Please write clearly in block capitals.

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

Surname ______________________________

Forename(s) ______________________________

Candidate signature ______________________________

AS
PHYSICS A

Unit 2 Mechanics, Materials and Waves

Thursday 9 June 2016 Afternoon Time allowed: 1 hour 15 minutes

Materials
For this paper you must have:
- a pencil and a ruler
- a calculator
- a Data and Formulae Booklet (enclosed).

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- 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 calculator, where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use specialist vocabulary where appropriate.

Answer **all** questions in the spaces provided.

1 (a) State what is meant by the centre of mass of an object.

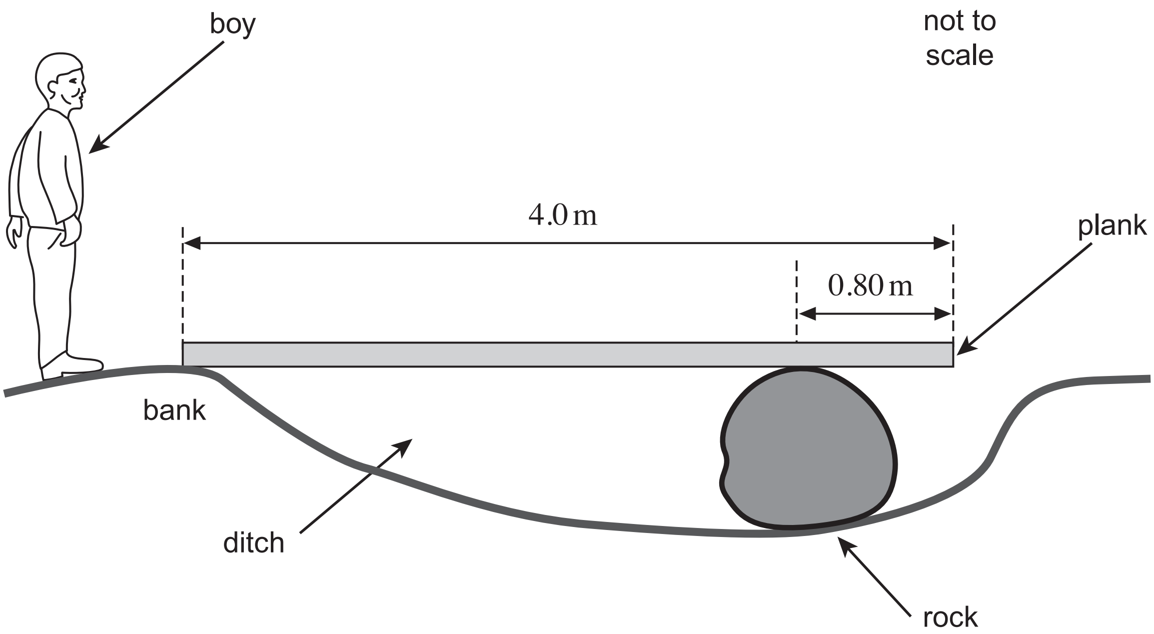
[1 mark]

____

____

1 (b) A uniform plank of wood of mass $32\ \mathrm{kg}$ and length $4.0\ \mathrm{m}$ is used by a boy to help him cross a ditch. In the ditch is a rock, which is used to support the plank horizontally $0.80\ \mathrm{m}$ from one end, as shown in **Figure 1**. The other end of the plank is supported by the bank.

Figure 1



Calculate the vertical supporting force from the rock when the plank is placed in position as shown in **Figure 1**.

[2 marks]

supporting force = ______________________ N

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1 (c) The boy has a mass of $46\ \text{kg}$.

Determine whether the boy can walk to the far end of the plank without it tipping. Support your answer with a calculation.

[3 marks]

