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	

General Certificate of Education
Advanced Subsidiary Examination
January 2011

Physics A PHYA2

Unit 2 Mechanics, Materials and Waves

Monday 17 January 2011 1.30 pm to 2.45 pm

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

Time allowed
- 1 hour 15 minutes

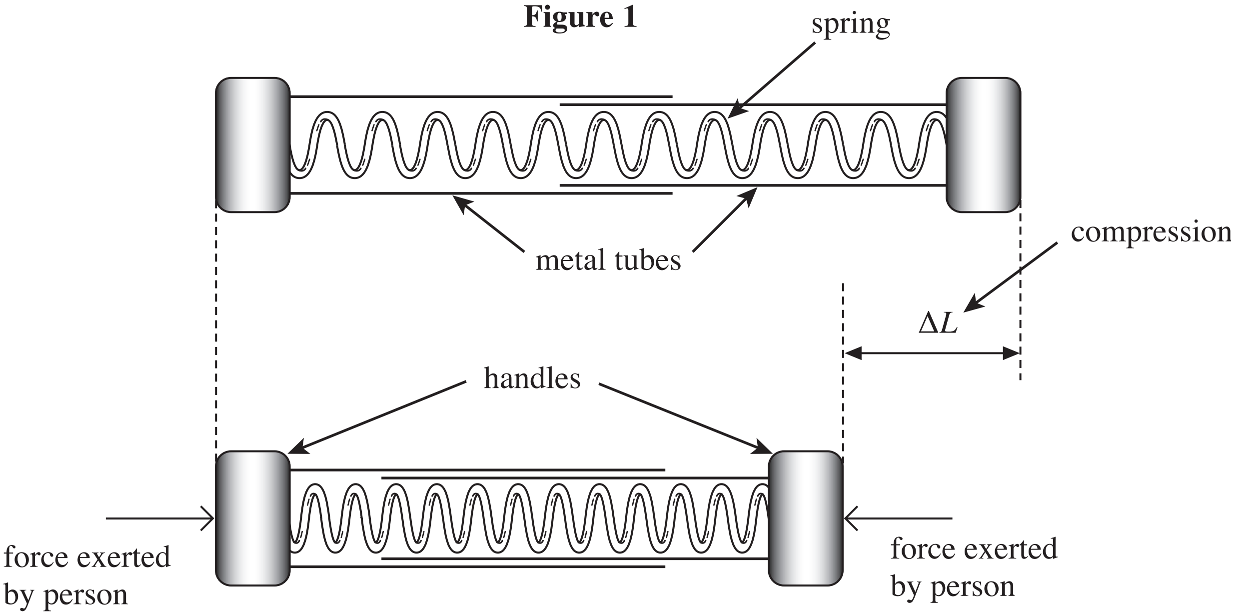
Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on a blank page.
- Do all rough work in this book. Cross through any work you do not want to be marked.

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.

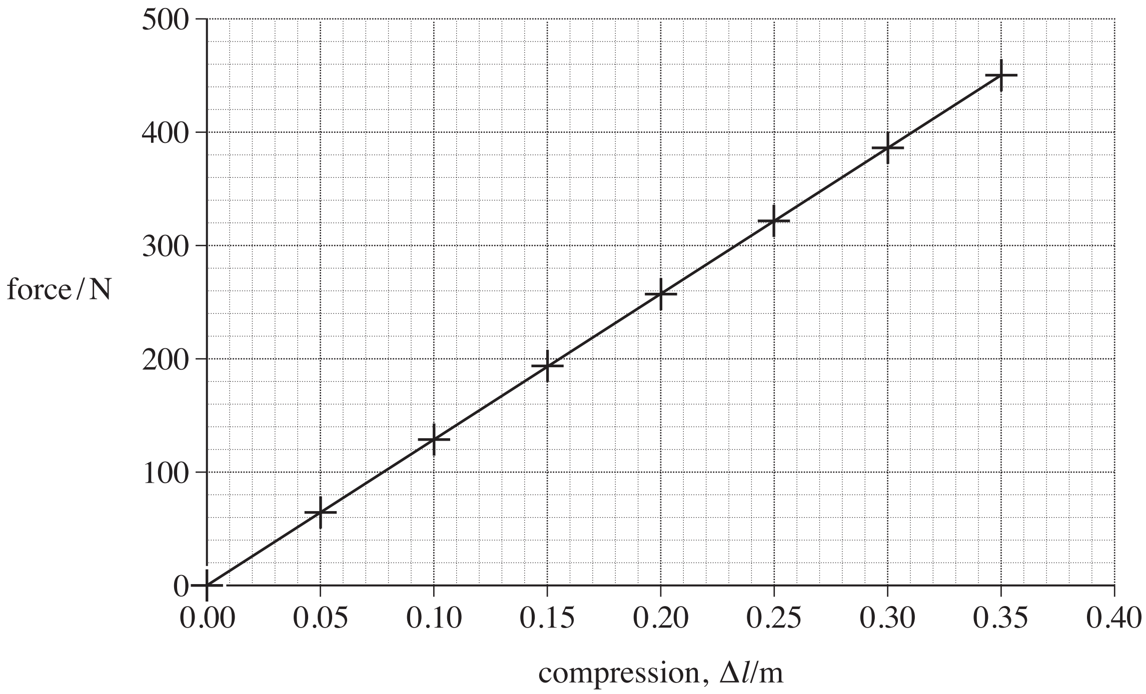
Answer **all** questions in the spaces provided.

