OCR
RECOGNISING ACHIEVEMENT

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

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.

For Examiner's Use

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]

For Examiner's Use

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.

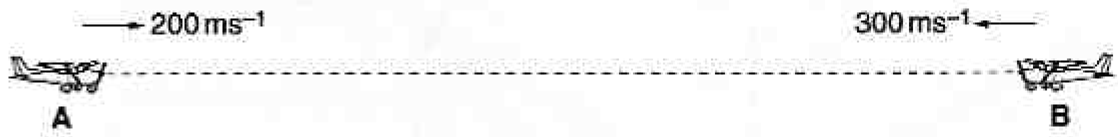


Fig. 2.1

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]

For Examiner's Use

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.

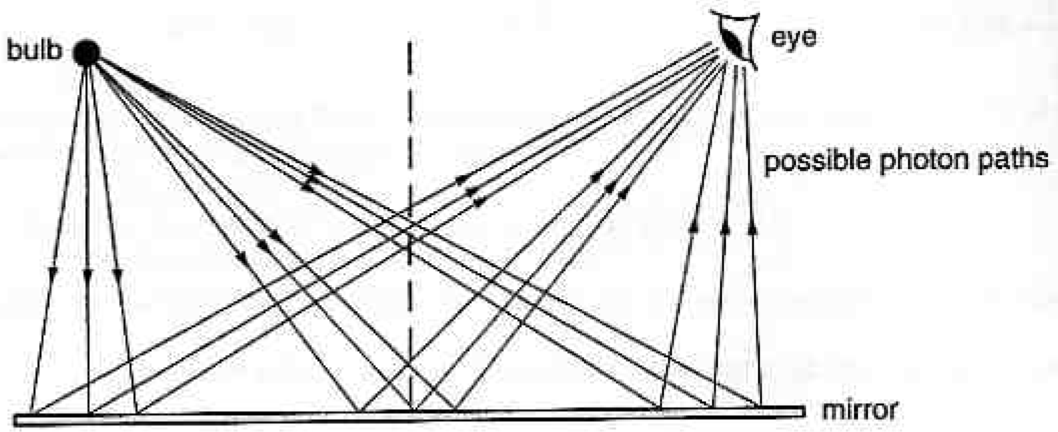


Fig. 3.1

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.

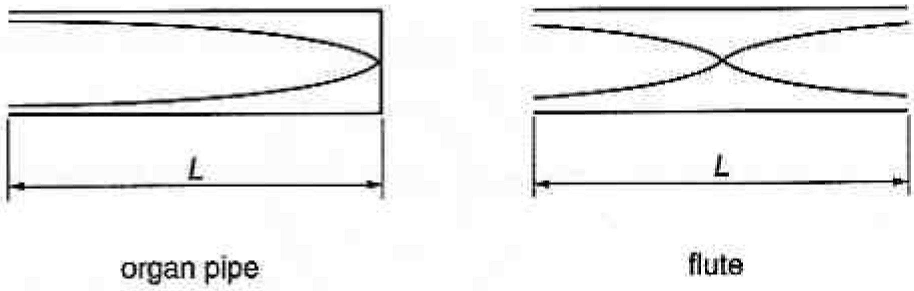


Fig. 4.1

(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]

For Examiner's Use

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.

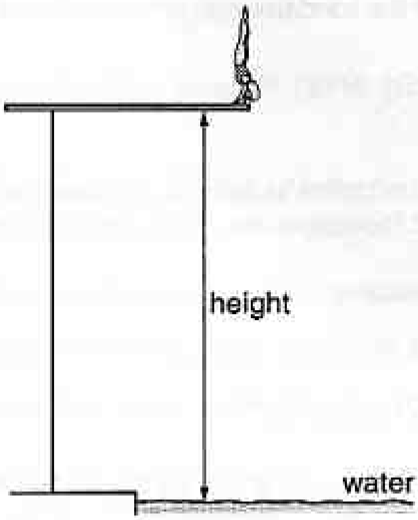


Fig. 6.1

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]

For Examiner's Use

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.

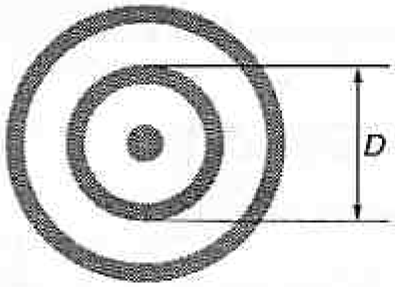


Fig. 7.1

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:

$$D = \frac{k}{\sqrt{V}}$$ where k 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]

[Turn over

For Examiner's Use

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.

