RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary GCE

PHYSICS B (ADVANCING PHYSICS) 2861

Understanding Processes

Monday **12 JANUARY 2004** Morning 1 hour 30 minutes

Candidates answer on the question paper.
Additional materials:
Data, Formulae and Relationships Booklet
Electronic calculator
Protractor

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.
- There are four 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.

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Answer **all** the questions.

Section A

1 Here is a list of four numbers.

0.6 6 60 600

Write down the number that is the best estimate of

(a) the wavelength of visible light, expressed in nm

wavelength = ... nm [1]

(b) the mass of a typical Advancing Physics student, expressed in kg

mass = ... kg [1]

(c) the top speed of a supersonic aircraft, expressed in **kilometre** per second.

speed = ... km s^{-1} [1]

For Examiner's Use

2 An apple falls onto the head of a philosopher sitting beneath an apple tree.

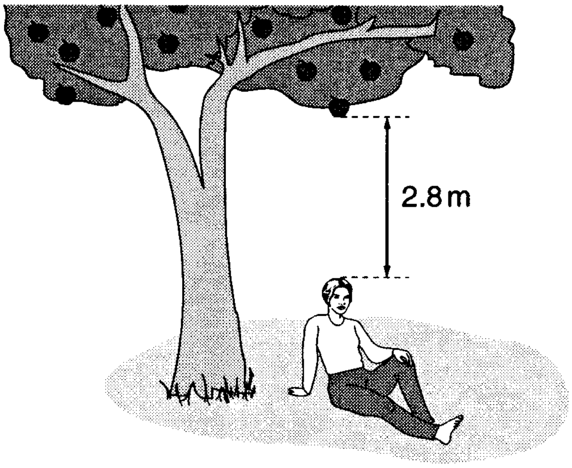

Fig. 2.1

The apple of mass 0.15 kg falls from rest through a vertical height of 2.8 m before striking the philosopher.

(a) Describe the energy change taking place as the apple falls.

[1]

(b) (i) Calculate the speed at which the apple is travelling when it strikes the philosopher.

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

speed = ... $\mathrm{m\ s^{-1}}$ [2]

(ii) State an assumption you have made.

[1]

For Examiner's Use

3 A beam of laser light falls on two closely spaced narrow parallel slits as shown in Fig. 3.1.

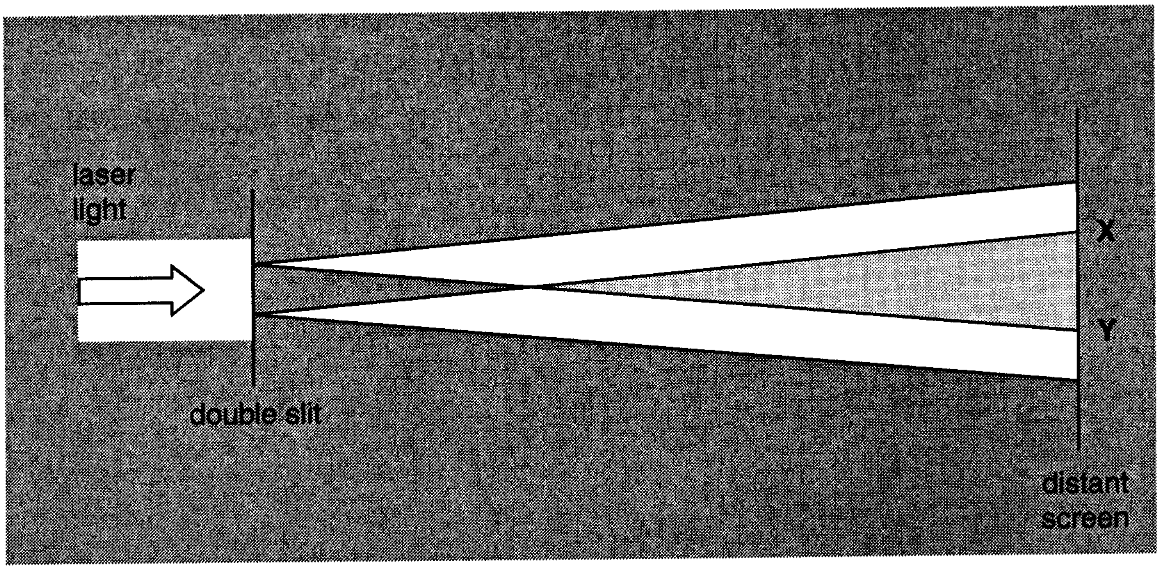

Fig. 3.1

An interference pattern is observed on the distant screen beyond the slits in the region between **X** and **Y**.

