OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary GCE

PHYSICS B (ADVANCING PHYSICS) 2861

Understanding Processes

Friday **6 JUNE 2003** Afternoon 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.
- 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.

[Turn over

For Examiner's Use

Answer **all** the questions.

Section A

1

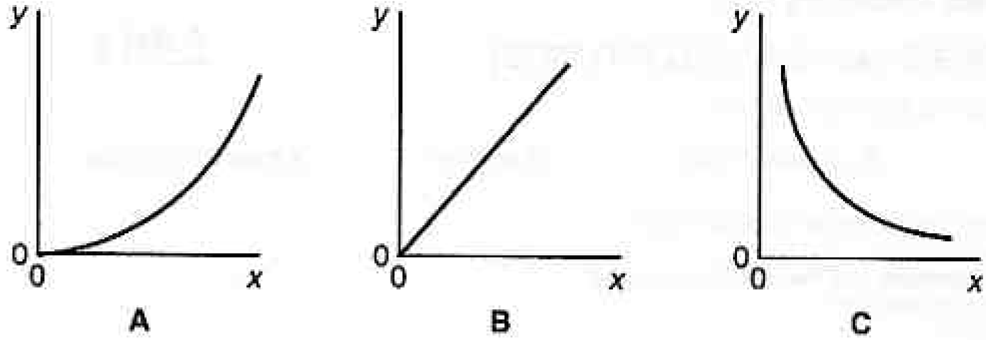


Fig. 1.1

Which graph, **A**, **B** or **C** in Fig. 1.1, is obtained when the y and x axes represent the two quantities given in each case below?

(a) y-axis: the **velocity** of a body moving from rest with constant acceleration

x-axis: **time**

answer .... [1]

(b) y-axis: the **distance** moved from rest by a body falling under gravity

x-axis: **time**

answer .... [1]

(c) y-axis: the **energy** of a photon of electromagnetic radiation

x-axis: the **wavelength** of the radiation

answer: .... [1]

For Examiner's Use

2 Electromagnetic radiation travels at $3.0 \times 10^8\,m\,s^{-1}$ in air and free space.

(a) Calculate the time taken for light to travel from the Sun to the Earth when the distance between them is $1.5 \times 10^{11}\,m$.

time = ... s [2]

(b) When Mars is at its closest distance from Earth, it takes 3 minutes for a pulse of microwave radiation sent from Earth to reach Mars.

Calculate the distance between Earth and Mars in this situation.

distance = ... m [2]

For Examiner's Use

3 Fig. 3.1 shows a ripple travelling across the surface of water in a tank. The ripple travels at speed v.

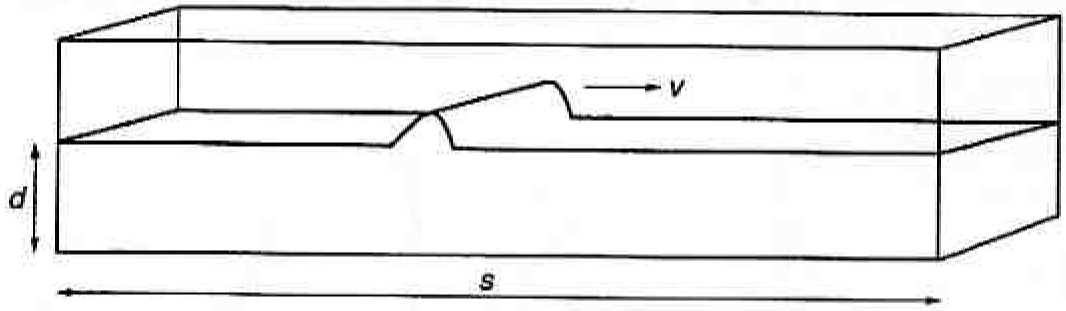


Fig. 3.1

In an experiment the depth d of the water is varied. It is found that v is related to d by the relationship

$$v = \sqrt{kd}$$

where k is a constant.

(a) Use $v = \sqrt{kd}$, with the relationship for v in terms of s and the time t for the pulse to travel down the tank, to show that

$$k = \frac{s^2}{t^2 d}$$

[1]

(b) Show that k has the units of acceleration.