1 A type of exercise device is used to provide resistive forces when a person applies compressive forces to its handles. The stiff spring inside the device compresses as shown in **Figure 1.**

Figure 1



1 (a) The force exerted by the spring over a range of compressions was measured. The results are plotted on the grid below.



1 (a) (i) State Hooke's law.

....

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(2 marks)

1 (a) (ii) State which two features of the graph confirm that the spring obeys Hooke's law over the range of values tested.

....

....

(2 marks)

1 (a) (iii) Use the graph to calculate the spring constant, stating an appropriate unit.

answer = ...

(3 marks)

1 (b) (i) The formula for the energy stored by the spring is

$$E = \frac{1}{2}\,F\Delta L$$

Explain how this formula can be derived from a graph of force against extension.

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(3 marks)

Question 1 continues on the next page

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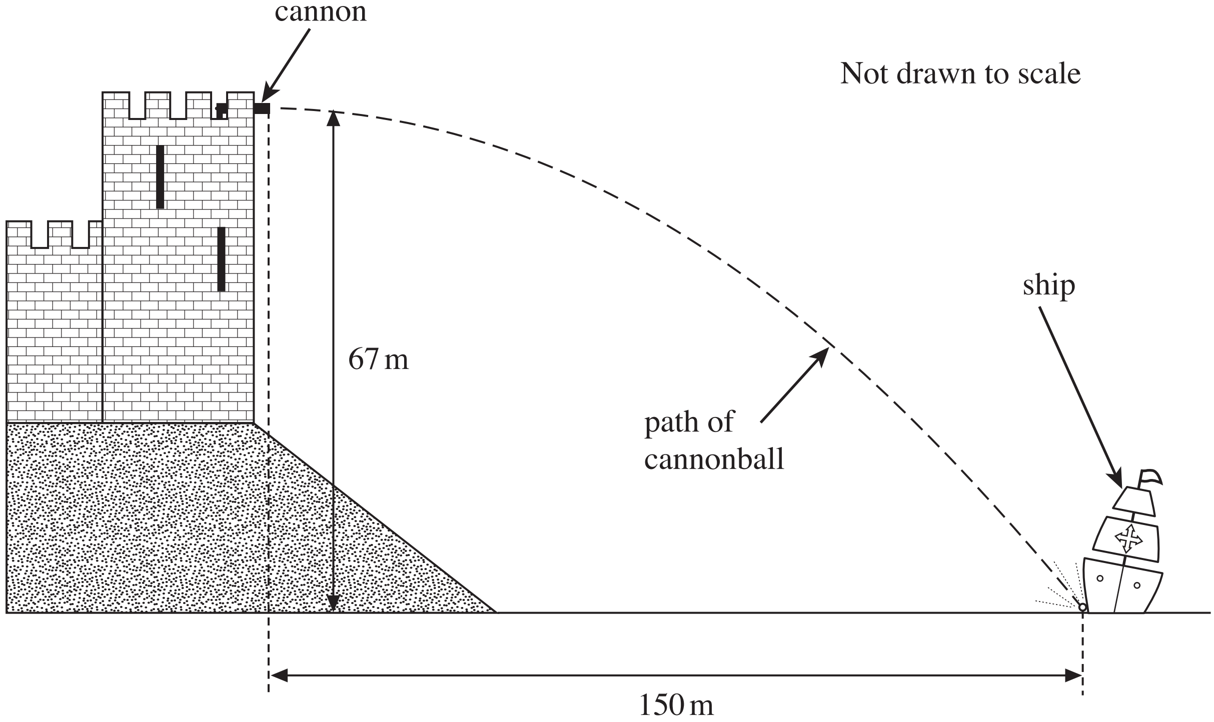
1 (b) (ii) The person causes a compression of 0.28 m in a time of 1.5 s. Use the graph in part (a) to calculate the average power developed.

