Centre Number						Candidate Number				
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For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
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TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
June 2015

Physics A PHYA2

Unit 2 Mechanics, Materials and Waves

Thursday 4 June 2015 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 (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.

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

1 (a) Indicate with ticks (✓) in **Table 1** which of the quantities are vectors and which are scalars.

[2 marks]

Table 1

	Velocity	**Speed**	**Distance**	**Displacement**
vector				
scalar				

1 (b) A tennis ball is thrown vertically downwards and bounces on the ground. The ball leaves the hand with an initial speed of $1.5\ \text{m s}^{-1}$ at a height of $0.65\ \text{m}$ above the ground. The ball rebounds and is caught when travelling upwards with a speed of $1.0\ \text{m s}^{-1}$.

Assume that air resistance is negligible.

1 (b) (i) Show that the speed of the ball is about $4\ \text{m s}^{-1}$ just before it strikes the ground.

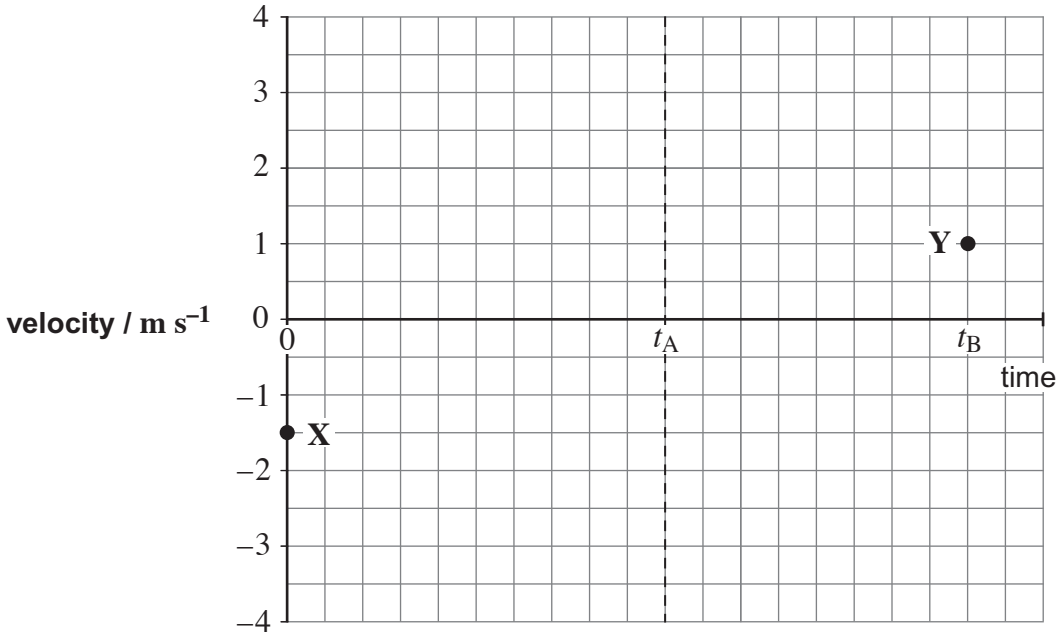
[3 marks]

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1 (b) (ii) The ball is released at time $t = 0$. It hits the ground at time t_A and is caught at time t_B. On **Figure 1**, sketch a velocity–time graph for the vertical motion of the tennis ball from when it leaves the hand to when it returns. The initial velocity **X** and final velocity **Y** are marked on **Figure 1**.

[3 marks]

Figure 1



1 (c) In a game of tennis, a ball is hit horizontally at a height of 1.2 m and travels a horizontal distance of 5.0 m before reaching the ground. The ball is at rest when hit.

Calculate the initial horizontal velocity given to the ball when it was hit.

[3 marks]

horizontal velocity = ... m s^{-1}

11

Turn over ▶

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2 (a) Define the moment of a force about a point.

[2 marks]

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2 (b) **Figure 2** shows a gripper which is used for hand strengthening exercises.