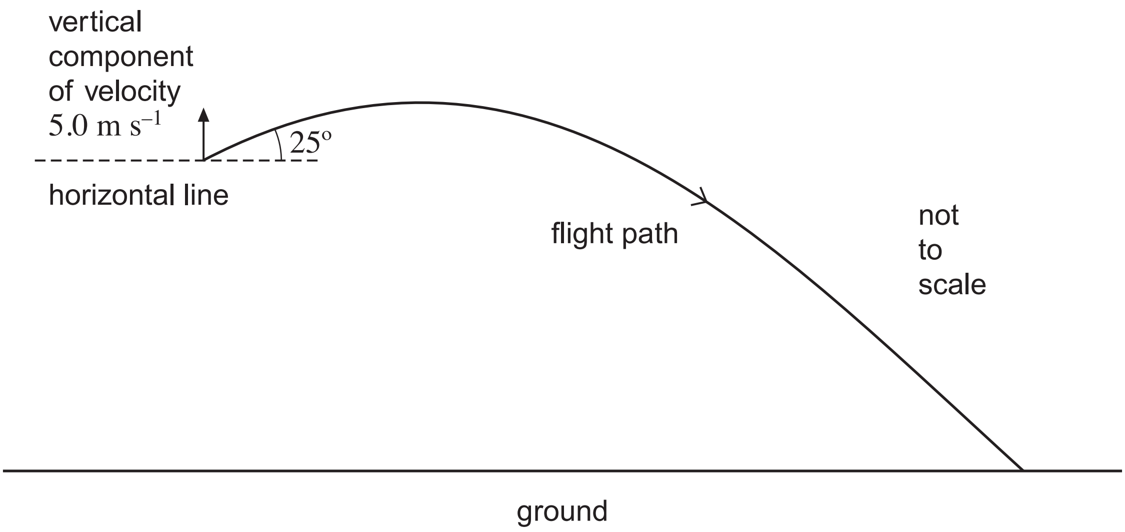
6

Turn over for the next question

2 A projectile is launched some distance above the ground at an angle of 25° above the horizontal with a vertical component of velocity of $5.0\ \mathrm{m\ s^{-1}}$. **Figure 2** shows the flight path of the projectile. The flight takes $1.3\ \mathrm{s}$.

Ignore the effects of air resistance throughout this question.

Figure 2



2 (a) (i) Show that the initial speed of the projectile is about $12\ \mathrm{m\ s^{-1}}$.

[2 marks]

2 (a) (ii) Calculate the horizontal component of velocity as the projectile hits the ground.

[2 marks]

horizontal component of velocity = ______________________ $\mathrm{m\ s^{-1}}$

2 (b) (i) Calculate the maximum height above the starting point reached by the projectile. Give your answer to an appropriate number of significant figures.

[2 marks]

maximum height reached = ____________________ m

2 (b) (ii) Calculate the total horizontal distance travelled by the projectile from its starting point.

[1 mark]

horizontal distance = ____________________ m

2 (c) (i) Mark with an **A** on the flight path in **Figure 2** the position where the speed of the projectile is greatest.

[1 mark]

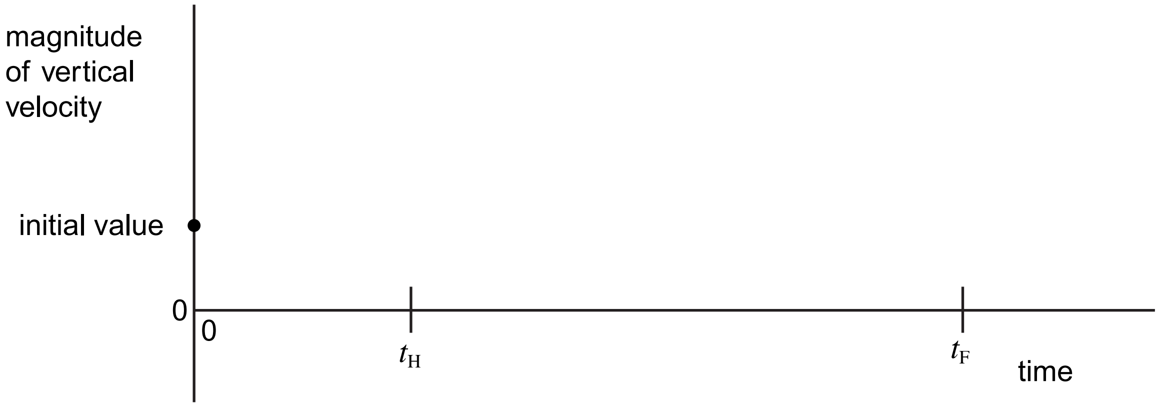
2 (c) (ii) Mark with a **B** on the flight path in **Figure 2** the position where the speed of the projectile is least.

[1 mark]

2 (d) The projectile reaches its maximum height at time t_H and finishes its flight at time t_F. Draw on **Figure 3** a graph to show how the **magnitude** of the vertical component of velocity of the projectile varies with time. Numerical values are **not** required.

[2 marks]

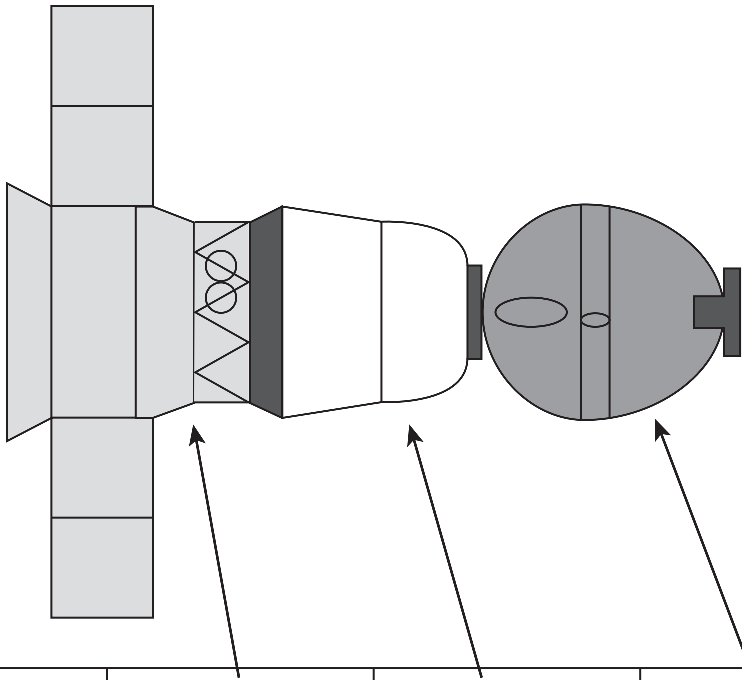
Figure 3



11

3 The Soyuz Spacecraft is used to transport astronauts to and from an orbiting space station. The spacecraft is made up of three sections as shown in **Figure 4**.