[2]

For Examiner's Use

4 A vertical cylinder rotating in a horizontal stream of air has two perpendicular forces acting on it.

Fig. 4.1 shows the magnitudes and directions of the forces acting on the cylinder.

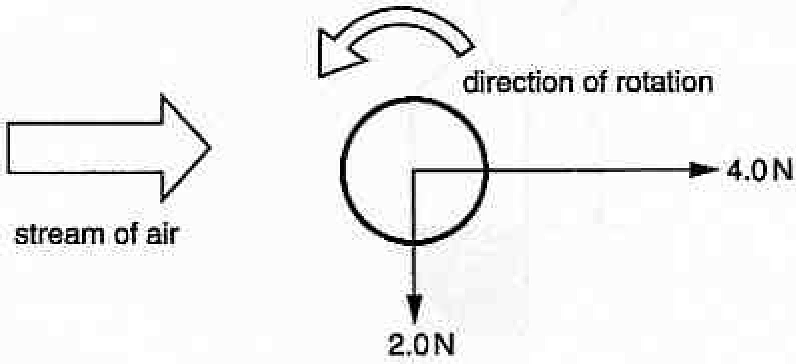


Fig. 4.1

The forces are drawn to the scale: 1 cm represents 1.0 N.

Find by scale drawing, or by some other method,

(a) the magnitude of the resultant force acting on the cylinder

force = ... N [2]

(b) the angle that the resultant force makes with the direction of the air stream.

angle = ... degrees [1]

[Turn over

For Examiner's Use

5 A musical note can be produced by blowing across the top of a wine bottle partially filled with water as shown in Fig. 5.1.

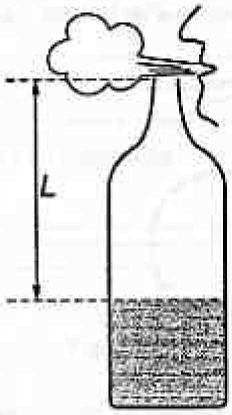


Fig. 5.1

The frequencies f of the notes produced for each of four lengths L of the air column are measured in an experiment. The results are shown below.

L / mm	f / Hz
50	1000
100	340
150	210
200	175

It is suggested that the relationship between f and L is given by the expression

$$f = \frac{k}{L}$$ where k is a constant.

(a) Propose and carry out a test to see whether the data fit the relationship.

test proposed | test carried out

[2]

(b) State your conclusion.

[1]

For Examiner's Use

6 (a) A cyclist riding along a level road maintains a steady speed of $8.0\,m\,s^{-1}$ against resistive forces totalling 30 N.

Calculate the power he must generate.

power = ... W [2]

(b) The cyclist's kinetic energy is 2000 J. He applies his brakes and comes to rest in 14 m.

Calculate the average decelerating force.

force = ... N [2]

[Section A Total: 20]

For Examiner's Use

Section B

7 This question is about waves passing through a slit.

A parallel beam of light passes through a wide rectangular slit as shown in Fig. 7.1.
A bright band is seen on the screen beyond the slit.