Figure 2

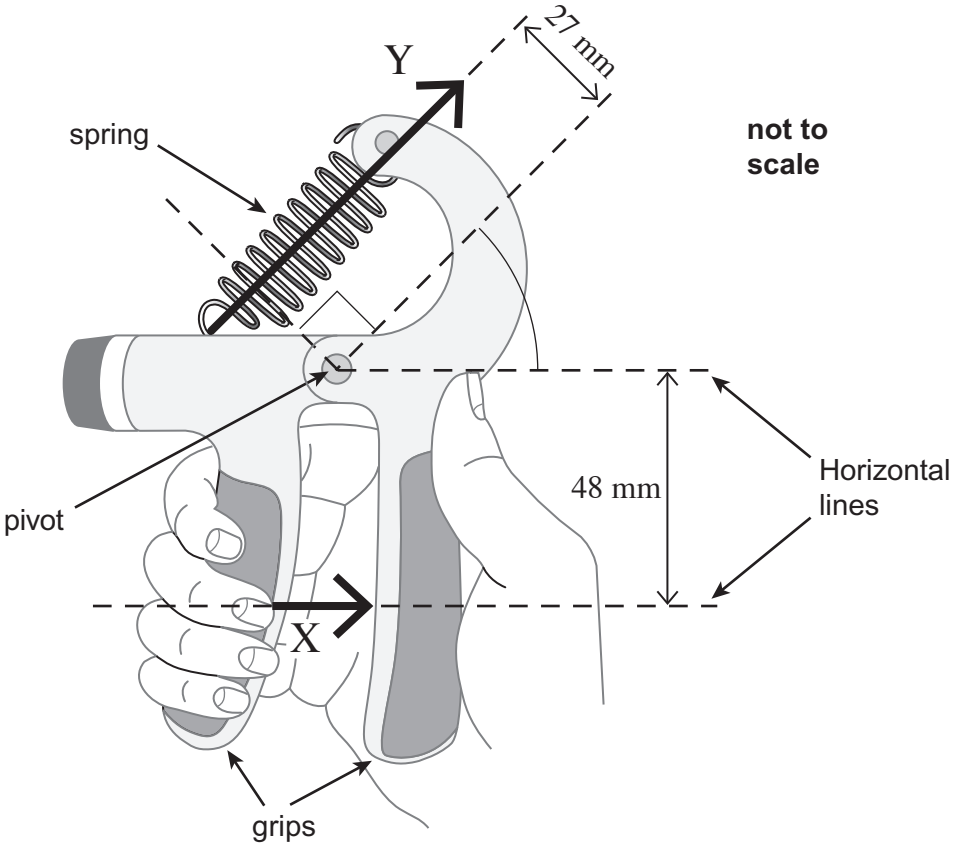


Figure 2 shows the gripper being squeezed. In this situation, the gripper is in equilibrium. The force produced by the fingers is equivalent to the single force **X** of magnitude 250 N acting in the direction shown in **Figure 2**. A force, **Y**, is exerted by the spring which obeys Hooke's law.

Do not write outside the box

2 (b) (i) Calculate the moment of force **X** about the pivot. State an appropriate unit.

[2 marks]

moment = ... unit .....

2 (b) (ii) Calculate force **Y**.

[2 marks]

force = ... N

2 (b) (iii) The extension of the spring is 15 mm.

Calculate the spring constant k of the spring. Give your answer in $\mathrm{N\ m^{-1}}$.

[2 marks]

spring constant = ... $\mathrm{N\ m^{-1}}$

2 (b) (iv) Calculate the work done on the spring to squeeze it to the position shown in **Figure 2**.

[2 marks]

