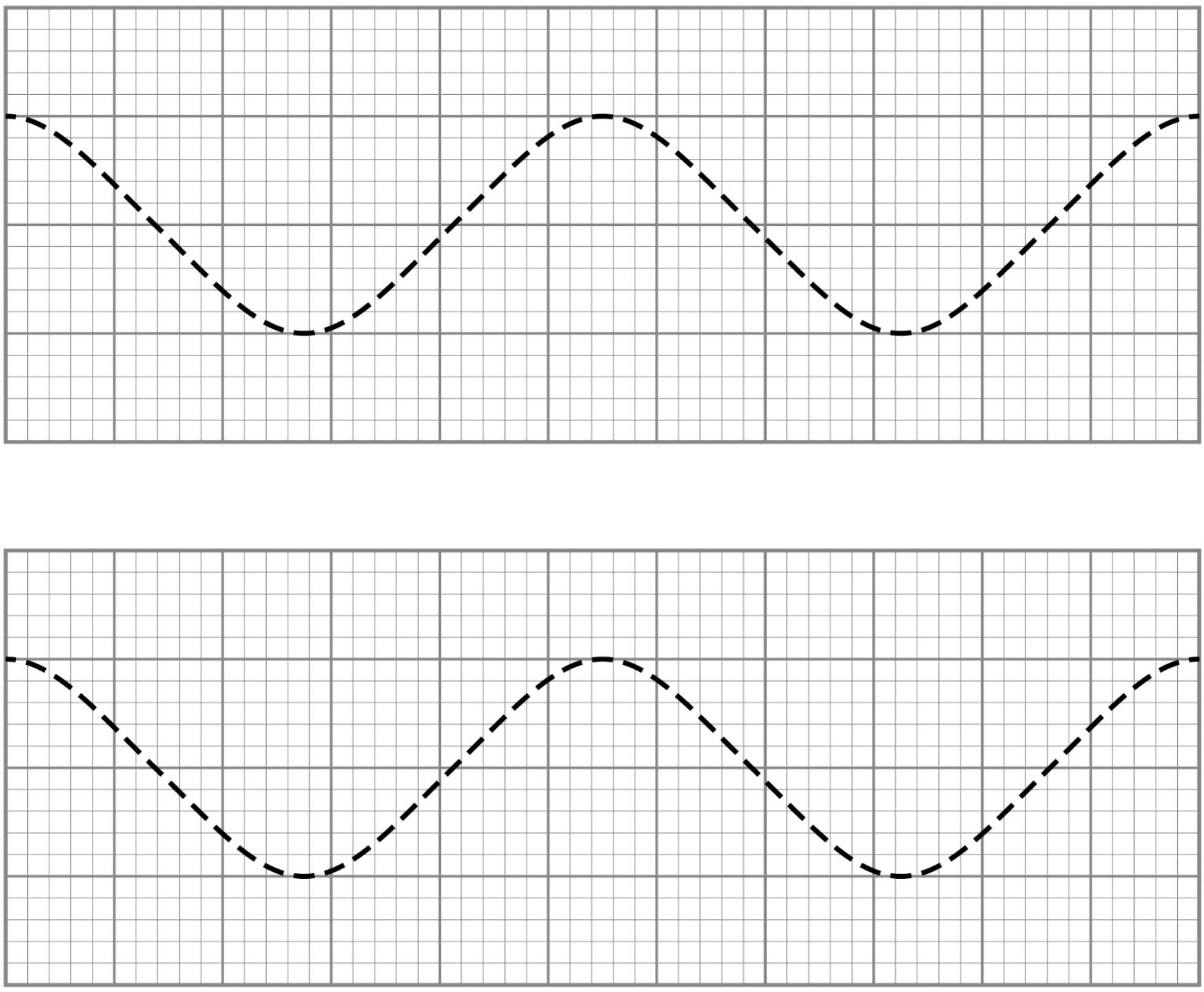
Calculate the wave speed. [2 marks]

wave speed = ________________________ $m\,s^{-1}$

[Turn over]

0 6 . 3 The instantaneous position of the string in FIGURE 9, on page 40, can be explained by the superposition of two waves. The instantaneous positions of these waves between P and Q are shown in FIGURE 10.