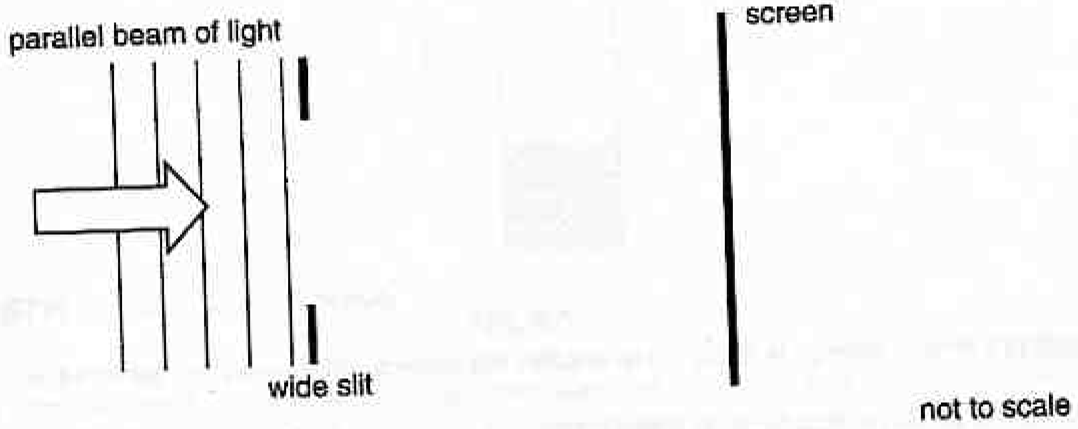


Fig. 7.1

(a) On Fig. 7.1

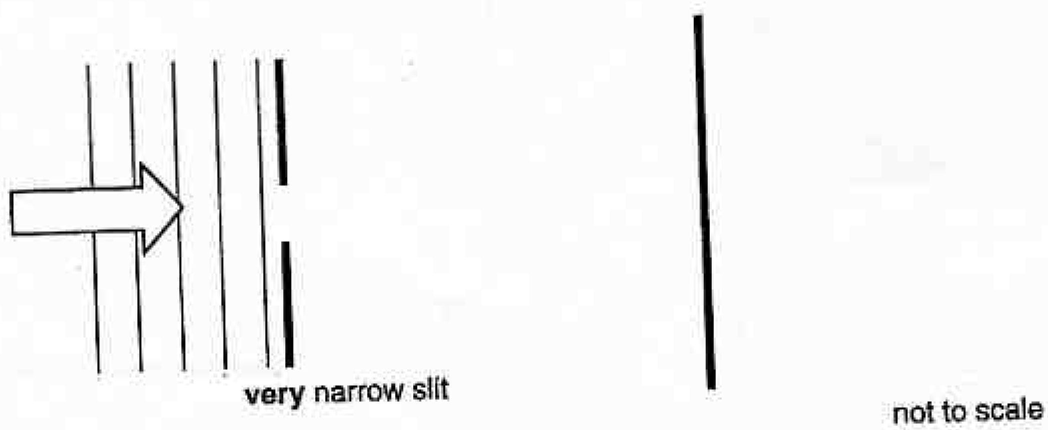
(i) draw crosses on the screen to indicate the edges of the bright band [1]

(ii) draw **three** successive wavefronts in the region between the slit and the screen. [2]

(b) (i) Describe how the appearance of the light on the screen changes as the slit becomes **very** narrow.

[2]

(ii) On Fig. 7.2, draw **three** successive wavefronts as they emerge from the very narrow slit.



[1]

Fig. 7.2

For Examiner's Use

(c) A rock band is playing on the stage inside a large hall. The hall is filled with sound. With the doors closed no sound can be heard in the open air outside.

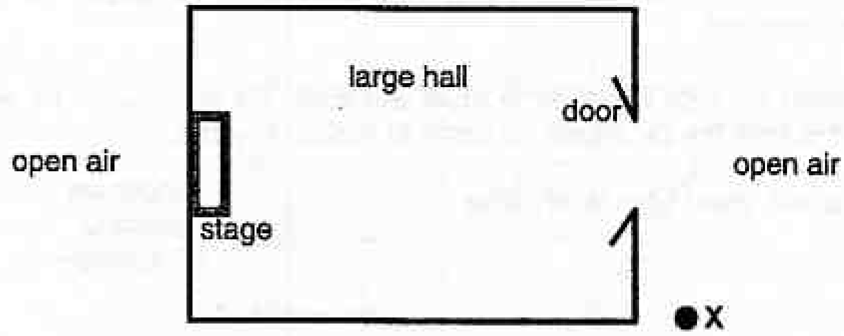


Fig. 7.3

When the doors are open, as shown in Fig. 7.3, a person standing in the open air at **X** can hear the band clearly.

Give **one** reason for this.

[1]

(d) The listener at **X** can hear a bass note at 100 Hz more easily than a treble note at 2000 Hz.

(i) Calculate the wavelengths of these notes.
speed of sound in air = $340\,\text{m}\,\text{s}^{-1}$

bass note	treble note
wavelength = ... m	wavelength = ... m

[2]

(ii) Use your answers to **(d)(i)** to explain why the listener at **X** can hear bass notes more easily than treble notes.
width of door opening = 3.0 m

[2]

[Total: 11]

[Turn over

8 This question is about a simplified model of the braking of a car.

A car of mass 1200 kg is travelling at a constant speed of $20\,m\,s^{-1}$ along a level road. The driver sees a hazard on the road ahead and applies the brakes as quickly as he can, bringing the car safely to a halt.