Figure 4



Section	**Service module**	**Descent module**	**Orbital module**
Mass / kg	2600	2900	1300

3 (a) On leaving the space station the spacecraft is given an initial horizontal thrust of 1400 N. Calculate the initial acceleration of the spacecraft during the firing of the thruster engines.

[2 marks]

acceleration = ______________________ m s^{-2}

3 (b) Newton's Third Law refers to pairs of forces.

3 (b) (i) State **one** way in which a pair of forces referred to in Newton's Third Law are the same.

[1 mark]

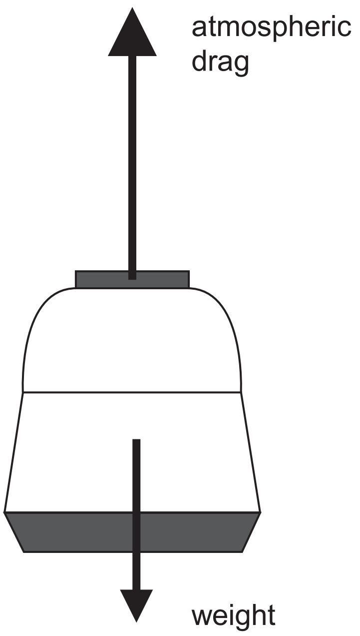
3 (b) (ii) State **one** way in which a pair of forces are different.

[1 mark]

3 (c) When the spacecraft returns to the Earth's atmosphere the orbital module and the service module are separated from the descent module. This descent module has its speed greatly reduced by drag from the atmosphere.

Figure 5 shows two of the forces acting on the descent module as it travels down through the atmosphere.

Figure 5



State **one** reason why the two forces shown in **Figure 5** are **no**t a pair of forces as referred to in Newton's Third Law.

[1 mark]

Question 3 continues on the next page

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3 (d) In one particular descent, the descent module has its speed reduced to $5.5\ \mathrm{m\ s^{-1}}$ by parachutes. The descent module also releases its empty tanks and shield to reduce its mass to $890\ \mathrm{kg}$.

A final speed reduction can be carried out by using engines which operate for a maximum time of $3.5\ \mathrm{s}$. When the engines are in use, the resultant upward force on the descent module is $670\ \mathrm{N}$. The safe landing speed of the descent module is $3.0\ \mathrm{m\ s^{-1}}$.

Determine whether these engines are able to reduce the speed of the descent module to its safe value.

At these landing speeds atmospheric drag is negligible.

[3 marks]

8

Turn to page 10 for the next question

Turn over for the next question

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4 (a) State the law of conservation of energy.

[2 marks]

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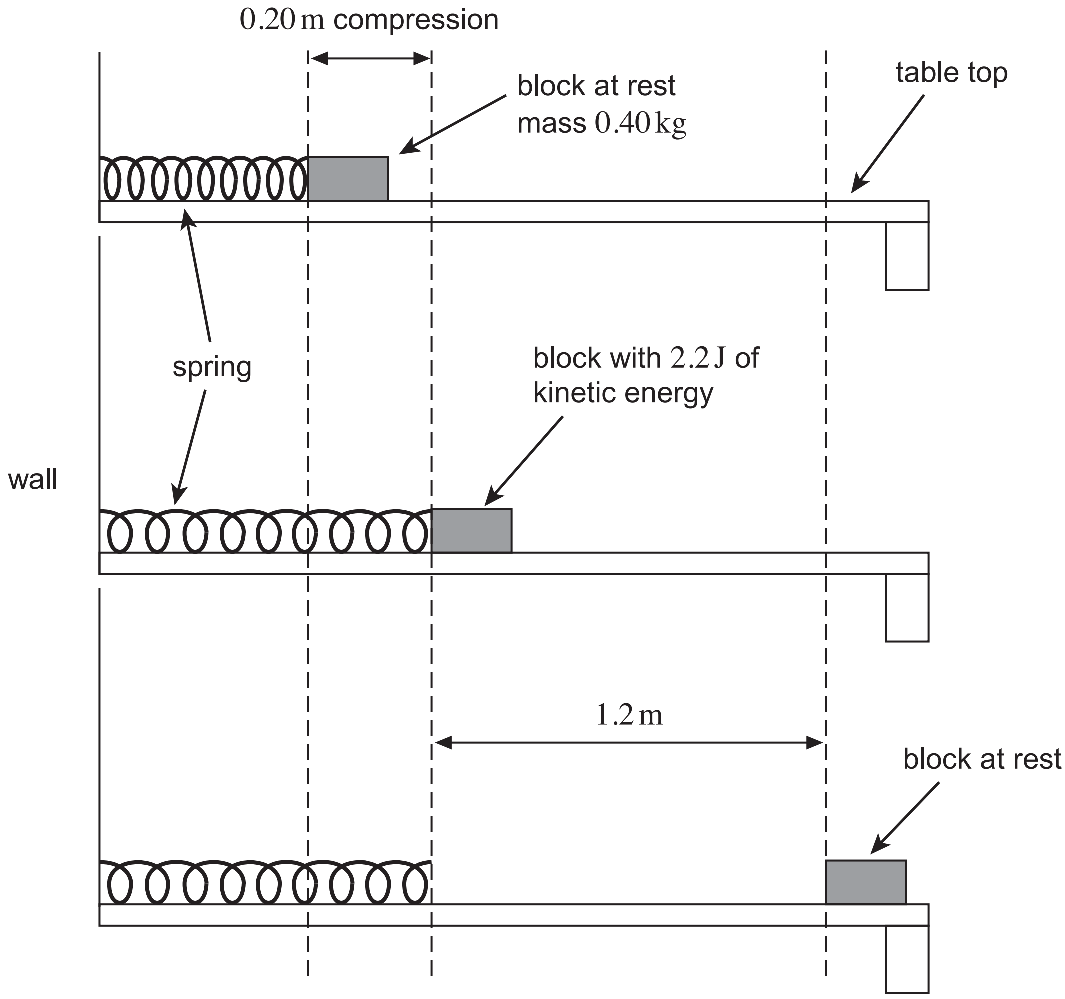
____

