Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	

AQA

General Certificate of Education
Advanced Subsidiary Examination
June 2014

Physics A PHYA2

Unit 2 Mechanics, Materials and Waves

Monday 9 June 2014 9.00 am to 10.15 am

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

Time allowed
- 1 hour 15 minutes

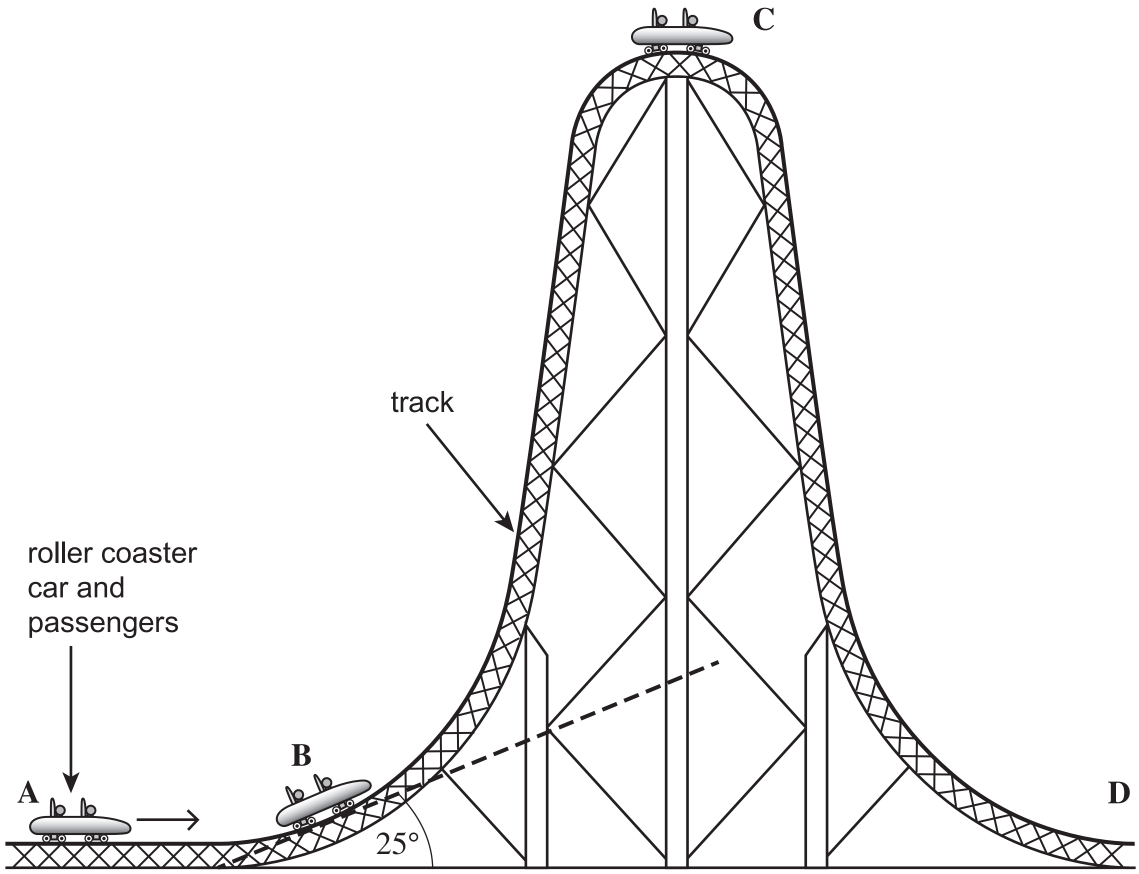
Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work 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 **Figure 1** shows a roller coaster car which is accelerated from rest to a speed of $56\,\mathrm{m\,s^{-1}}$ on a horizontal track, **A**, before ascending the steep part of the track. The roller coaster car then becomes stationary at **C**, the highest point of the track. The total mass of the car and passengers is $8300\,\mathrm{kg}$.

Figure 1



1 (a) The angle of the track at **B** is 25° to the horizontal. Calculate the component of the weight of the car and passengers acting along the slope when the car and passengers are in position **B** as shown in **Figure 1**.