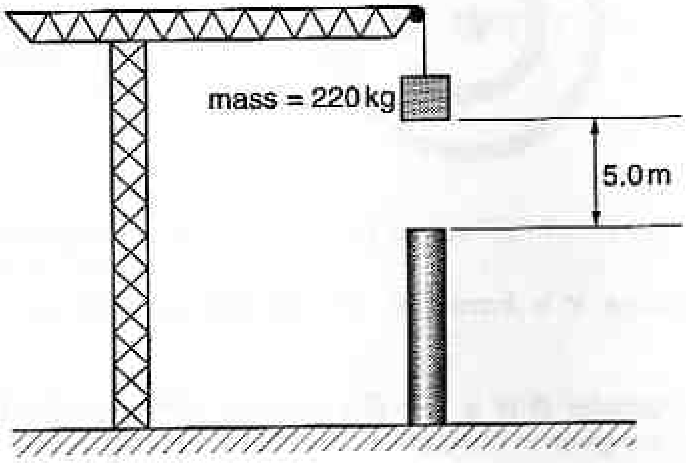


Fig. 8.1

(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 $10\,\mathrm{m\,s^{-1}}$ when it strikes the top of the pole.

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

[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]

For Examiner's Use

(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.

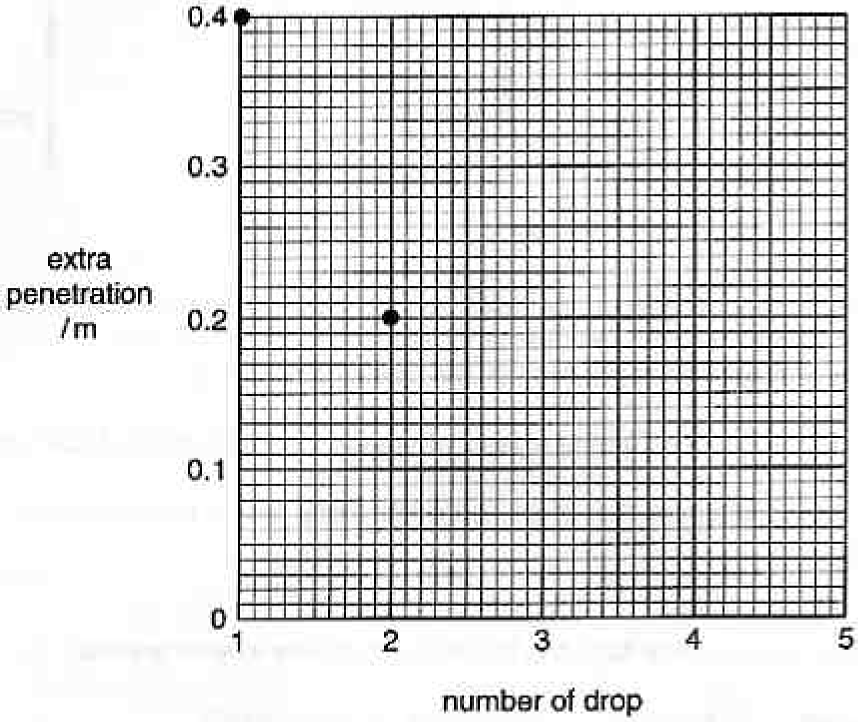


Fig. 8.2

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]

For Examiner's Use

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.