answer = ...W
(3 marks)

13

2 In a castle, overlooking a river, a cannon was once employed to fire at enemy ships. One ship was hit by a cannonball at a horizontal distance of 150 m from the cannon as shown in **Figure 2**. The height of the cannon above the river was 67 m and the cannonball was fired horizontally.

Figure 2



2 (a) (i) Show that the time taken for the cannonball to reach the water surface after being fired from the cannon was 3.7 s. Assume the air resistance was negligible.

(2 marks)

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2 (a) (ii) Calculate the velocity at which the cannonball was fired. Give your answer to an appropriate number of significant figures.

answer = ... $m\,s^{-1}$
(2 marks)

2 (a) (iii) Calculate the vertical component of velocity just before the cannonball hit the ship.

answer = ... $m\,s^{-1}$
(2 marks)

2 (a) (iv) By calculation or scale drawing, find the magnitude and direction of the velocity of the cannonball just before it hit the ship.

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

direction = ...
(4 marks)

2 (b) (i) Calculate the loss in gravitational potential energy of the cannonball.
mass of the cannonball = 22 kg

answer = ... J
(1 mark)

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2 (b) (ii) Describe the energy changes that take place from the moment the cannonball leaves the cannon until just before it hits the water. Include the effects of air resistance.

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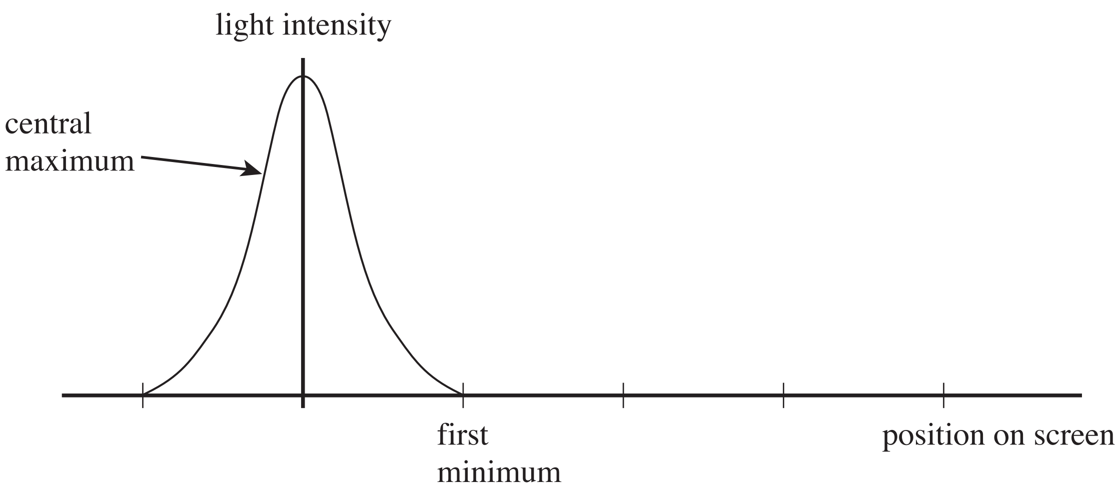
(2 marks)

13

3 A single slit diffraction pattern is produced on a screen using a laser. The intensity of the central maximum is plotted on the axes in **Figure 3**.

Figure 3



3 (a) On **Figure 3**, sketch how the intensity varies across the screen to the right of the central maximum.

(2 marks)

3 (b) A laser is a source of *monochromatic*, *coherent* light. State what is meant by

monochromatic light ....

....

coherent light ....

....

(2 marks)

3 (c) Describe how the pattern would change if light of a longer wavelength was used.

....

....

(1 mark)

3 (d) State **two** ways in which the appearance of the fringes would change if the slit was made narrower.

....

....

