

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary GCE

PHYSICS B (ADVANCING PHYSICS)

2861

Understanding Processes

Thursday **16 JANUARY 2003** Afternoon 1 hour 30 minutes

Candidates answer on the question paper.

Additional materials:

Data, Formulae and Relationships Booklet

Electronic calculator

Candidate Name	Centre Number	Candidate Number									
	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> </tr> </table>						<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> </tr> </table>				

TIME 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

- Write your name in the space above.
- Write your Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Write your answers in the spaces provided on the question paper.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Show clearly the working in all calculations and give answers to only a justifiable number of significant figures.

INFORMATION FOR CANDIDATES

- You are advised to spend about 20 minutes on Section A, 40 minutes on Section B and 30 minutes on Section C.
- The number of marks is given in brackets [] at the end of each question or part question.
- You will be awarded marks for the quality of written communication in Section C.
- The values of standard physical constants are given in the Data, Formulae and Relationships Booklet. Any additional data required are given in the appropriate question.

FOR EXAMINER'S USE		
Section	Max.	Mark
A	20	
B	40	
C	30	
TOTAL	90	

This question paper consists of 20 printed pages.

Answer all the questions.

Section A

- 1 The energy carried by light from a light emitting diode (LED) is radiated at a rate of 15 mW. The frequency of the light is 5.0×10^{14} Hz.

- (a) Calculate the energy of a photon of frequency 5.0×10^{14} Hz.
the Planck constant $h = 6.6 \times 10^{-34}$ J s

energy =J [2]

- (b) Calculate the number of photons emitted every second by the LED.

number of photons = [2]

- 2 Two aircraft, **A** and **B**, are travelling towards each other in level flight along a common flight path, as shown in Fig. 2.1.



Not to scale

Fig. 2.1

The speeds of the two aircraft, relative to the ground, are 200 m s^{-1} and 300 m s^{-1} as shown.

- (a) Calculate the magnitude of the relative velocity of approach of the two aircraft.

relative velocity = m s^{-1} [1]

- (b) Radar establishes that the two aircraft are 40 km apart. Calculate the time it would take for the aircraft to collide, if avoiding action is not taken.

time = s [2]

- 3 Light from a small bulb is reflected to your eye from a mirror. Some possible paths for photons are shown in Fig. 3.1.

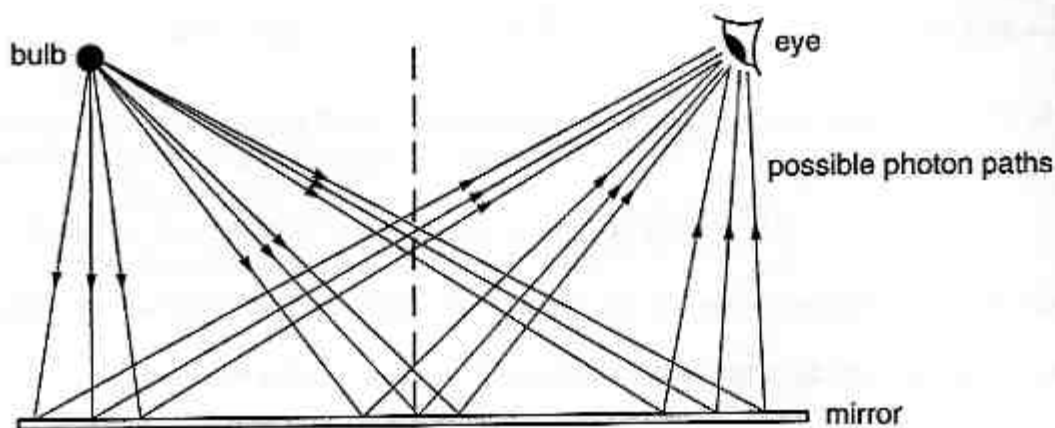


Fig. 3.1

Photons could reach your eye by many possible paths, glancing off the mirror at different places.

The paths close to the one obeying the law of reflection, angle of incidence = angle of reflection, are important because

- A ... they are the only paths that photons can be considered to take.
- B ... the phasors associated with these paths all point in similar directions.
- C ... the phasors associated with these paths are opposite in phase to those for all other paths.