[2 marks]

component of weight .... N

Do not write outside the box

1 (b) (i) Calculate the kinetic energy of the car including the passengers when travelling at $56\,\mathrm{m\,s^{-1}}$.

[2 marks]

kinetic energy .... J

1 (b) (ii) Calculate the maximum height above **A** that would be reached by the car and passengers if all the kinetic energy could be transferred to gravitational potential energy.

[2 marks]

maximum height .... m

1 (c) The car does not reach the height calculated in part (b).

1 (c) (i) Explain the main reason why the car does not reach this height.

[2 marks]

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1 (c) (ii) The car reaches point **C** which is at a height of $140\,\mathrm{m}$ above **A**. Calculate the speed that the car would reach when it descends from rest at **C** to its original height from the ground at **D** if 87% of its energy at **C** is converted to kinetic energy.

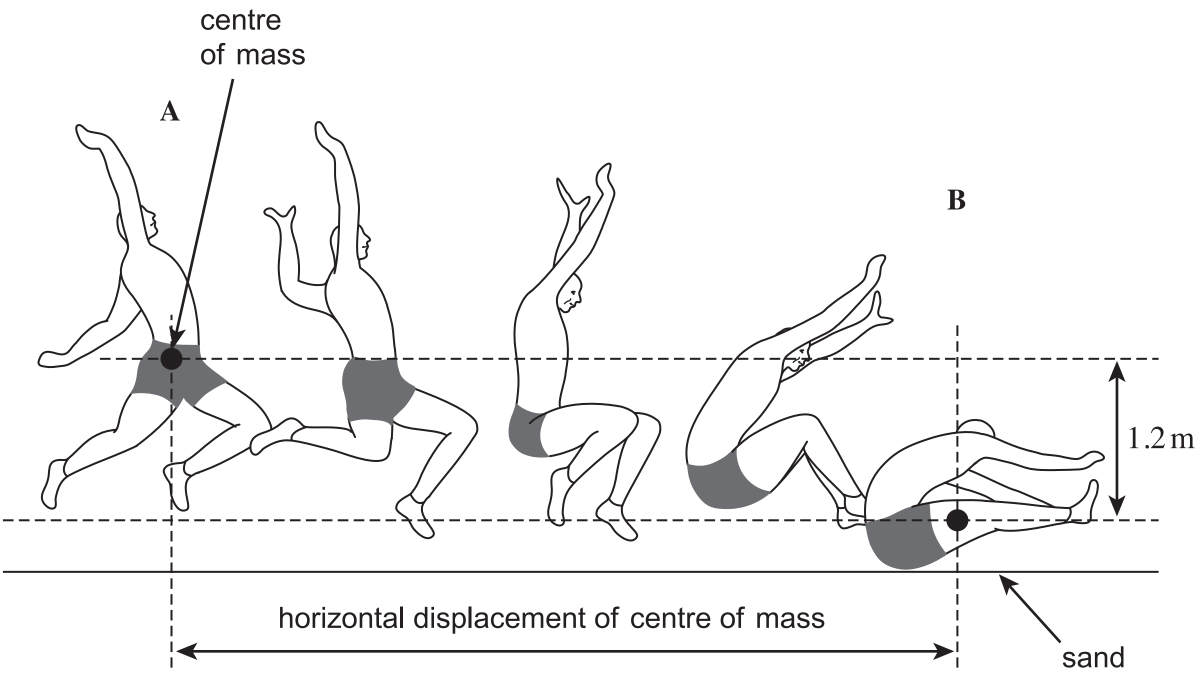
[2 marks]

speed .... $\mathrm{m\,s^{-1}}$

10

2 The motion of a long jumper during a jump is similar to that of a projectile moving under gravity. **Figure 2** shows the path of an athlete above the ground during a long jump from half-way through the jump at position **A**, to position **B** at which contact is made with sand on the ground. The athlete is travelling horizontally at **A**.

Figure 2



2 (a) During this part of the jump, the centre of mass of the athlete falls 1.2 m.

2 (a) (i) Calculate the time between positions **A** and **B**.