(a) In the box below, sketch the pattern of light you would expect to see on the screen between **X** and **Y**.

[2]

(b) The laser is replaced by one emitting light of a **longer** wavelength. Nothing else is changed.

In the box below, sketch the pattern of light you would now expect to see on the screen, using the same scale as the sketch above.

[1]

For Examiner's Use

4 Radiowaves of wavelength $\lambda = 1500\,m$ are all around us. They carry a radio programme into our homes.

(a) Calculate the frequency of a radiowave photon.

$c = 3.0 \times 10^{8}\,m\,s^{-1}$

frequency = ... Hz [2]

(b) High frequency X-rays of frequency $f = 2.4 \times 10^{17}$ Hz are used in hospitals to obtain images of the internal structure of the body.

Calculate the value of the ratio

$$\frac{\text{energy of an X-ray photon}}{\text{energy of a radiowave photon}}.$$

the Planck constant $h = 6.6 \times 10^{-34}\,J\,s$

ratio = ... [2]

[Turn over

For Examiner's Use

5 A gardener is levelling his lawn using a garden roller.

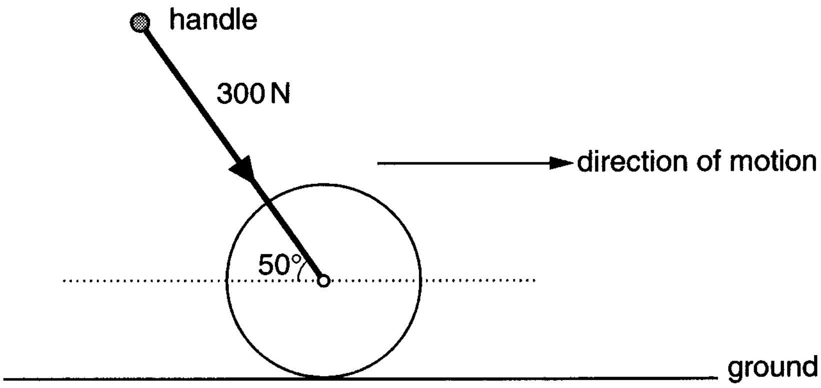

Fig. 5.1

The gardener exerts a force of 300 N through the handle of the roller, as shown in Fig. 5.1.

(a) Show that the horizontal component of the force is about 200 N.

[1]

(b) The gardener pushes the roller with this force at a steady speed of 0.6 m s^{-1} in a straight line, as he rolls a strip of grass.

Calculate the power required.

power = ... W [2]