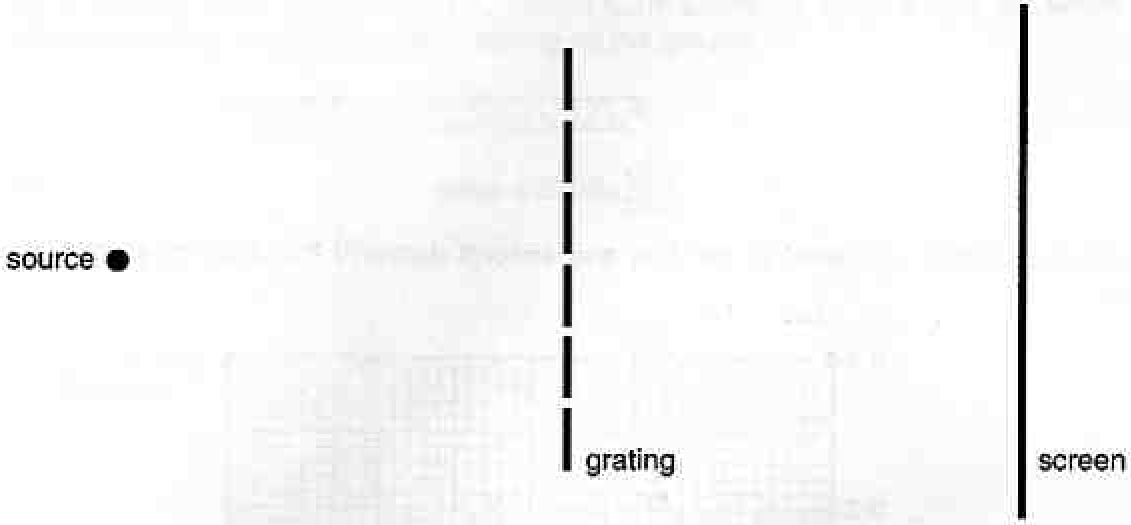


Fig. 9.1

(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]

For Examiner's Use

(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.

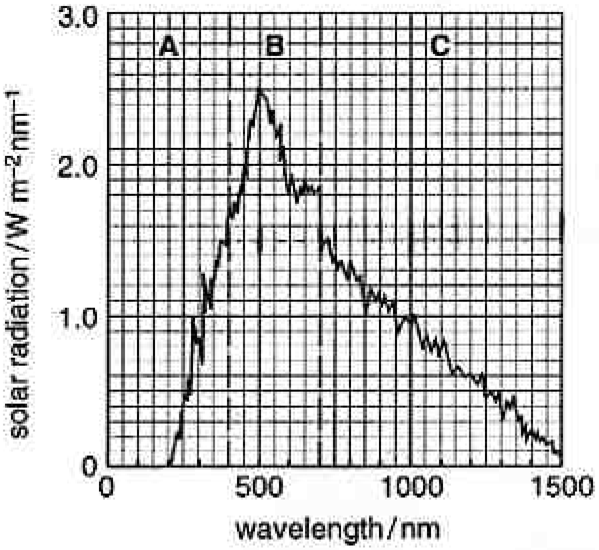
[3]

(ii) Mark with the letter **X** on your diagram a place where the probability of arrival of photons is **high.** [1]

[Total: 10]

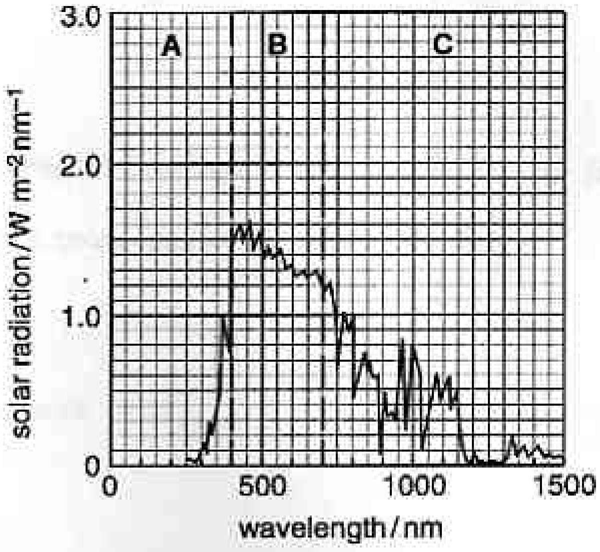
10 This question is about the energy spectrum received at the Earth from the Sun.

Fig. 10.1 shows the solar energy arriving **at the top of the atmosphere.**
The rate of arrival of energy ($W\,m^{-2}$), per nm range of wavelength, is plotted against wavelength (nm).



solar spectrum at the top of the atmosphere

Fig. 10.1



solar spectrum at the surface of the Earth

Fig. 10.2

(a) The three main parts of the solar spectrum are in the **visible, ultraviolet** and **infrared** wavelengths. Three regions are labelled **A, B** and **C** on Fig. 10.1.

Complete the table below, by identifying the type of radiation corresponding to each of the three regions shown.

region	type of electromagnetic radiation
A	
B	
C	

[2]

(b) The table below shows the energy arriving every second, per square metre, at the top of the atmosphere in each region of the spectrum (**A, B** and **C**).

region	**A**	**B**	**C**	total energy *S*
energy / $W\,m^{-2}$	175	645	570	

(i) Complete the table by calculating the **total** energy *S* that the Earth receives every second, per square metre, at the top of the atmosphere.

[1]

For Examiner's Use

(ii) The energy arriving every second, per square metre, is equal to the **area under the graph**.

Show that the area under the graph in region **C** is approximately $570\,W\,m^{-2}$ as stated in the table above.

[2]

(c) The solar spectrum arriving **at the surface of the Earth** is quite different, as shown in Fig. 10.2.

(i) Describe **two** ways in which the solar spectrum at the surface of the Earth is different from that at the top of the atmosphere.