FIGURE 10

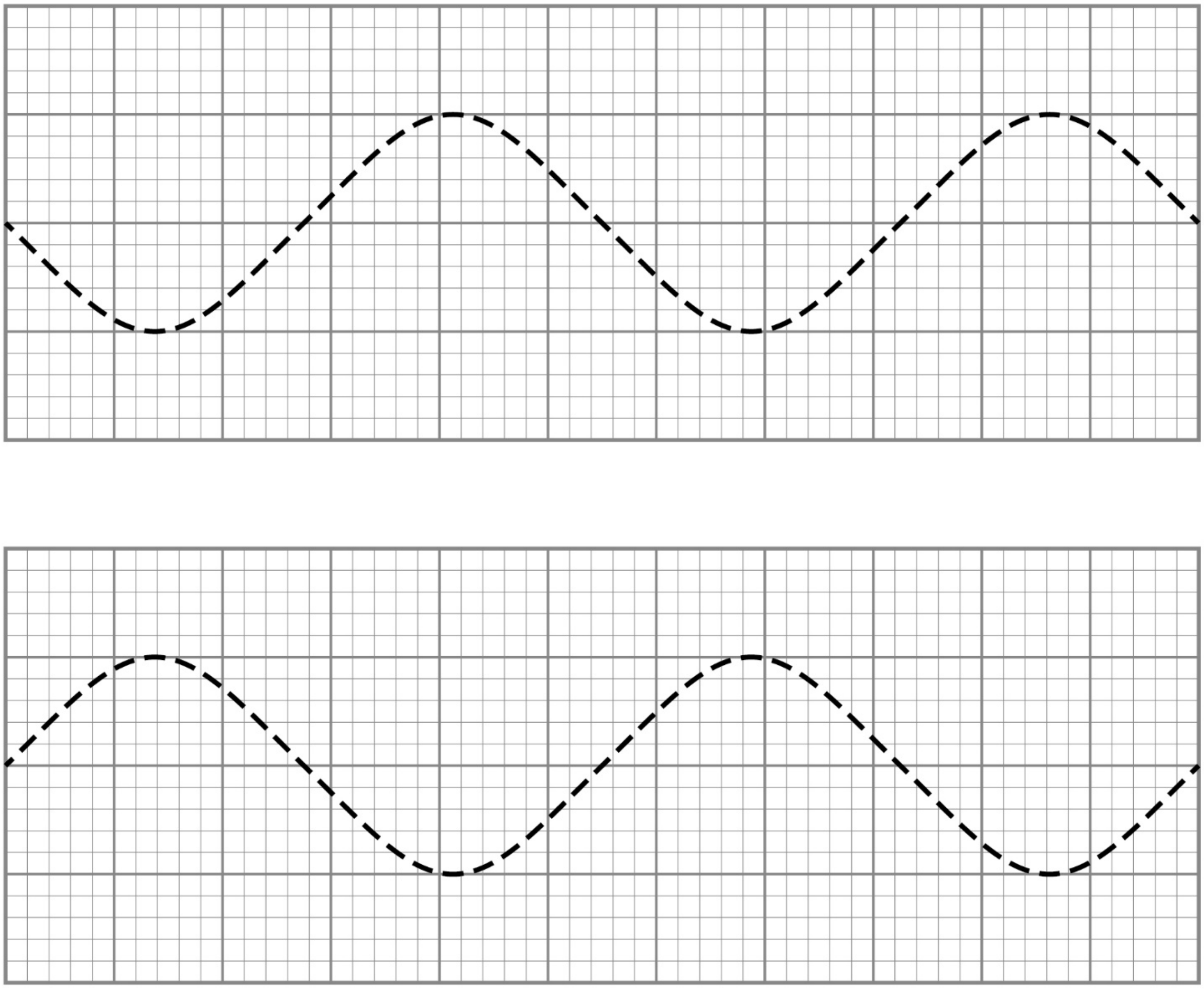


Describe the properties that the waves must have to form the shape shown in FIGURE 9. [3 marks]

[Turn over]