____

4 (b) **Figure 6** shows a block on a horizontal table top initially held against a spring so that the spring is compressed. The other end of the spring is fixed to a wall. When released the block is pushed away by the spring. When the spring reaches its natural length the block leaves the spring and then slides along the table top. A constant frictional force acting between the moving block and the table top eventually brings the block to rest.

Figure 6



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4 (b) (i) When the block leaves the spring, the block has a kinetic energy of $2.2\ \mathrm{J}$. The mass of the block is $0.40\ \mathrm{kg}$.
Calculate the maximum velocity of the block.

[1 mark]

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

4 (b) (ii) The block travels $1.2\ \mathrm{m}$ after leaving the spring before coming to rest.
Show that the frictional force between the block and the table top is about $1.8\ \mathrm{N}$.

[1 mark]

4 (b) (iii) The spring was initially compressed through $0.20\ \mathrm{m}$. The constant frictional force acts on the block whenever it is moving.
Calculate the elastic potential energy in the spring when in its initial compressed position.
Assume the spring has negligible mass.
State an appropriate unit for your answer.

[3 marks]

elastic potential energy = ________________ unit = ________

4 (b) (iv) The force exerted on the block by the spring is proportional to the compression of the spring.
Calculate the maximum force exerted on the block by the spring.

[1 mark]

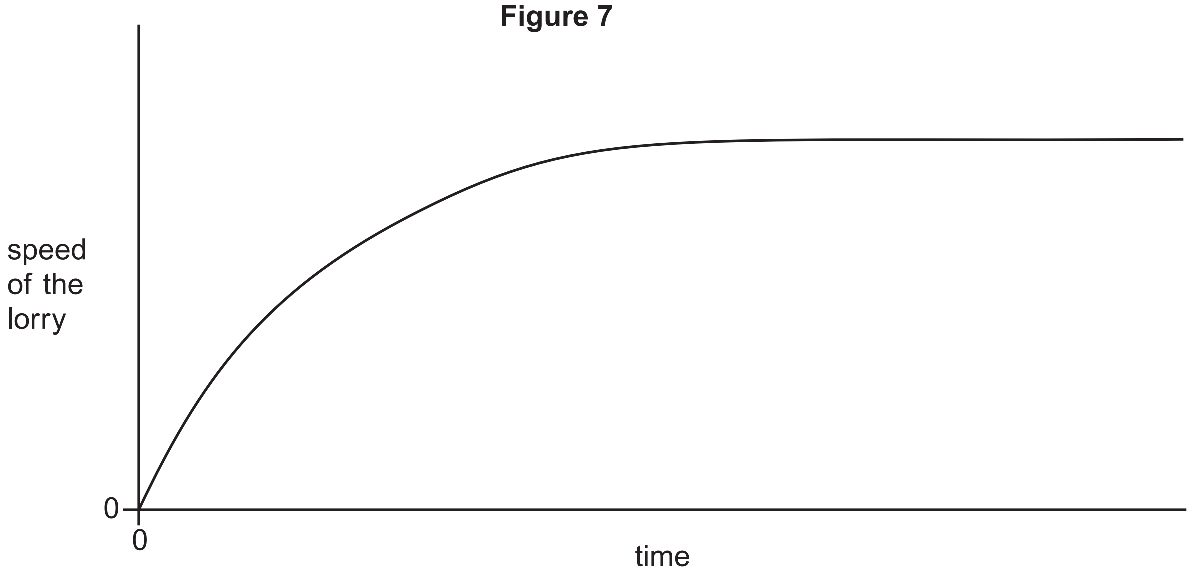
maximum force = _________________________ N

8

5 A fully-loaded lorry transporting water starts from rest and travels along a straight road. **Figure 7** is a graph showing how the speed of the lorry varies with time. The driving force on the lorry remains constant.