1.

2.

[2]

(ii) Describe a physical process that might account for one difference you have described.

[2]

(iii) Suggest why a solar panel on a satellite at the top of the atmosphere can produce a larger power output than an identical panel on the surface of the earth.

[1]

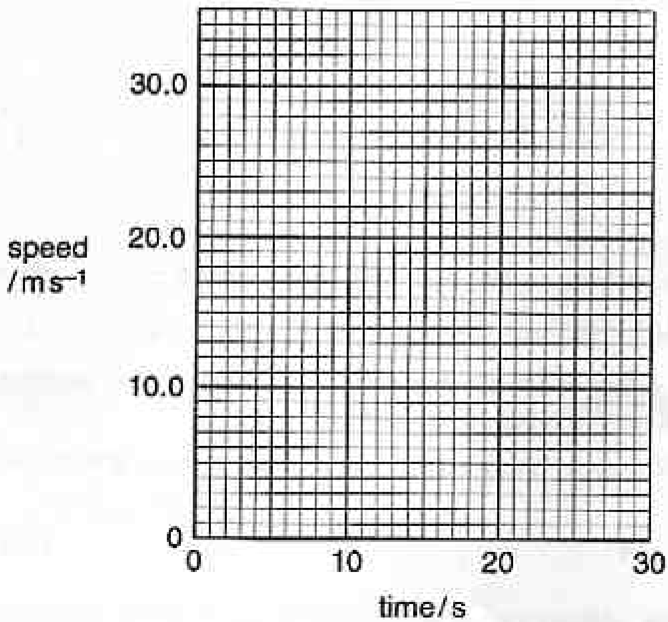
[Total: 10]

For Examiner's Use

11 A car of mass 1200 kg accelerates from rest to a speed of 30.0 m s^{-1}. The table below shows the speed of the car at 5 second intervals.

time /s	0	5	10	15	20	25	30
speed /m s^{-1}	0	13.0	21.5	26.5	29.0	30.0	30.0

(a) Plot a graph of speed against time on the axes below.



[2]

(b) **(i)** Calculate the **average** acceleration of the car between 0 s and 25 s. Show how you get your answer.

[2]

(ii) Using the speed-time graph, show that the distance the car travels in the first 25 s is about 500 m.

[2]

For Examiner's Use

(c) The kinetic energy gained by the car in accelerating from rest to a speed of $30.0\,m\,s^{-1}$ is 540 kJ.

(i) Explain why the car still needs to use fuel even when travelling at a steady speed of $30.0\,m\,s^{-1}$ on a level road.

[2]

(ii) Explain why less fuel is used to travel at a steady speed than when repeatedly accelerating and braking, even though the average speed may be the same.

[2]

[Total: 10]

[Section B Total: 40]

For Examiner's Use

Section C

In this section of the paper you will choose the context in which you give your answers.
Use diagrams to help your explanations and take particular care with your written English. Up to four marks in this section will be awarded for the quality of written communication.

12 Read this short passage carefully.

'The principle of superposition of waves may be expressed in a simple way. When two or more coherent waves superimpose, energy is usually distributed into a pattern of maxima and minima. To find the maxima and minima the amplitudes are added together – not the energies of the waves. The energy (intensity) at any point in the pattern is proportional to (amplitude)^2. Most detectors measure energy rather than amplitude.'

In this question you are to choose, and write about, one particular example of a superposition effect which depends on this principle.

(a) State the superposition effect you have chosen.

[1]

(b) Show, with the aid of a suitably labelled diagram, how this superposition effect may be observed.

[4]

(c) Describe what could be observed. You may find it useful to draw a diagram to help in your description.

[4]

(d) Write a detailed explanation of the observations you have described in part **(c)** using the ideas presented in the passage.

[4]

[Total: 13]

For Examiner's Use

13 In this question you are to write about a method of measuring the distance to a remote object. The distance measurement you choose to describe should be one that you can justify as being of particular use, interest, or importance.

(a) State the distance measurement you have chosen.

[1]

(b) Explain, in a few sentences, why you consider this distance measurement to be particularly useful, or interesting, or important to make.

[2]

(c) Show, with the aid of a carefully labelled diagram, the arrangement of equipment that would be needed to make the measurement.

[3]

For Examiner's Use

(d) Explain how the equipment is used to collect the necessary information, and how the information can be used to calculate the distance.

[4]

(e) **(i)** Suggest **one** factor that could limit the accuracy of the measurement. Explain your reasoning.

[2]

(ii) Suggest how the accuracy might be improved.

[1]

[Total: 13]

Quality of Written Communication [4]

[Section C Total: 30]