[3 marks]

time .... s

Do not write outside the box

2 (a) (ii) The athlete is moving horizontally at **A** with a velocity of $8.5\,\mathrm{m\,s^{-1}}$. Assume there is no air resistance. Calculate the horizontal displacement of the centre of mass from **A** to **B**.

[2 marks]

horizontal displacement .... m

2 (b) (i) The athlete in **Figure 2** slides horizontally through the sand a distance of $0.35\,\mathrm{m}$ before stopping.

Calculate the time taken for the athlete to stop. Assume the horizontal component of the resistive force from the sand is constant.

[2 marks]

time .... s

2 (b) (ii) The athlete has a mass of $75\,\mathrm{kg}$. Calculate the horizontal component of the resistive force from the sand.

[3 marks]

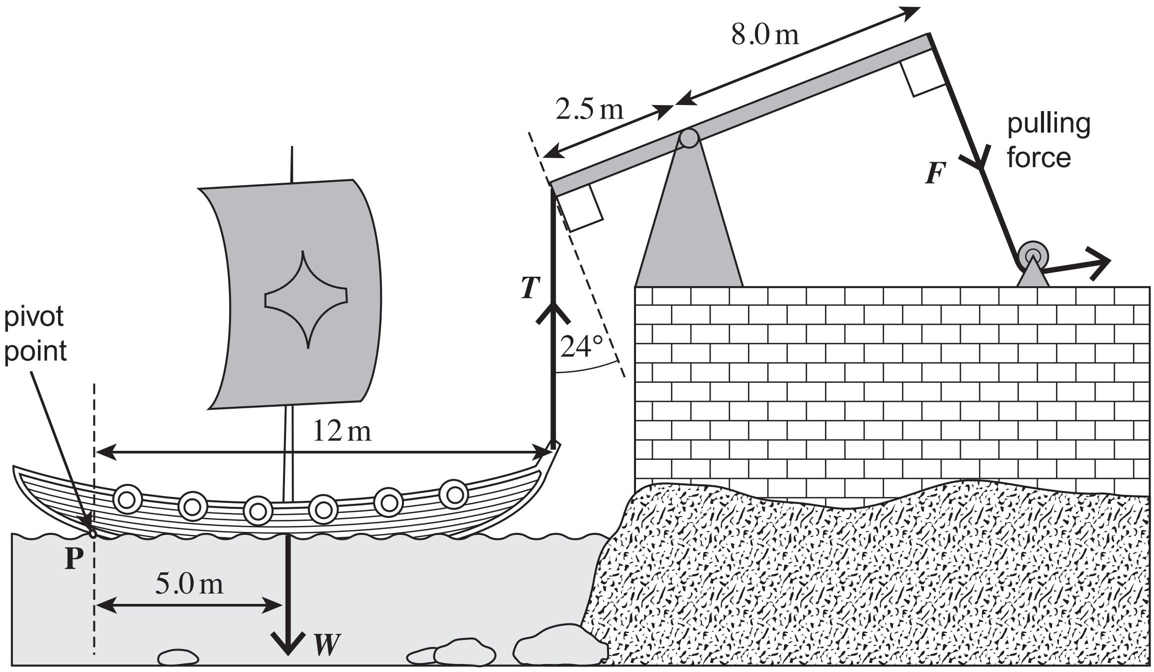
horizontal component of resistive force .... N

10

Turn over ▶

3 It is said that Archimedes used huge levers to sink Roman ships invading the city of Syracuse. A possible system is shown in **Figure 3** where a rope is hooked on to the front of the ship and the lever is pulled by several men.

Figure 3



3 (a) (i) Calculate the mass of the ship if its weight was 3.4×10^4 N.

[1 mark]

mass .... kg

3 (a) (ii) Calculate the moment of the ship's weight about point **P**. State an appropriate unit for your answer.

[2 marks]

moment .... unit ....

Do not write outside the box

3 (a) (iii) Calculate the minimum vertical force, T, required to start to raise the front of the ship. Assume the ship pivots about point $\mathbf{P}$.

[2 marks]

minimum vertical force .... N

3 (a) (iv) Calculate the minimum force, F, that must be exerted to start to raise the front of the ship.