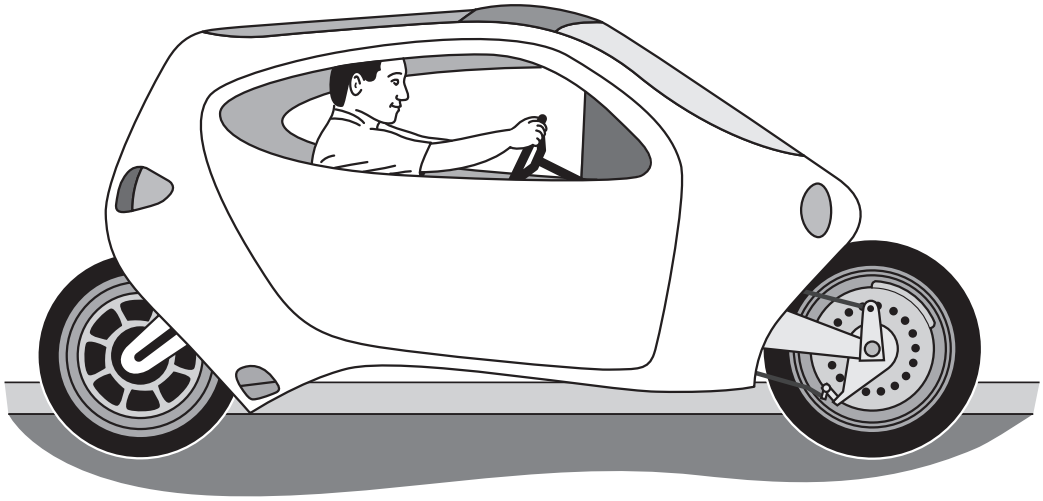
work done = ... J

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3 **Figure 3** shows an electric two-wheeled vehicle and driver.

Figure 3



3 (a) The vehicle accelerates horizontally from rest to $27.8\ \text{m s}^{-1}$ in a time of $4.6\ \text{s}$. The mass of the vehicle is $360\ \text{kg}$ and the rider has a mass of $82\ \text{kg}$.

3 (a) (i) Calculate the average acceleration during the $4.6\ \text{s}$ time interval.
Give your answer to an appropriate number of significant figures.

[2 marks]

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

3 (a) (ii) Calculate the average horizontal resultant force on the vehicle while it is accelerating.

[2 marks]

resultant force = ... N

Do not write outside the box

3 (b) State and explain how the horizontal forward force on the vehicle has to change for **constant** acceleration to be maintained from 0 to $27.8\ \text{m s}^{-1}$.

[3 marks]

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3 (c) The electric motors drive both wheels of the vehicle.

Add labelled force arrows to **Figure 3** to show the horizontal forces acting on the vehicle when it is moving at a constant speed.

[2 marks]

3 (d) The vehicle now accelerates to a constant speed of $55\ \text{m s}^{-1}$. The useful power output of the motors is $22\ \text{kW}$ at this speed.

Calculate the horizontal resistive force acting on the vehicle.

[2 marks]

horizontal resistive force = ... N

11

Turn over ▶

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4 An aerospace engineer has built two differently designed wings. One wing is made from an aluminium alloy and the other is made from a carbon fibre composite.

The engineer tests a sample of each material by applying a varying stress.

4 (a) Tick (✓) **two** of the boxes in **Table 2** to indicate which are properties of the material from which the wing is made.

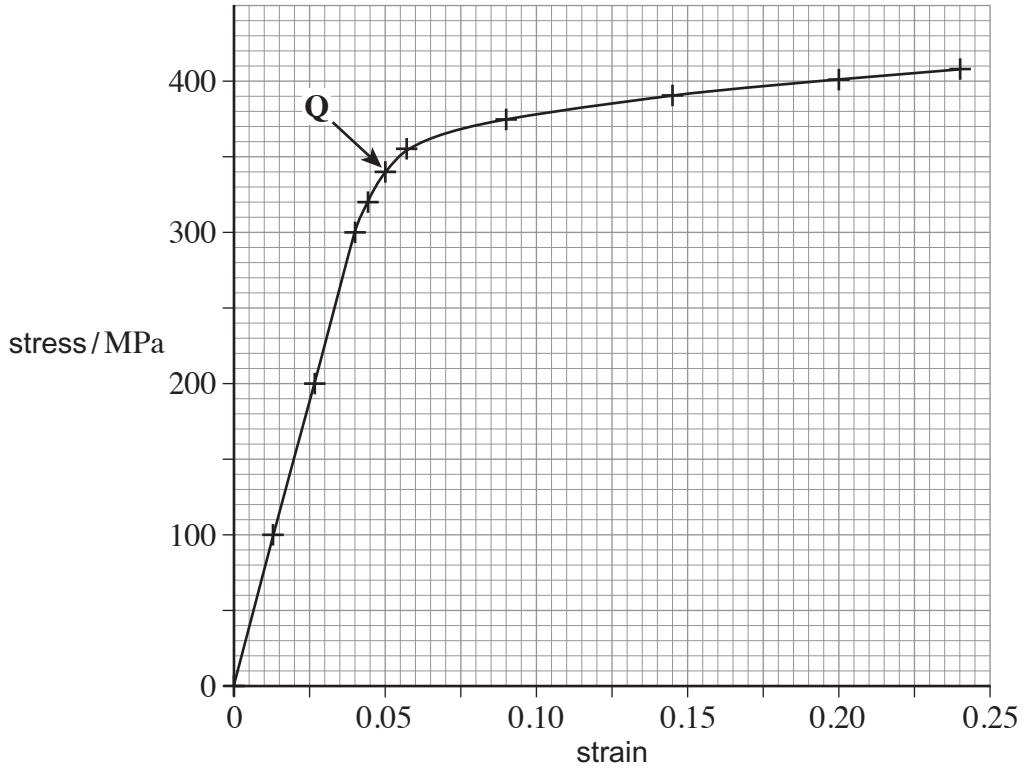
[1 mark]