(2 marks)

3 (e) The laser is replaced with a lamp that produces a narrow beam of white light. Sketch and label the appearance of the fringes as you would see them on a screen.

(3 marks)

10

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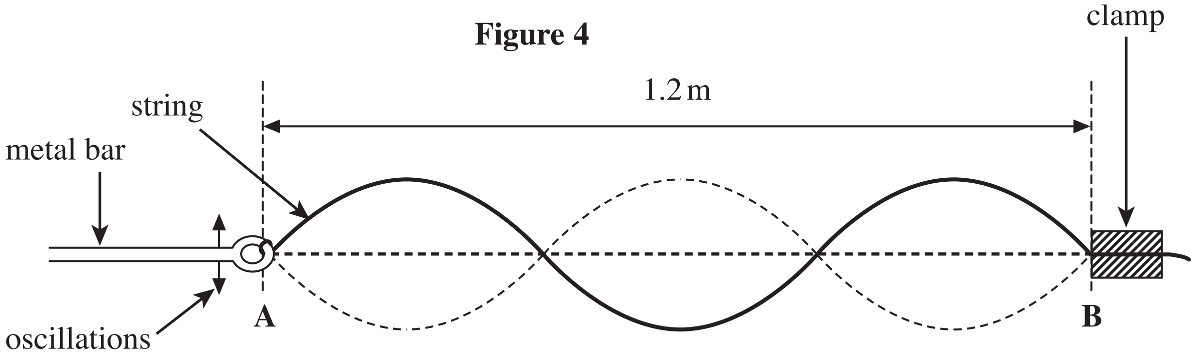
4 **Figure 4** shows a stationary wave on a string. The string is tied onto a thin metal bar at **A** and fixed at **B**. A vibration generator causes the bar to oscillate at a chosen frequency.

Figure 4



Explain how a stationary wave is formed. Then describe the key features of the stationary wave shown in **Figure 4.**

The quality of your written answer will be assessed in this question.

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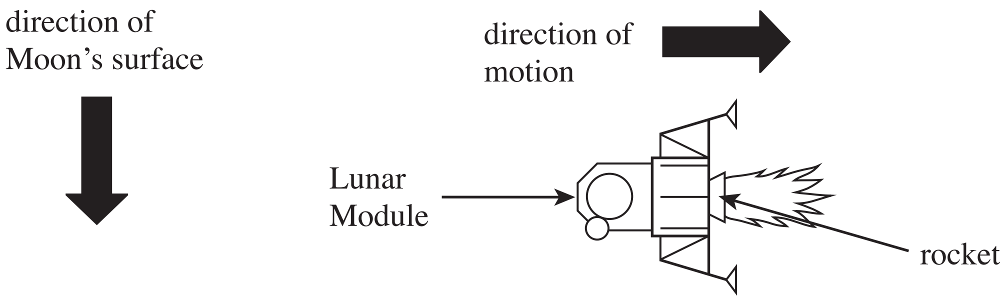
(6 marks)

6

Turn over ▶

5 In the 1969 Moon landing, the Lunar Module separated from the Command Module above the surface of the Moon when it was travelling at a horizontal speed of $2040\,\text{ms}^{-1}$. In order to descend to the Moon's surface the Lunar Module needed to reduce its speed using its rocket as shown in **Figure 5**.

Figure 5



5 (a) (i) The average thrust from the rocket was 30 kN and the mass of the Lunar Module was 15100 kg. Calculate the horizontal deceleration of the Lunar Module.

answer = ... m s^{-2}

(2 marks)

5 (a) (ii) Calculate the time for the Lunar Module to slow to the required horizontal velocity of $150\,\text{m s}^{-1}$. Assume the mass remained constant.

answer = ... s

(2 marks)

5 (b) The rocket was then used to control the velocity of descent so that the Lunar Module descended vertically with a constant velocity as shown in **Figure 6**. Due to the use of fuel during the previous deceleration, the mass of the Lunar Module had fallen by 53%.

Figure 6

acceleration due to gravity near the Moon's surface = 1.61 m s^{-2}

5 (b) (i) Draw force vectors on **Figure 6** to show the forces acting on the Lunar Module at this time. Label the vectors.