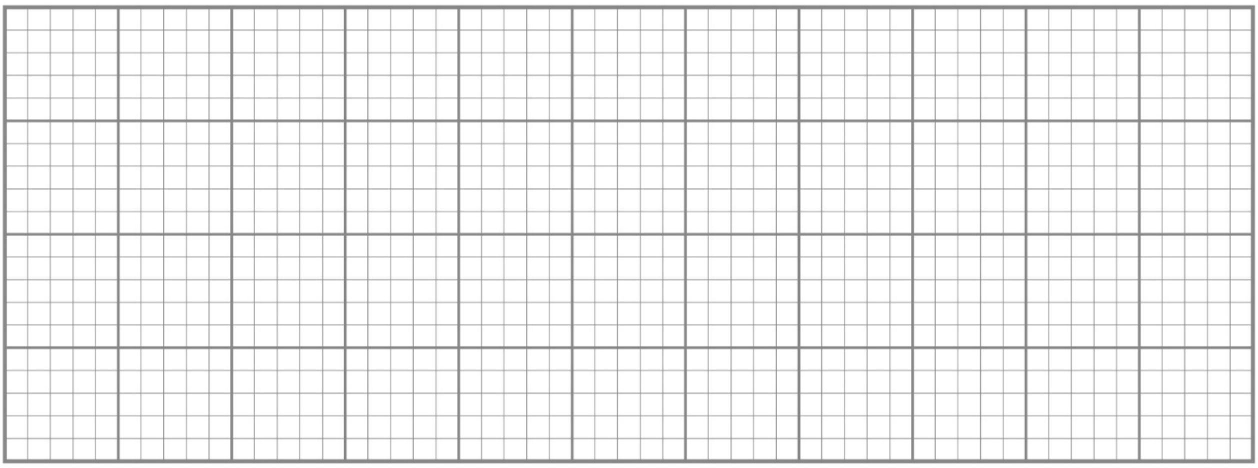
0 6 . 4 **FIGURE 11 shows the positions of the two waves between P and Q a short time later.**

FIGURE 11



Draw, on FIGURE 12, the appearance of the string between P and Q at this instant.
[1 mark]

FIGURE 12

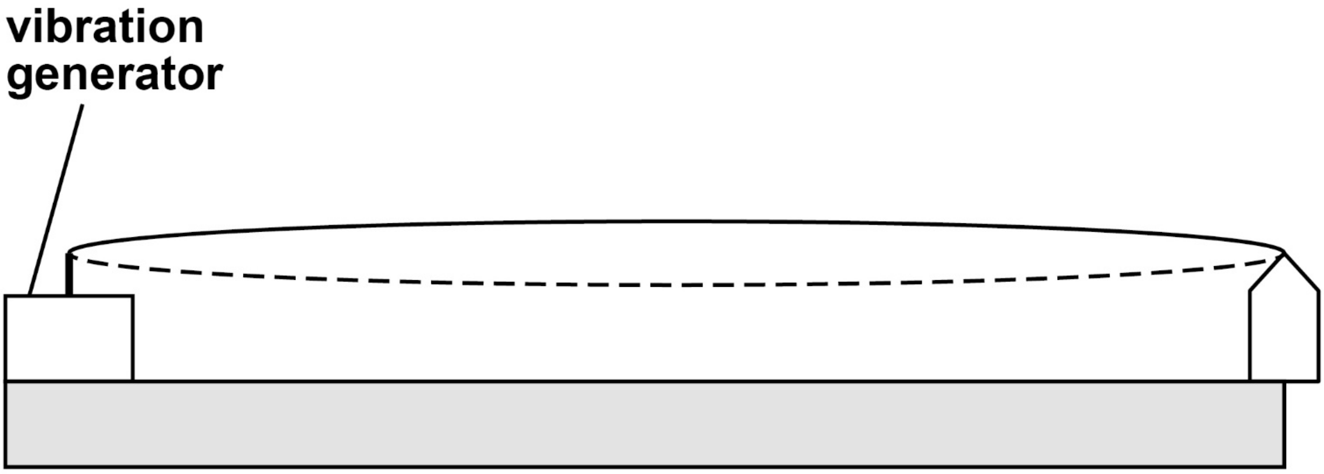


0 6 . 5 Annotate (with an A) the positions of any antinodes on your drawing in FIGURE 12.
[2 marks]

[Turn over]

0 6 . 6 The frequency of the vibration generator is reduced until the first harmonic is observed in the string, as shown in FIGURE 13.

FIGURE 13



The string in FIGURE 13 is replaced with one that has 9 times the mass per unit length of the original string. All other conditions are kept constant, including the frequency of the vibration generator and the tension in the string.

Deduce the harmonic observed. [3 marks]

END OF QUESTIONS

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Additional page, if required.
Write the question numbers in the left-hand margin.

Additional page, if required.
Write the question numbers in the left-hand margin.

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For Examiner's Use	
Question	Mark
1	
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