Table 2

breaking stress	
stiffness constant, k	
tensile strain	
tensile stress	
Young modulus	

4 (b) **Figure 4** shows the stress–strain graph that the engineer obtains for the aluminium alloy.

Figure 4



4 (b) (i) The engineer has labelled a point **Q** on the graph in **Figure 4**. This is a point beyond which the behaviour of the material changes irreversibly. State the name for this point.

[1 mark]

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4 (b) (ii) Use the graph to determine the Young modulus of the aluminium alloy. Show your working.

[2 marks]

Young modulus = ... Pa

4 (c) The engineer who carried out the experiment to obtain the stress–strain graph decided to stretch another sample to a strain of 0.10. She then gradually reduced the stress to zero.

Show by drawing on **Figure 4** how you would expect the stress to vary with strain as the stress is reduced.

[2 marks]

Question 4 continues on the next page

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4 (d) Calculate the volume of $25.0\ \text{kg}$ of the aluminium alloy.

density of aluminium alloy = $2.78 \times 10^3\ \text{kg m}^{-3}$.

[1 mark]

volume = ... m^3

4 (e) 1.28% of the aluminium alloy's volume is copper.
Calculate the mass of pure aluminium needed to make $25.0\ \text{kg}$ of the aluminium alloy.

density of pure aluminium = $2.70 \times 10^3\ \text{kg m}^{-3}$.

[2 marks]

mass of pure aluminium = ... kg

9

Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

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5 (a) Tick (✓) the appropriate boxes in **Table 3** to indicate how the wavelength, frequency and speed of light are affected when a ray of light travels from air into glass.

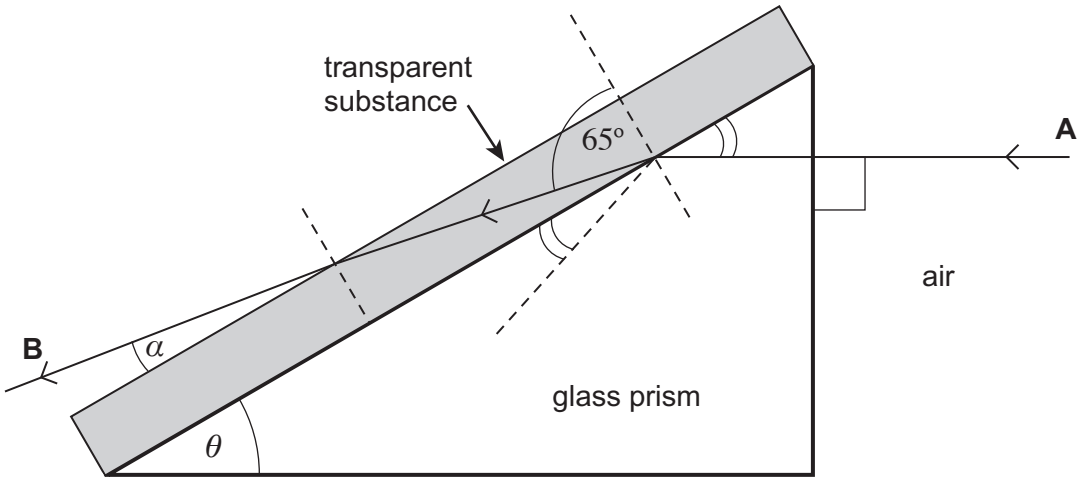
[2 marks]