(2 marks)

5 (b) (ii) Calculate the thrust force needed to maintain a constant vertical downwards velocity.

answer = ... N

(2 marks)

5 (c) When the Lunar Module was 1.2 m from the lunar surface, the rocket was switched off. At this point the vertical velocity was 0.80 m s^{-1}. Calculate the vertical velocity at which the Lunar Module reached the lunar surface.

answer = ... m s^{-1}

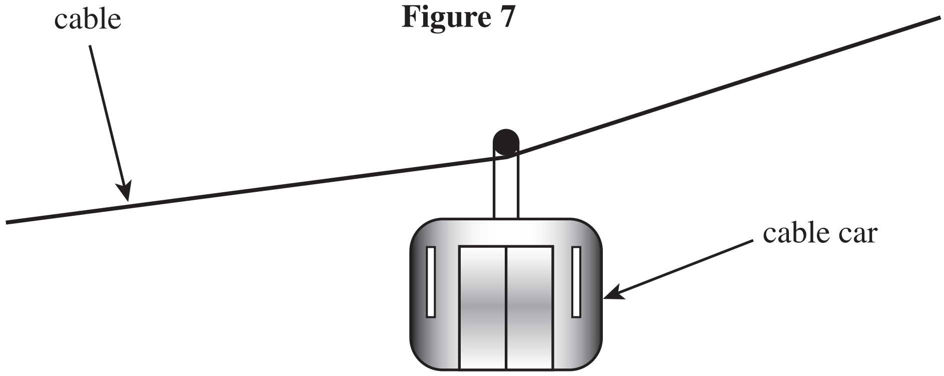
(2 marks)

Turn over for the next question

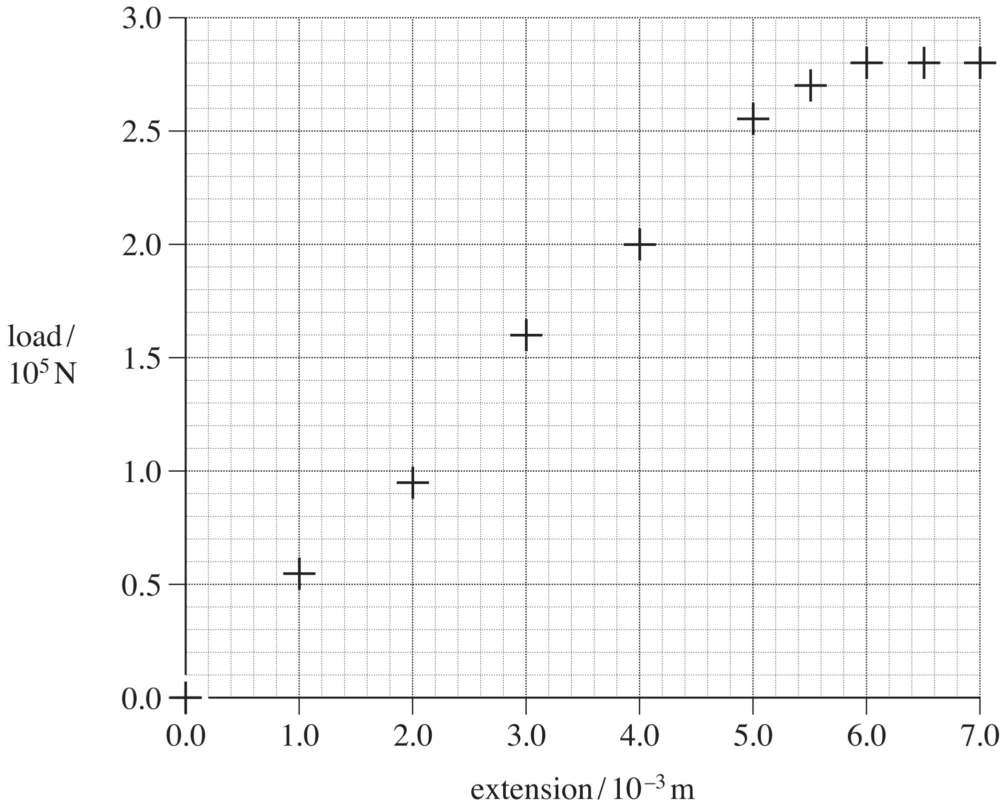
10

6 A cable car system is used to transport people up a hill. **Figure 7** shows a stationary cable car suspended from a steel cable of cross-sectional area $2.5 \times 10^{-3}\,m^2$.

Figure 7



6 (a) The graph below is for a 10 m length of this steel cable.