The total resistive force acting on the lorry increases with both speed and mass of the lorry. A large proportion of the mass of the lorry is due to the water which it is carrying.

Figure 7



A similar lorry, also loaded with water, has the same initial mass. However, at the instant it begins to move, a large leak develops and all the water leaks out during the time covered by the graph.

Discuss how the speed–time graph will be different from that shown in **Figure 7**.

Your answer should include an explanation of:

- the shape of the graph in **Figure 7**
- the effect of water loss on the initial gradient of the graph
- the effect of water loss on the final speed of the lorry.

You may draw on **Figure 7** to help you with your answer.

The quality of your written communication will be assessed in your answer.

[6 marks]

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6

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6 (a) Explain what is meant by a progressive wave.

[2 marks]

6 (b) **Figure 8** shows the variation with time of the displacement of one point in a progressive wave.

Figure 8

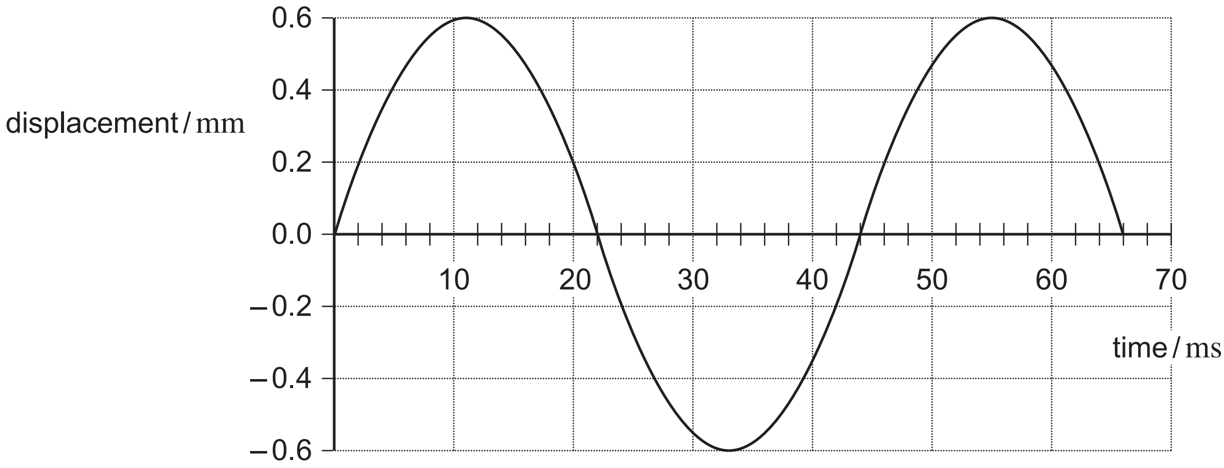
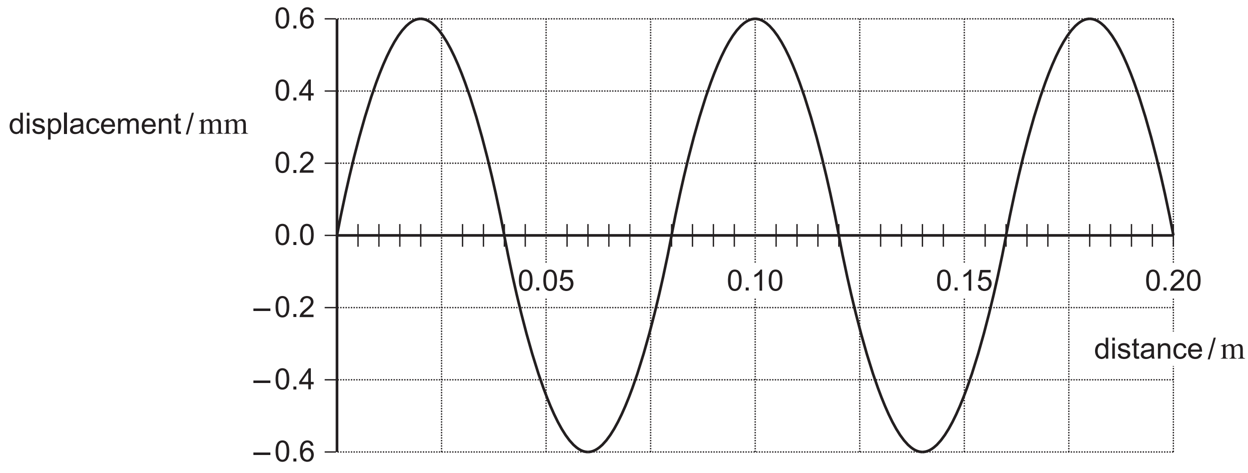


Figure 9 shows the variation of displacement of the same wave with distance.

Figure 9



Use **Figures 8 and 9** to determine

6 (b) (i) the amplitude of the wave

[1 mark]

amplitude = ______________________ mm

6 (b) (ii) the wavelength of the wave

[1 mark]

wavelength = ______________________ m

6 (b) (iii) the frequency of the wave

[1 mark]

frequency = ______________________ Hz

6 (b) (iv) the speed of the wave.