(a) Assume that it takes 0.5 s for the driver to react and apply the brakes after he sees the hazard. During this time the car travels forwards at constant speed.

Show that the car will travel 10 m in this time.

[1]

(b) Assume that the braking system of the car is designed to produce a constant decelerating force of 7.1×10^3 N.

(i) Show that, when the brakes are applied

1. the deceleration of the car is $5.9\,m\,s^{-2}$

[1]

2. the car travels a further distance of about 34 m.

[2]

(ii) Calculate the total stopping distance of this car travelling at an initial speed of $20\,m\,s^{-1}$.

[1]

For Examiner's Use

(c) Fig. 8.1 shows how the measured stopping distance for this particular car and driver varies with the speed of the car in a road test.

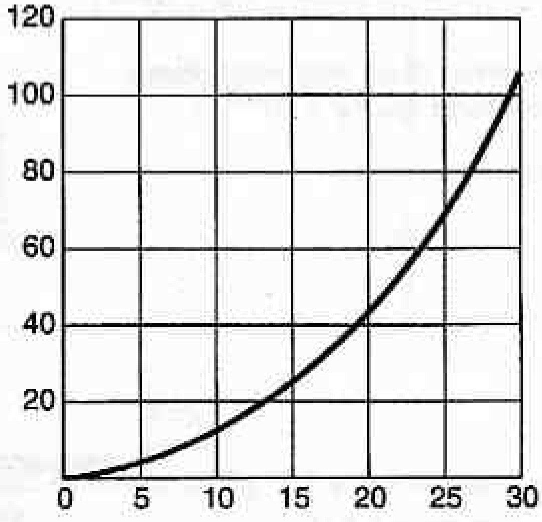


Fig. 8.1

By drawing suitable construction lines on Fig. 8.1

(i) show that for the car travelling at $20\,m\,s^{-1}$ the measured stopping distance agrees with the calculated stopping distance

[1]

(ii) find the measured stopping distance for the car travelling at a speed of $30\,m\,s^{-1}$.

measured stopping distance = ... m [1]

(d) In the road test, the results at low speed seem to be consistent with the simple calculations. But at a higher speed of $30\,m\,s^{-1}$ the calculated stopping distance is only about 91 m.

Suggest and explain **one** reason why the calculation may be oversimplified when applied to the car moving at higher speeds.

[2]

[Total: 9]

[Turn over

For Examiner's Use

9 This question is about photon energies.

(a) A powerful laser emits a single pulse of ultraviolet radiation lasting 5.0×10^{-9} s. The energy of each photon in the beam is 5.6×10^{-19} J.

(i) Calculate the frequency of an ultra violet photon.
the Planck constant $h = 6.6 \times 10^{-34}$ J s

frequency = ... Hz [2]

(ii) The energy in each pulse is 1.8 MJ.

Show that the pulse contains 3.2×10^{24} photons.

[1]

(iii) Calculate the power delivered by the laser pulse. Give a suitable unit for your answer.

power = ... unit .... [3]

For Examiner's Use

(b) A photon of the laser light strikes the clean surface of a sheet of metal. This causes an electron to be emitted from the metal surface.

The minimum energy required to release an electron from this surface is 4.8×10^{-19} J.

(i) Show that the maximum kinetic energy of the emitted electron is 8.0×10^{-20} J.

[1]

(ii) Show that the speed of an electron with this maximum energy is about $4 \times 10^5 \, \mathrm{m\,s^{-1}}$.

mass of electron = 9.1×10^{-31} kg

[2]

(iii) Electrons are quantum objects. The wavelength λ associated with an electron is given by the de Broglie equation

$$\lambda = \frac{h}{mv}$$

where m is the mass of the electron and v is the speed at which the electron is travelling.

Calculate the wavelength associated with the emitted electron.

[1]

[Total: 10]

[Turn over

For Examiner's Use

10 A parallel beam of light of a single wavelength falls on a double slit arrangement. Bright and dark fringes are observed on the screen at different angles θ shown in Fig. 10.1.