Write down the letter (A, B or C) of the statement which correctly completes the *italicised* sentence.

answer [1]

- 4 An organ pipe, closed at one end, and a flute, open at both ends, have the same length L . The fundamental standing wave in each is shown in Fig. 4.1.

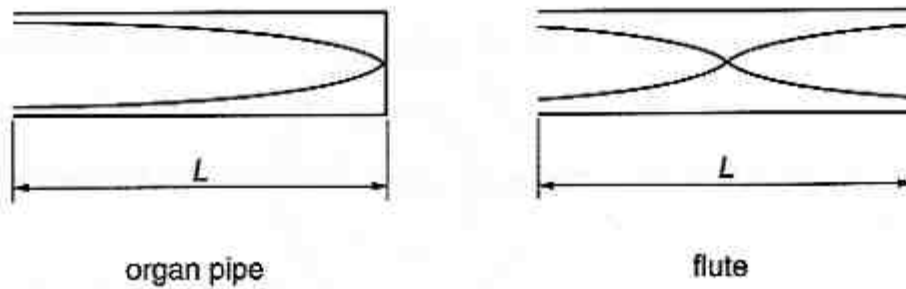


Fig. 4.1

- (a) The organ pipe produces a fundamental note of frequency 130 Hz.

Explain why the frequency of the fundamental note produced by the flute is 260 Hz.

[2]

- (b) The length L of the organ pipe is 0.65 m.

Show that the speed of sound in the air in the pipe is about 340 m s^{-1} .

[2]

- 5 The speed, v , of water waves in deep water is given by the expression $v^2 = \frac{\lambda g}{2\pi}$, where λ is the wavelength of the wave, and g is the gravitational field strength.

Here is a list of four graphs that could be plotted relating wave speed v and wavelength λ .

- A v against λ B v against λ^2 C v^2 against λ D v^2 against λ^2

Write down the letter (A, B, C or D) of the graph you would plot in order to obtain a straight line through the origin.

answer [1]

- 6 A girl takes up a hand-stand position on the edge of a high board above the water surface in the pool, as shown in Fig. 6.1.

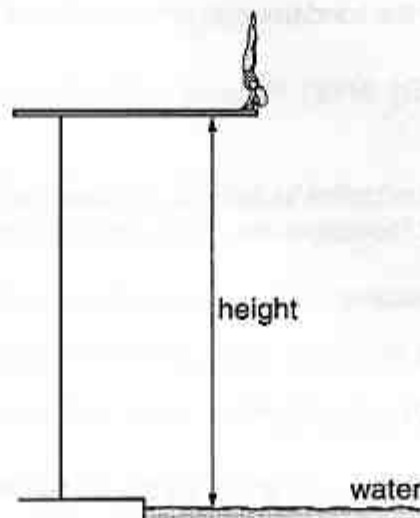


Fig. 6.1

She then dives vertically from rest through the air and enters the water 1.75 s after leaving the board.

Calculate the height of the diving board above the water surface. Neglect any effects of air resistance.

$$g = 9.8 \text{ m s}^{-2}$$

height =m [3]

- 7 Electrons move through an accelerating voltage V in an electron gun. The beam of electrons, emerging from the electron gun, strikes a graphite target. On a fluorescent screen at the far end of the evacuated tube a ring pattern is produced, as shown in Fig. 7.1.

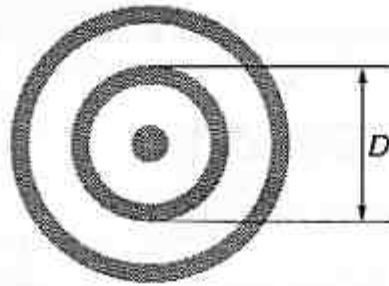


Fig. 7.1

As the accelerating voltage V is increased, the diameter of each ring is observed to decrease.

Measurements of the diameter D of a ring are made at different values of accelerating voltage V . The readings are given in the table.