Table 3

	Wavelength	Frequency	Speed
increases			
stays the same			
decreases			

5 (b) **Figure 5** shows a right-angled glass prism in contact with a transparent substance on one of the faces. One of the other angles of the prism is θ.

Figure 5



refractive index of glass prism = 1.70
refractive index of transparent substance = 1.09

angles are not shown to scale

Do not write outside the box

5 (b) (i) A ray **A** enters perpendicularly to one face of the prism. It is partially refracted and partially reflected at the interface between the glass and the transparent substance. The angle of refraction is 65.0°. The ray eventually leaves at an angle α to the surface of the transparent substance.

Determine the angle α.

[2 marks]

angle α = ... degree

5 (b) (ii) Determine the angle θ in **Figure 5**.

[2 marks]

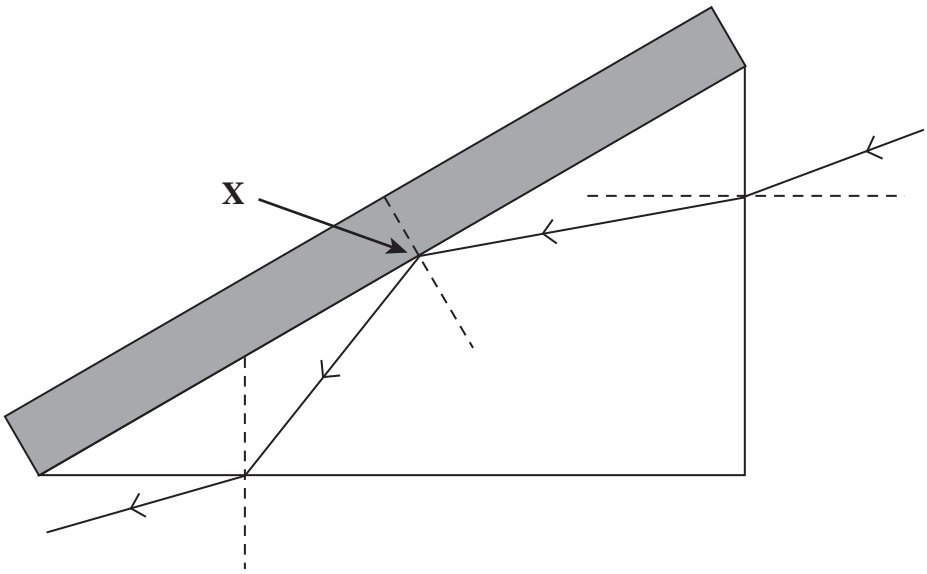
angle θ = ... degree

Question 5 continues on the next page

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5 (c) **Figure 6** shows another ray entering the prism.

Figure 6



5 (c) (i) Identify the effect that takes place at **X** in **Figure 6**.

[1 mark]

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5 (c) (ii) Explain, with a diagram, how the effect that occurs at **X** is used to transmit information along an optic fibre.

[3 marks]

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There are no questions printed on this page

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ANSWER IN THE SPACES PROVIDED

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6 A stationary wave is formed on a stretched string. Discuss the formation of this wave. Your answer should include:

- an explanation of how the stationary wave is formed
- a description of the features of the stationary wave
- a description of the processes that produce these features.