For Examiner's Use

6 Fig. 6.1 shows the profile of a wave at a particular instant.

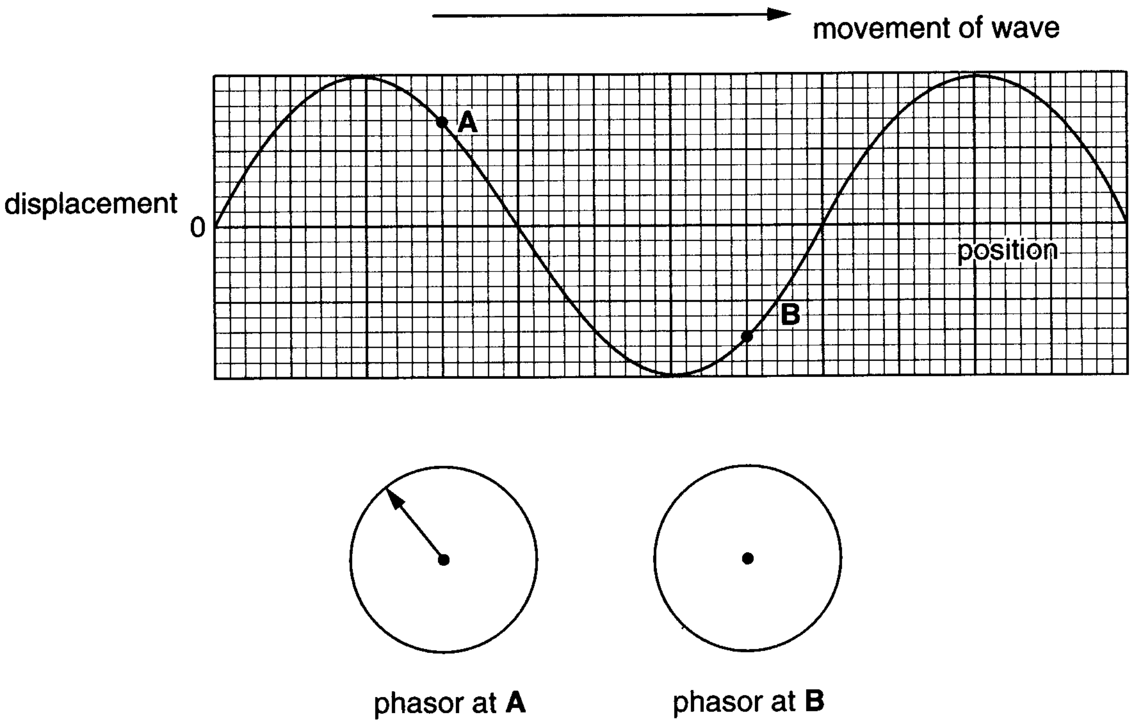

Fig. 6.1

The wave is moving from left to right in the diagram. The phasor arrow corresponding to **point A** on the wave is shown in the circle below the wave profile.

(a) Complete the diagram by drawing in the phasor arrow corresponding to **point B** on the wave. [1]

(b) Draw on the axes of Fig. 6.1 another wave of the same amplitude and wavelength, but which has a 180° (π radian) phase difference with the wave shown. [2]

[Section A Total: 20]

[Turn over

Section B

7 This question is about a camera lens.

The amount of light reflected from the lens of a camera can be reduced considerably by coating the surface with a thin film of transparent material. A lens surface treated in this way is said to be 'bloomed', as shown in Fig. 7.1.

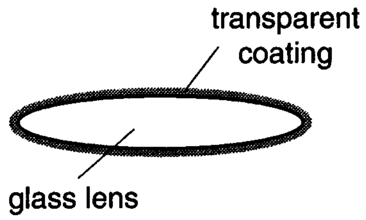

Fig. 7.1

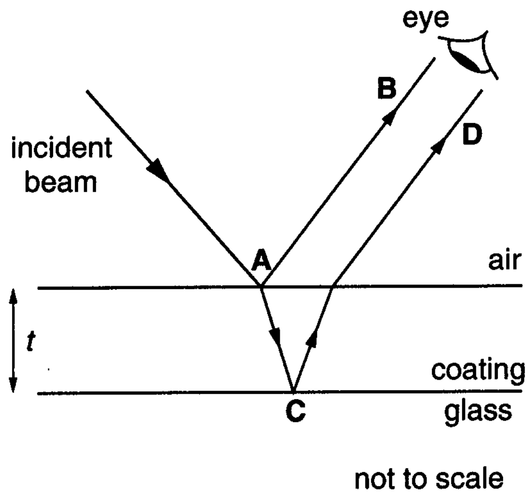

Fig. 7.2

A narrow beam of green light, of a particular wavelength, is incident on the coated surface of the lens, as shown in Fig. 7.2.

The light is partially reflected from this surface along the path **AB**.
Light passing through to the lower surface of the coating is partially reflected at **C**, and emerges along the path **CD**.

(a) The thickness t of the coating is such that the resultant intensity of green light entering the eye is very small, and the lens appears dark.

(i) What must be true about the light reaching the eye along the two paths shown?

[1]

(ii) Explain how the resultant intensity of green light reflected from the transparent coating in this way can be a minimum.

[2]

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(iii) Suggest and explain why the minimum is not necessarily zero.

[2]

(b) When the surface of this bloomed lens is viewed in white light, consisting of many wavelengths, the lens appears purple in colour.

Explain this observation.

[3]

(c) Blooming a lens surface reduces the intensity of reflected light for a wide range of wavelengths.

Suggest and explain **one** effect on the image produced in a camera fitted with a 'bloomed' lens.

[2]

[Total: 10]

For Examiner's Use

8 This question is about a violin.

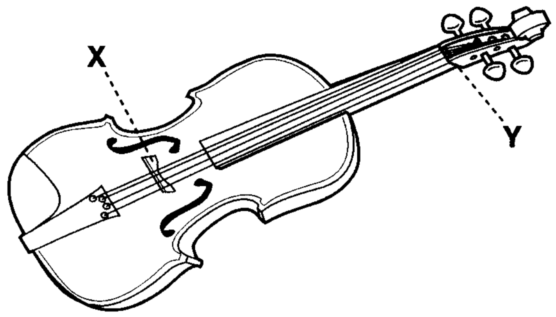


Fig. 8.1

Fig. 8.1 shows a violin with its four strings in place. Each string is in tension between the bridge **X** and the nut **Y**. At **X** and **Y** the movement of the strings is restricted.