[1 mark]

speed = ______________________ $m\ s^{-1}$

Question 6 continues on the next page

Turn over ▶

6 (c) Which of the following statements apply?
Place a tick (✓) in the right-hand column for each correct statement.

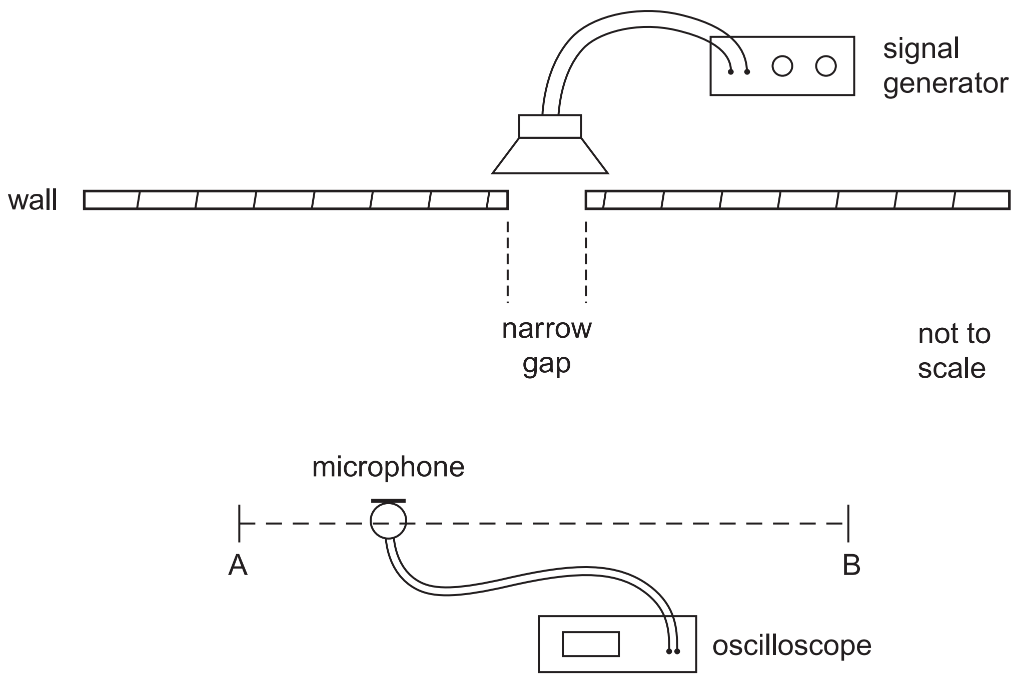
[1 mark]

	✓ if correct
sound waves are transverse	
sound waves are longitudinal	
sound waves can interfere	
sound waves can be polarised	

6 (d) In an investigation, a single loudspeaker is positioned behind a wall with a narrow gap as shown in **Figure 10**.

A microphone attached to an oscilloscope enables changes in the amplitude of the sound to be determined for different positions of the microphone.

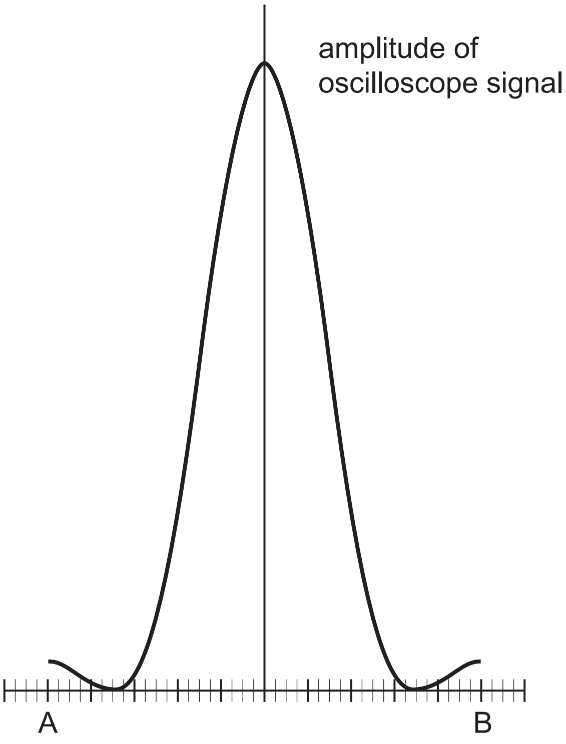
Figure 10



The amplitude of sound is recorded as the microphone position is moved along the line AB a large distance from the gap.

The result of the measurements is shown in **Figure 11**.