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

[6 marks]

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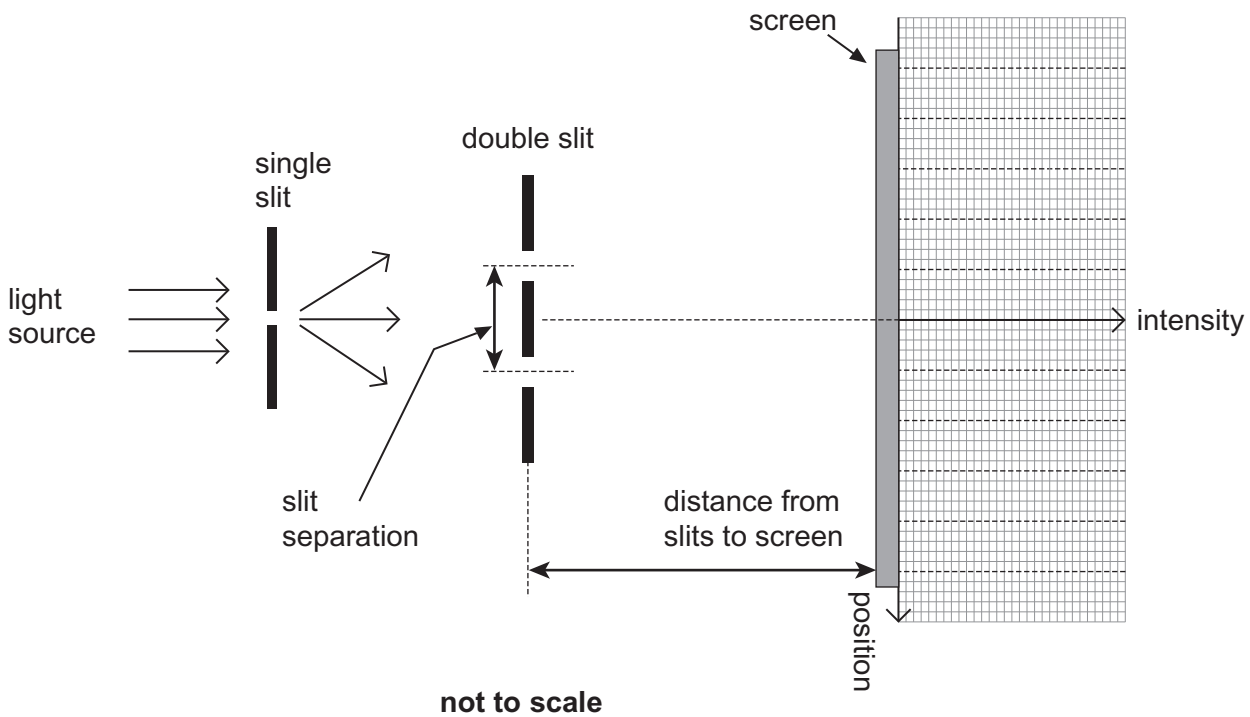
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7 **Figure 7** shows Young's double-slit experiment performed with a tungsten filament lamp as the light source.

Figure 7



not to scale

7 (a) On the axes in **Figure 7**, sketch a graph to show how the intensity varies with position for a **monochromatic** light source.

[2 marks]

7 (b) (i) For an interference pattern to be observed the light has to be emitted by two **coherent sources**.
Explain what is meant by coherent sources.

[1 mark]

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7 (b) (ii) Explain how the use of the single slit in the arrangement in **Figure 7** makes the light from the two slits sufficiently coherent for fringes to be observed.

[1 mark]

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7 (b) (iii) In this experiment light behaves as a wave.
Explain how the bright fringes are formed.

[3 marks]

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7 (c) (i) A scientist carries out the Young double-slit experiment using a laser that emits violet light of wavelength $405\ \text{nm}$. The separation of the slits is $5.00 \times 10^{-5}\ \text{m}$.

Using a metre ruler the scientist measures the separation of two adjacent bright fringes in the central region of the pattern to be $4\ \text{mm}$.

Calculate the distance between the double slits and the screen.

[2 marks]

distance = ... m

Question 7 continues on the next page

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7 (c) (ii) Describe the change to the pattern seen on the screen when the violet laser is replaced by a green laser. Assume the brightness of the central maximum is the same for both lasers.

[1 mark]

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7 (c) (iii) The scientist uses the same apparatus to measure the wavelength of visible electromagnetic radiation emitted by another laser.
Describe how he should change the way the apparatus is arranged and used in order to obtain an **accurate** value for the wavelength.

[3 marks]

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13

END OF QUESTIONS

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