D / mm	V / kV
28	3.0
25	3.8
23	4.4

It is suggested that the relationship between ring diameter D and accelerating voltage V for any ring, is given by:

$$D = \frac{k}{\sqrt{V}} \quad \text{where } k \text{ is a constant for the apparatus.}$$

Propose and carry out a test to check if the relationship is true for this data.

test proposed

working

conclusion:[4]

[Section A Total: 20]

Section B

- 8 This question is about driving poles into the ground.

Fig. 8.1 shows a 220 kg mass held in position 5.0 m above the top of a rigid, cylindrical pole. The lower end of the vertical pole is resting on the ground.

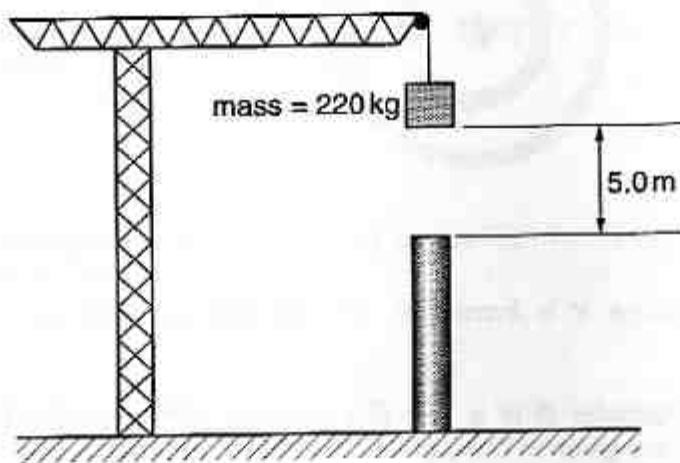


Fig. 8.1

- (a) When released, the mass drops freely from rest under gravity and strikes the top of the pole.

- (i) Describe the energy changes taking place from the moment the mass falls until it strikes the top of the pole.

[2]

- (ii) Show that the speed of the mass is about 10 m s^{-1} when it strikes the top of the pole.

$$g = 9.8 \text{ N kg}^{-1}$$

[2]

- (iii) In bringing the moving mass to rest on top of the vertical pole, the pole is pushed down into the ground. The depth of penetration of the pole into the ground is 0.4 m.

Show that the average force exerted by the pole on the mass is about 27 kN.

[2]

- (b) The process is repeated several times to drive the pole into the ground. Each time the mass is raised to a position 5.0 m above the top of the pole, and dropped onto it. For each successive drop, the **extra** depth of penetration achieved decreases.
- (i) Suggest why this might be so.

[1]

The extra penetration achieved in the first and second drops of the mass is plotted on Fig. 8.2.