[3 marks]

force .... N

8

Turn over for the next question

Do not write outside the box

4 (a) In order to compare the mechanical properties of two different types of metal alloy, an engineer decides to measure the Young modulus for each of them. She has a sample of each alloy in the form of a wire. Each wire is about $1.5\,\mathrm{m}$ in length but they have different diameters.

Describe an experimental method that she could use to obtain the data necessary to accurately determine the Young modulus of these metals. You may wish to illustrate your answer with a diagram.

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

[6 marks]

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Do not write outside the box

4 (b) In this experiment, wire **A** is found to have a higher Young modulus than wire **B** and it fractures before any permanent deformation takes place. Wire **B** stretches well beyond its elastic limit before fracturing.

4 (b) (i) From this evidence, state a mechanical property of the metal that wire **A** is made from.

[1 mark]

4 (b) (ii) On the axes below, sketch possible stress-strain graphs for wires **A** and **B**. Label the axes and label the lines **A** and **B**.

[3 marks]

Question 4 continues on the next page

Turn over ▶

4 (c) The engineer found that the Young modulus of alloy **A** was 2.80×10^{11} Pa. During the experiment, the 1.5 m wire underwent a 0.24% increase in length.

4 (c) (i) Calculate the stress on the wire for this extension.

[3 marks]

stress .... Pa

4 (c) (ii) For the same extension as in part (c)(i), calculate the load that must be applied to wire **A**. The diameter of the wire **A** is 1.40 mm.

[3 marks]

load .... N

16

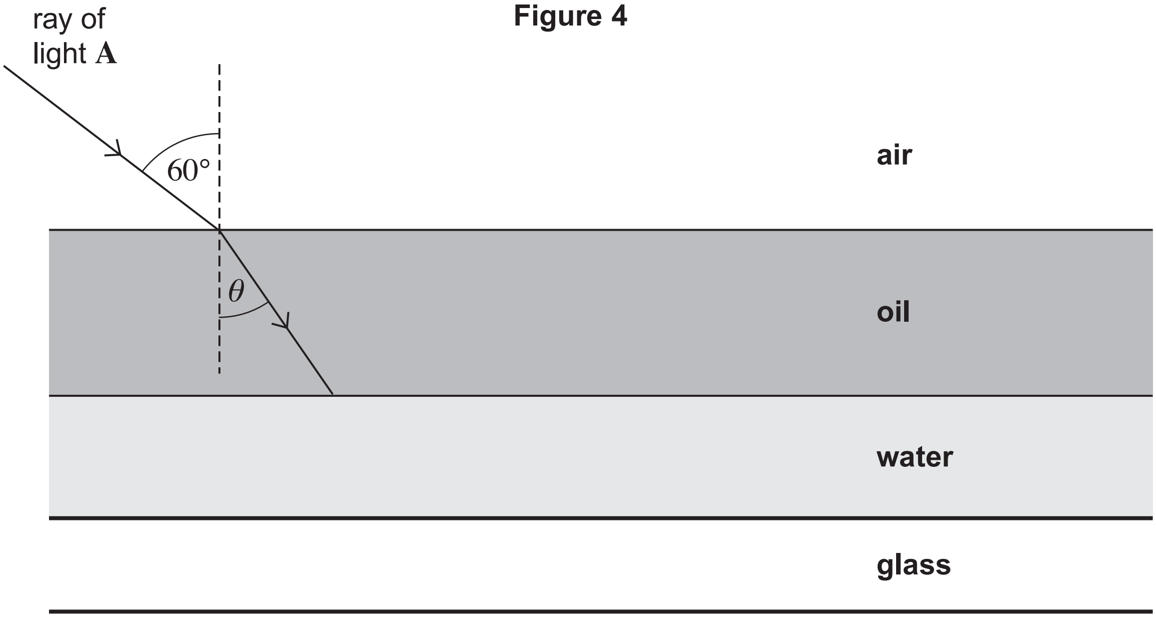
Do not write outside the box

5 **Figure 4** shows a ray of light **A** incident at an angle of 60° to the surface of a layer of oil that is floating on water.

refractive index of oil = 1.47

refractive index of water = 1.33

Figure 4



5 (a) (i) Calculate the angle of refraction θ in **Figure 4**.