Figure 11



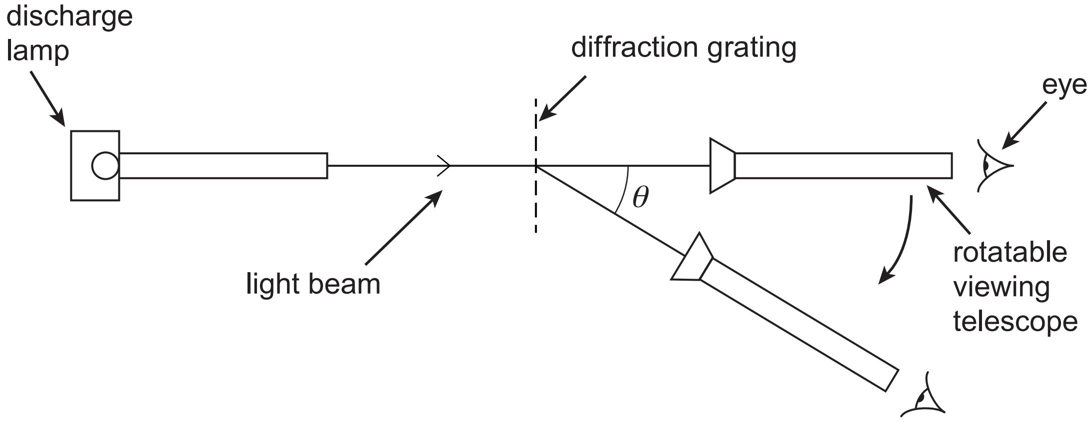
The signal generator is adjusted so that sound waves of the same amplitude but of a higher frequency are emitted by the loudspeaker. The investigation using the apparatus shown in **Figure 10** is then repeated.
Explain the effect this has on **Figure 11**.

[3 marks]

10

7 A discharge lamp emits light of four colours: red, green, blue and violet. **Figure 12** shows light from the lamp incident normally on a diffraction grating with slit separations of 1.8×10^{-6} m. The light is viewed through a telescope which can be rotated as shown.

Figure 12



As the telescope is rotated from the straight-through position, each of the four colours is observed as a bright line at its corresponding first-order diffraction angle.

7 (a) Which colour would be observed first as the telescope is rotated from the straight-through position?
Place a tick (✓) in the right-hand column to show the correct answer.

[1 mark]

	✓ if correct
red	
green	
blue	
violet	

7 (b) Explain how a bright line is formed by the diffraction grating at the first-order diffraction angle.

[3 marks]

____

____

____

____

____

____

____

7 (c) (i) The wavelength of the green light is 5.3×10^{-7} m.
Calculate the first-order diffraction angle for this colour.

[2 marks]

angle = ____________________ degree

7 (c) (ii) As the telescope is rotated further, higher-order diffraction maxima are observed.
Calculate the highest order observed for the green light.

[3 marks]

highest order = ____________________

9

Turn over for the next question

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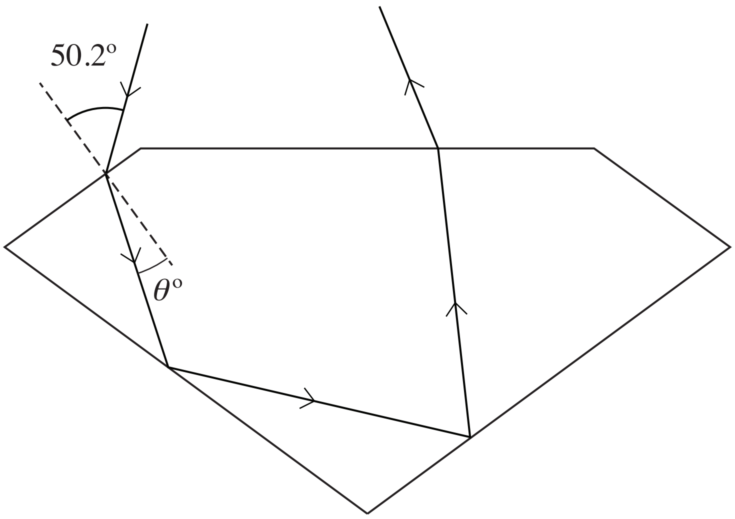
8 Diamond jewels sparkle because light that enters the diamond at different incident angles is reflected back to an observer. **Figure 13** shows the path of one of these incident rays through a diamond.

Figure 13



8 (a) (i) Calculate the critical angle for diamond.

[2 marks]