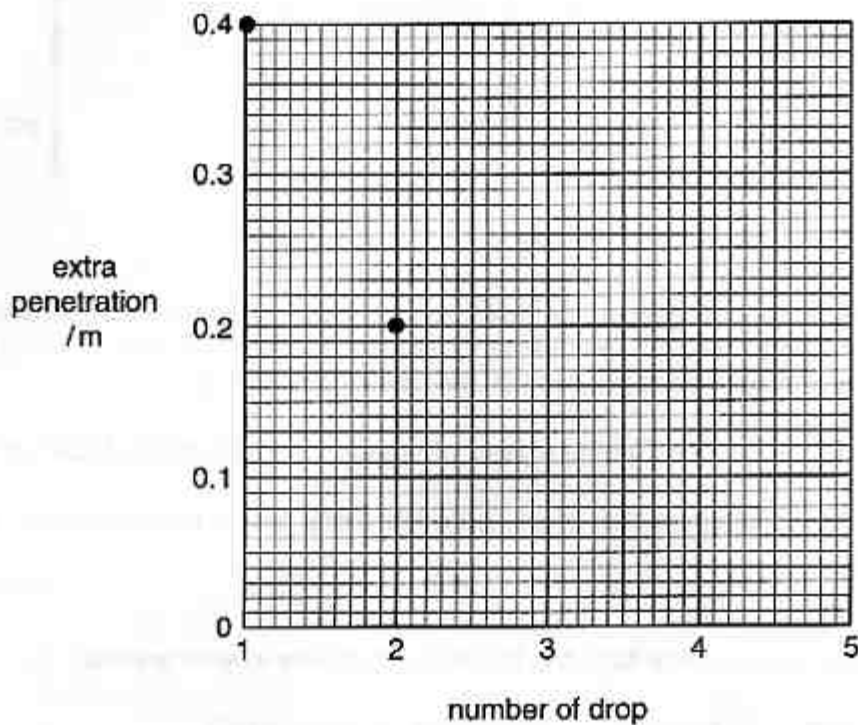


Fig. 8.2

The extra penetration at each successive drop is a constant fraction of the extra penetration achieved at the previous drop.

- (ii) Complete Fig. 8.2 by marking on the graph the values of extra penetration achieved by the third, fourth and fifth drops. Show your reasoning below.

[3]

[Total: 10]

[Turn over

- 9 This question is about using the idea of rotating phasors.

Light of a particular frequency passes through a diffraction grating on its way to a screen. The arrangement is shown in Fig. 9.1.

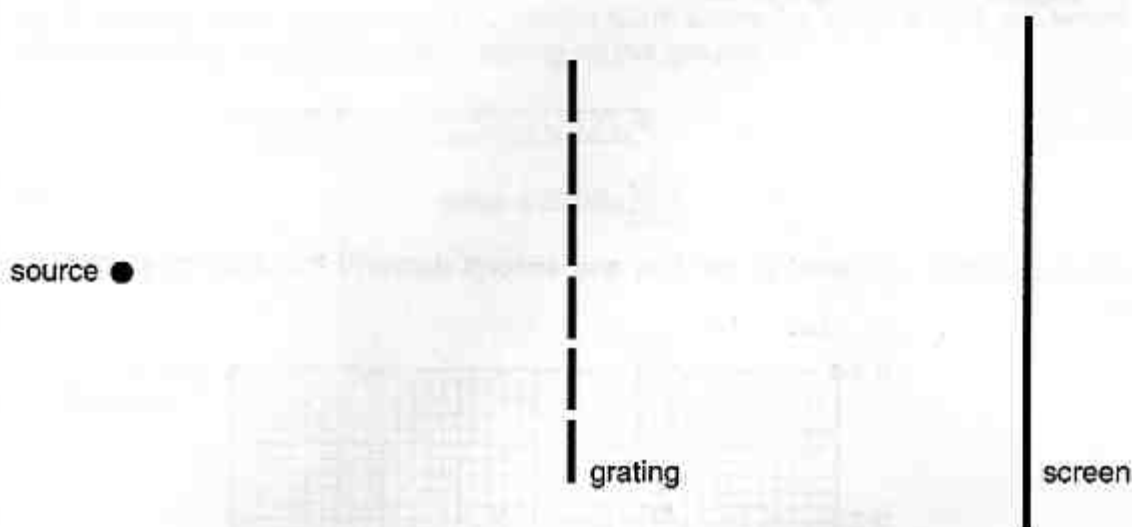


Fig. 9.1

- (a) In travelling from the source to some point on the screen, a photon is supposed to have explored all possible paths available to it. The probability of arrival of the photon is determined by combining the phasors for the paths considered.

- (i) Mark on Fig. 9.1 a point on the screen where photons may arrive. Label this point P.
- (ii) Sketch on the diagram **two** of the possible paths that a photon would explore in arriving at P.

[2]

- (b) In this question, select ideas from the following list to use in your answer.

rotating phasor frequency difference in path length
speed of photon angle between phasors

- (i) Explain how the resultant phasor amplitude at P would be determined for the paths shown.

[3]

- (ii) State how the probability of arrival of photons at **P** is related to the resultant phasor amplitude there.

[1]

- (c) (i) Draw a diagram to represent the pattern that could be observed on the screen.
Label the important features using appropriate scientific terms.

[3]

- (ii) Mark with the letter **X** on your diagram a place where the probability of arrival of photons is **high**.

[1]

[Total: 10]