[2 marks]

angle .... degrees

5 (a) (ii) Calculate the critical angle for a ray of light travelling from oil to water.

[2 marks]

angle .... degrees

5 (a) (iii) On **Figure 4** continue the path of the ray of light **A** immediately after it strikes the boundary between the oil and the water.

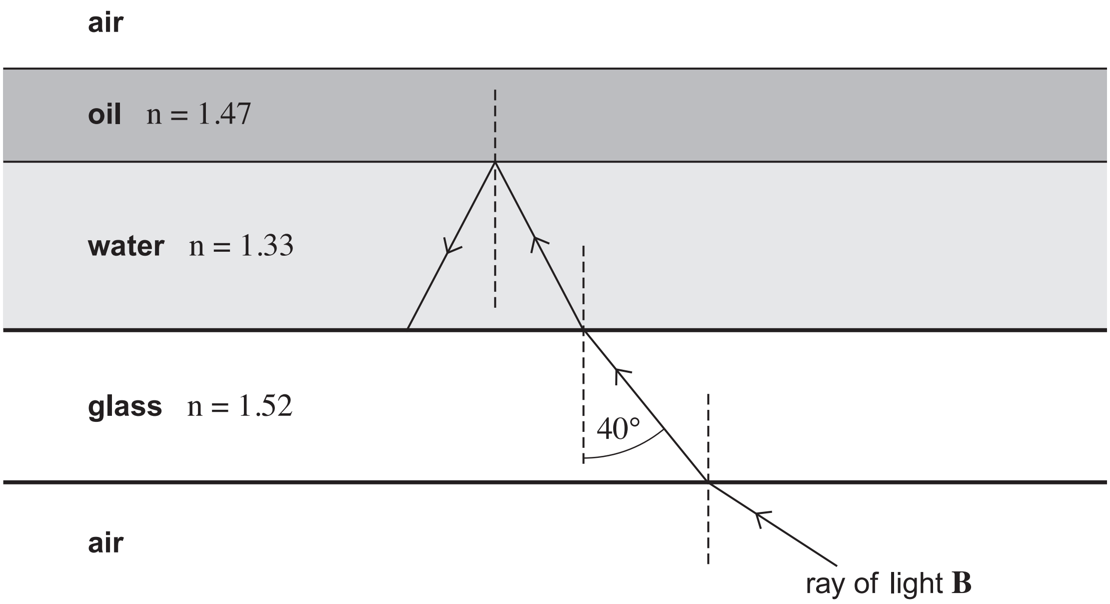
[2 marks]

Turn over ▶

Do not write outside the box

5 (b) In **Figure 5** a student has incorrectly drawn a ray of light **B** entering the glass and then entering the water before totally internally reflecting from the water–oil boundary.

Figure 5



The refractive index of the glass is 1.52 and the critical angle for the glass–water boundary is about 60°.

Give **two** reasons why the ray of light **B** would **not** behave in this way. Explain your answers.

[4 marks]

reason 1 ....

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explanation ....

....

....

reason 2 ....

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explanation ....

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10

6 **Figure 6** shows a spectrometer that uses a diffraction grating to split a beam of light into its constituent wavelengths and enables the angles of the diffracted beams to be measured.

6 (a) Give **one** possible application of the spectrometer and diffraction grating used in this way.

[1 mark]