6 (a) (i) Draw a line of best fit on the graph. *(2 marks)*

6 (a) (ii) Use the graph to calculate the initial gradient, *k*, for this sample of the cable.

answer = ... Nm^{-1}
(2 marks)

6 (b) The cable breaks when the extension of the sample reaches 7.0 mm. Calculate the breaking stress, stating an appropriate unit.

answer = ...

(3 marks)

6 (c) In a cable car system a 1000 m length of this cable is used. Calculate the extension of this cable when the tension is 150 kN.

answer = ...m

(2 marks)

9

Turn over for the next question

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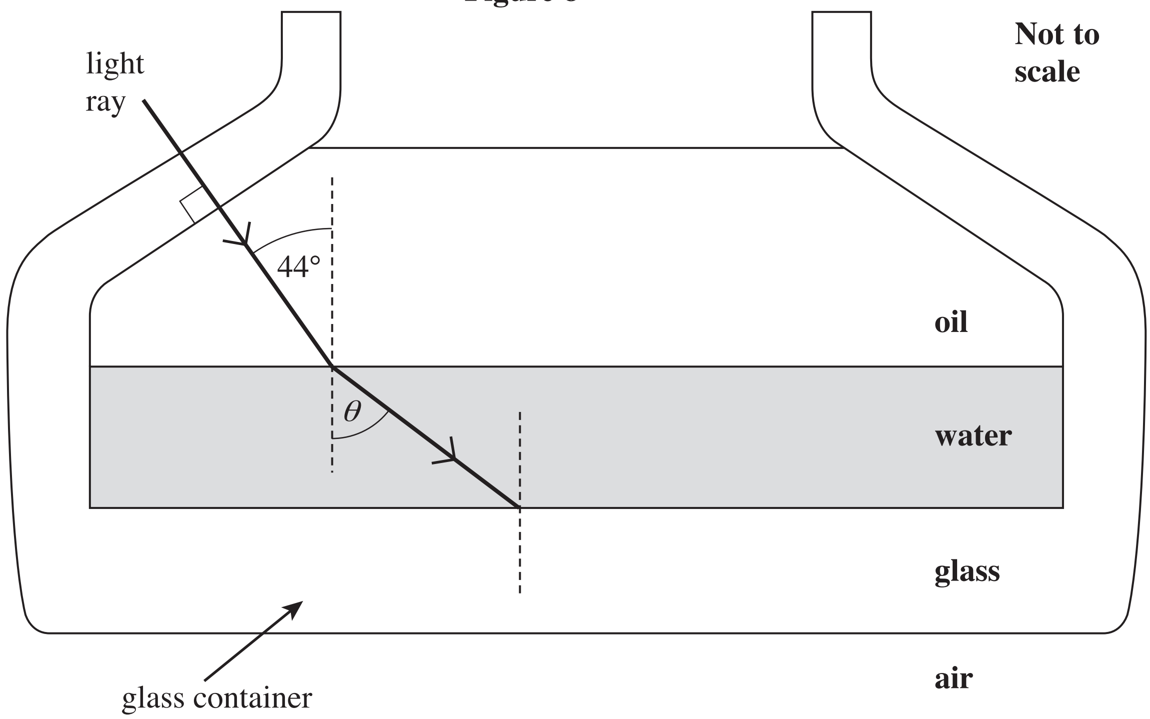
7 **Figure 8** shows a layer of oil that is floating on water in a glass container. A ray of light in the oil is incident at an angle of 44° on the water surface and refracts.

Figure 8



The refractive indices of the materials are as follows.

refractive index of oil	= 1.47
refractive index of water	= 1.33
refractive index of the glass	= 1.47

7 (a) Show that the angle of refraction θ in **Figure 8** is about 50°.

(2 marks)

7 (b) The oil and the glass have the same refractive index. On **Figure 8**, draw the path of the light ray after it strikes the boundary between the water and the glass and enters the glass. Show the value of the angle of refraction in the glass.

(2 marks)

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7 (c) Explain why the total internal reflection will not occur when the ray travels from water to glass.

....

....

....

(1 mark)

7 (d) Calculate the critical angle for the boundary between the glass and air.

answer = ...degrees

(2 marks)

7 (e) On **Figure 8**, complete the path of the ray after it strikes the boundary between the glass and air.

(2 marks)

9

END OF QUESTIONS

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