(a) Fig. 8.2 shows one of the four strings on the violin.

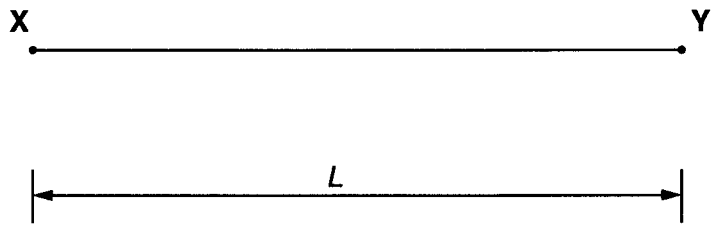


Fig. 8.2

(i) Draw on Fig. 8.2 the lowest frequency standing wave that can be obtained on the string. Label any nodes and antinodes with the letters 'N' and 'A' respectively. [2]

(ii) The length L of the string between **X** and **Y** is 0.40 m.

State the wavelength of the standing wave you have drawn.

wavelength = ...m [1]

(iii) The frequency of the lowest frequency standing wave is 440 Hz.

Calculate the velocity v of the transverse wave on the string.

velocity = ... m s^{-1}. [2]

For Examiner's Use

(b) The velocity v of the transverse wave on the stretched string is given by the expression

$$v = \sqrt{\frac{T}{\mu}}$$

where T is the tension, in N, in the string and μ is the mass per unit length, in kg m^{-1}.

Show that $\sqrt{\frac{T}{\mu}}$ has the units of velocity.

[2]

(c) The frequencies of the fundamental notes produced by each of the four violin strings shown in Fig 8.1 are given by the expression

$$f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}.$$

The frequencies f of the fundamental notes produced are 195 Hz, 293 Hz, 440 Hz and 660 Hz. The violin is designed so that the tension T in each string is the same.

(i) Explain how the frequencies of the notes produced can increase from one string to the next even though the strings are under the same tension.

[2]

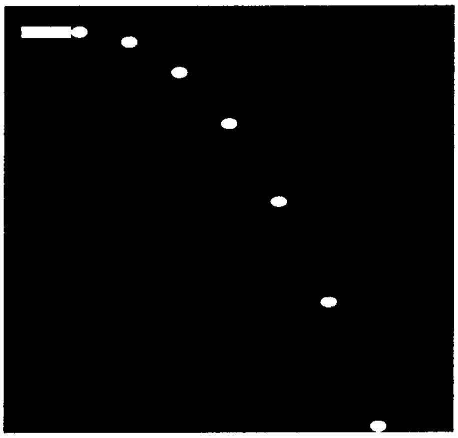
(ii) Suggest a mechanical reason why violins are designed such that each string is at the same tension.

[1]

[Total: 10]

9 This question is about a projectile.

Fig. 9.1 shows a multi-flash picture of the motion of a dried pea fired horizontally from a pea shooter in a classroom.



Multi-flash picture of the motion of a dried pea fired horizontally from a pea shooter

Fig. 9.1

(a) The time interval between successive flashes is constant. At each flash, the new position of the pea is shown on the picture as a bright image on the dark background.

(i) Explain why the horizontal displacement of the pea increases by equal amounts between flashes.

[2]

(ii) Explain why the vertical displacement of the pea increases by increasing amounts between flashes.

[2]

(b)

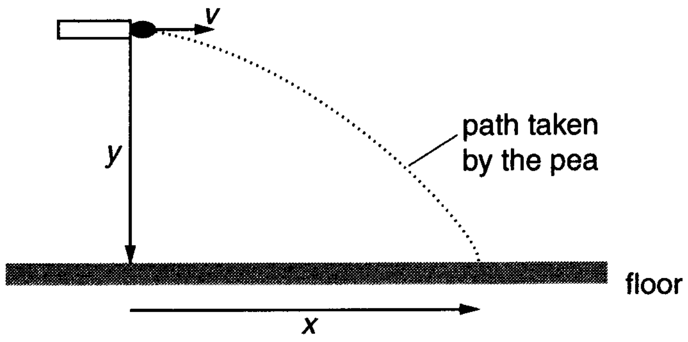


Fig. 9.2

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The pea is fired horizontally at speed v from a vertical distance y above the floor. It strikes the ground a time t later after travelling a horizontal distance x as shown in Fig. 9.2.