Refractive index of diamond = 2.42

critical angle = ______________________ degree

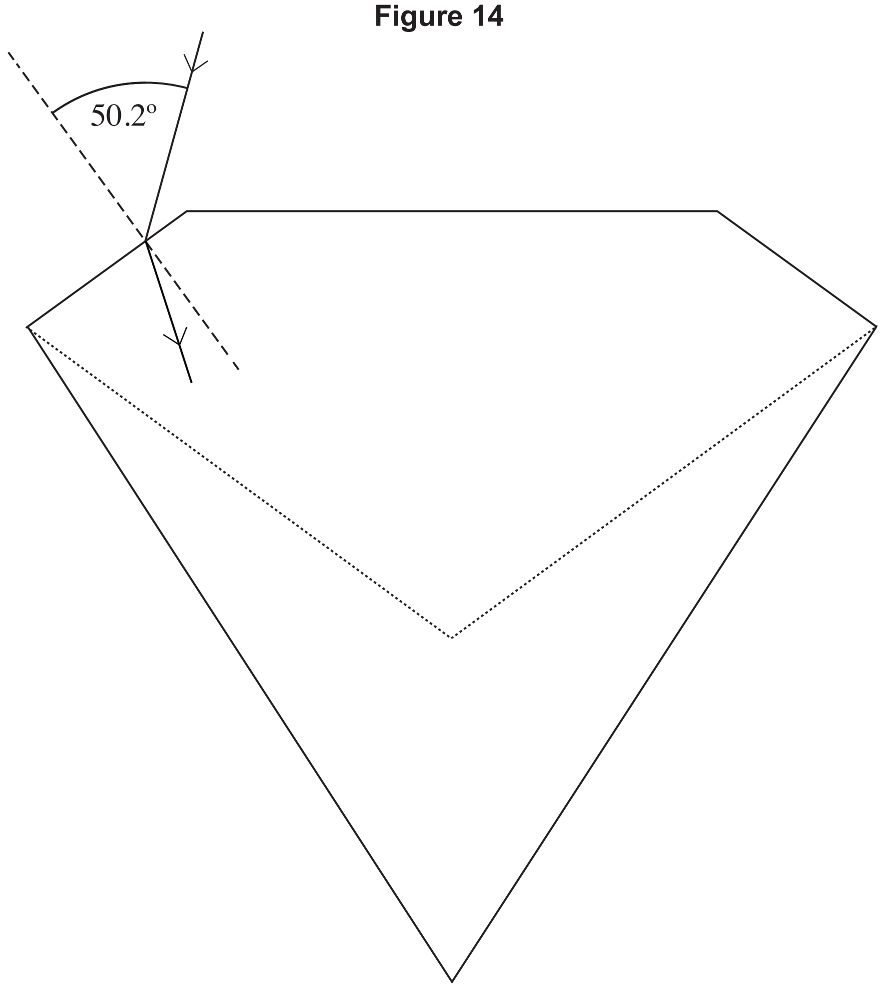
8 (a) (ii) The ray shown in **Figure 13** enters at an angle of incidence of 50.2°. Calculate the angle of refraction θ.

[2 marks]

θ = ______________________ degree

8 (a) (iii) The angles of a diamond are chosen to maximise the amount of light reflected.
Figure 14 shows a diamond with different angles to that of a normally shaped diamond.
The dotted lines show the normal shape of a diamond.

Figure 14



Draw on **Figure 14** the path of the ray until it leaves the diamond.

[2 marks]

Question 8 continues on the next page

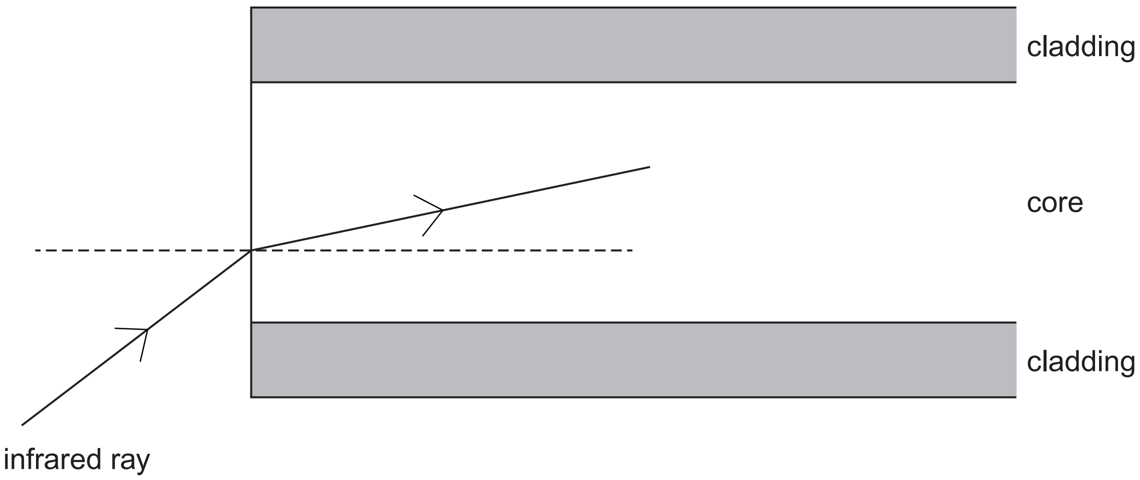
8 (a) (iv) Moissanite is a transparent material with a refractive index of 2.67.

Discuss whether this material, if made to the diamond shape shown in **Figure 13**, would reflect light back more or less than diamond.

[2 marks]

8 (b) **Figure 15** shows an infrared ray entering an optical fibre. The refractive index of the core is 1.55 at infrared frequencies.

Figure 15



8 (b) (i) Calculate the speed at which infrared radiation travels in the core.

[1 mark]

speed = ______________________ $\mathrm{m\ s^{-1}}$

8 (b) (ii) The wavelength of this infrared radiation is $1300\ \mathrm{nm}$ in air.
Calculate the wavelength of infrared in the core.

[2 marks]

wavelength = ______________________ m

8 (b) (iii) State **one** reason for surrounding the core with cladding.

[1 mark]

____

____

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END OF QUESTIONS

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