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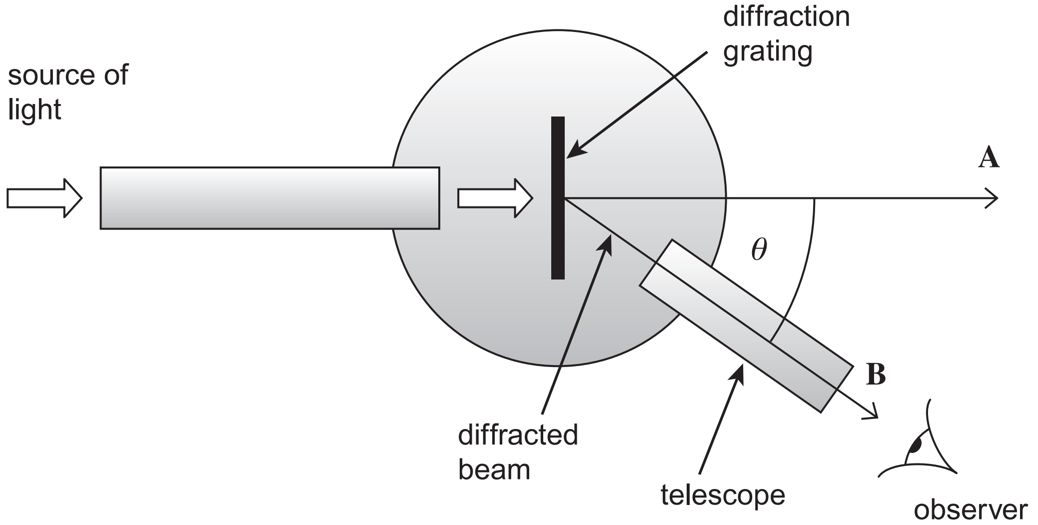
Figure 6



6 (b) (i) When the spectrometer telescope is rotated from an initial angle of zero degrees, a spectrum is not observed until the angle of diffraction θ is about 50°. State the order of this spectrum.

[1 mark]

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6 (b) (ii) White light is directed into the spectrometer. Light emerges at **A** and **B**. State **one** difference between the light emerging at **B** compared to that emerging at **A**.

[1 mark]

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Do not write outside the box

6 (c) The angle of diffraction θ at the centre of the observed beam **B** in **Figure 6** is 51.0° and the grating has 1480 lines per mm.

Calculate the wavelength of the light observed at the centre of beam **B**.

[3 marks]

wavelength .... m

6 (d) Determine by calculation whether any more orders could be observed at the wavelength calculated in part (c).

[2 marks]

8

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7 Ultrasound waves are used to produce images of a fetus inside a womb.

7 (a) Explain what is meant by the frequency of a wave.

[1 mark]

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7 (b) Ultrasound is a longitudinal wave. Describe the nature of a longitudinal wave.

[2 marks]

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7 (c) In order to produce an image with sufficient detail, the wavelength of the ultrasound must be $0.50\,\mathrm{mm}$. The speed of the ultrasound in body tissue is $1540\,\mathrm{m\,s^{-1}}$. Calculate the frequency of the ultrasound at this wavelength.
Give your answer to an appropriate number of significant figures.

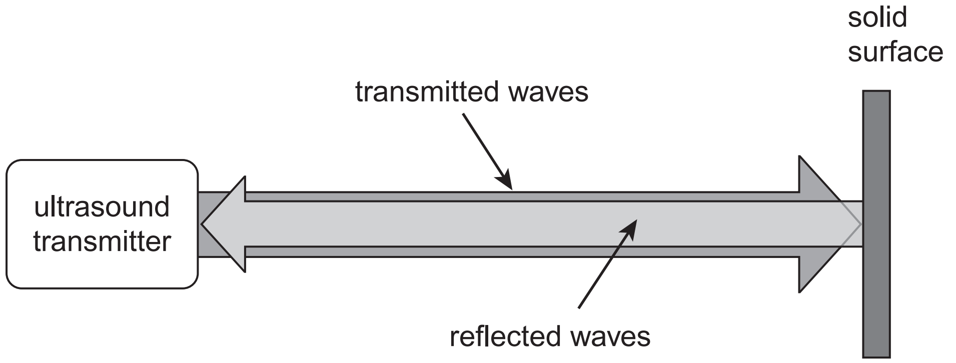
[2 marks]

frequency .... Hz

Question 7 continues on the next page

7 (d) A continuous ultrasound wave of constant frequency is reflected from a solid surface and returns in the direction it came from.

Figure 7



Assuming there is no significant loss in amplitude upon reflection, describe and explain the effect the waves have on the particles in the medium between the transmitter and the solid surface.

[3 marks]

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END OF QUESTIONS