The horizontal range x, and the vertical distance fallen y, are given by the equations

$x = vt$ **equation 1** and $y = \frac{1}{2}gt^2$ **equation 2**

where g is the acceleration due to gravity.

(i) Rearrange **equation 1** and obtain an expression for t^2 in terms of x and v.

$t^2 =$ .... [2]

(ii) Rearrange **equation 2** and obtain an expression for t^2 in terms of y and g.

$t^2 =$ ....[1]

(iii) By combining the two expressions for t^2 obtained in **(i)** and **(ii)** above, show that the horizontal speed v of the pea can be calculated from $v^2 = \dfrac{gx^2}{2y}$.

[1]

(c) Calculate the speed v at which a dried pea leaves the pea shooter when it is fired horizontally from a height of 1.5 m above the ground to hit the bottom of a waste bin 4.0 m away.

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

[2]

[Total: 10]

10 This question is about a small radio-controlled aircraft.

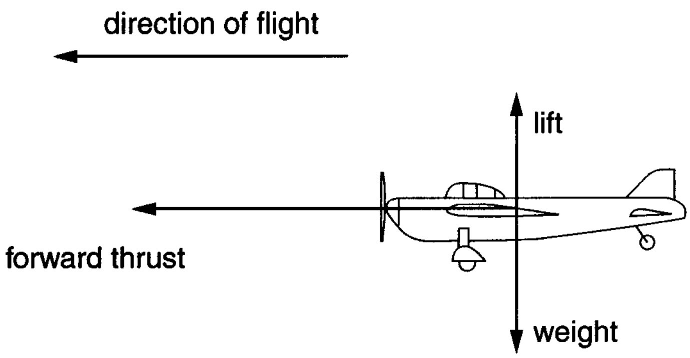

Fig. 10.1

(a) Fig. 10.1 is a diagram of the aircraft in flight through the air. Three forces acting on the aircraft are indicated by the labelled arrows.

(i) Complete the diagram by drawing and labelling an arrow representing another force that must be acting on the aircraft.

[2]

(ii) The aircraft is travelling in level flight at constant velocity.

State, and explain, any relationships that must exist between the forces shown in the diagram.

[3]

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(b) By means of radio control, flaps on the aircraft are adjusted to make the aircraft start to climb with a vertical component of velocity of $4\,\mathrm{m\,s^{-1}}$. The horizontal component of velocity is $10\,\mathrm{m\,s^{-1}}$.

(i) In the space below, draw a vector diagram **to scale** showing the vertical and horizontal velocities of the aircraft.

[1]

(ii) By drawing, or by some other method of your choosing, find

1. the magnitude of the resultant velocity of the aircraft

[2]

2. the angle to the horizontal at which the aircraft climbs.

[2]

[Total: 10]

[Section B Total: 40]

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Section C

In this section of the paper, you choose the context in which you give your answers.

Use diagrams to help your explanations and take particular care with your written English. In this section, four marks are available for the quality of written communication.

11 In this question, you are to write a short account of a method to measure the distance to a remote, or inaccessible, object of interest. In such situations, direct measurement of the distance by ruler or tape measure is impossible.

(a) (i) Describe the distance measurement to be made.

[1]

(ii) Give an estimate of the distance to be measured.

[1]

(b) (i) Draw a diagram to show how the apparatus is to be arranged to make the measurement. Label the important parts of the diagram.

[3]

(ii) Describe how your method works. Make clear the physical principles involved.

[3]

(c) (i) State what data are obtained, and explain how the data can be used to find the distance to the object of interest.

[4]

(ii) State **two** factors that may limit the accuracy achieved in this measurement of distance.

.[2]

[Total: 14]

[Turn over

For Examiner's Use

12 In this question, you are to choose and write about a phenomenon in which quantum behaviour is important.

(a) State the phenomenon you have chosen that can be explained in terms of quantum behaviour.

[1]

(b) Draw a labelled diagram to show how the phenomenon can be observed.

[3]

(c) Describe what could be observed with this apparatus. You may find it helpful to use further diagrams.

[4]

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(d) Explain the observations you have described in **(c)**, in terms of quantum behaviour. Give any relevant equations as part of your explanation.

[4]

[Total: 12]

Quality of Written Communication [4]

[Section C Total: 30]

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