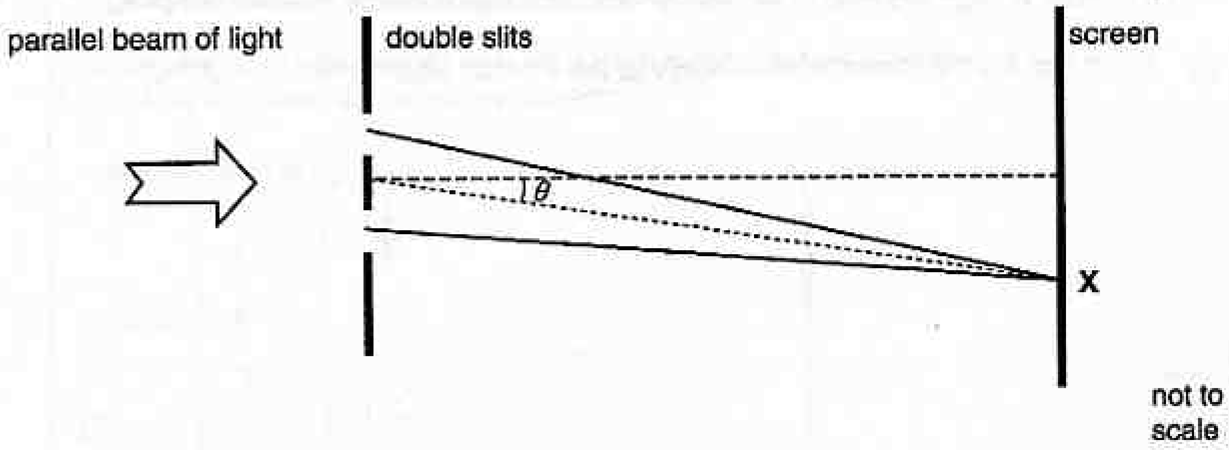


Fig. 10.1

(a) (i) What effect causes the bright and dark fringes?

....[1]

(ii) Describe the condition necessary for a bright fringe to be produced at the place marked **X** on the screen.

[2]

(iii) Explain why there is a dark fringe on either side of the bright fringe.

[2]

For Examiner's Use

(b) Fig. 10.2 shows how the intensity, at different places on the screen, varies with sin θ in a particular experiment.

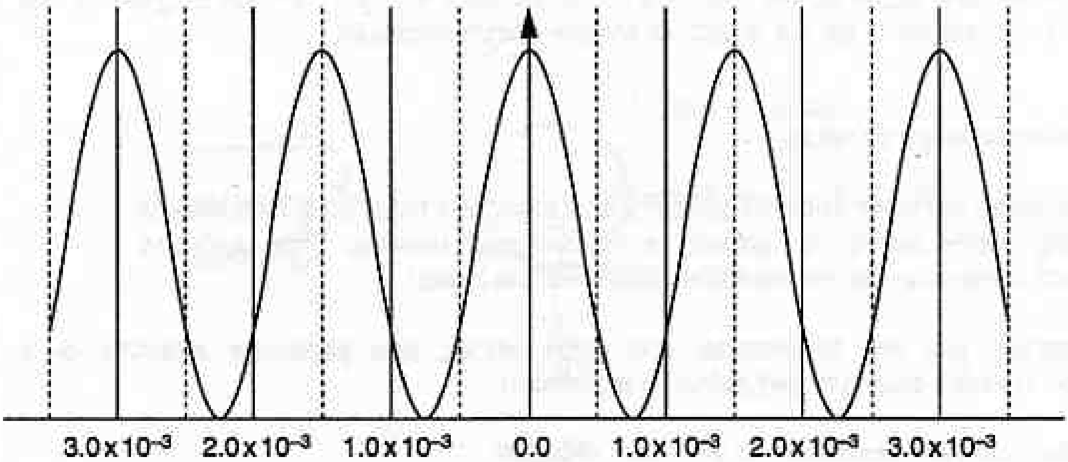


Fig. 10.2

Use the information given to show that the wavelength of the light used is about 600 nm. The separation of the slits is 0.4 mm in this experiment.

[3]

(c) The double slit arrangement is then replaced by a diffraction grating which has slits of the same width and spacing as previously used. Nothing else is altered.

State **two** ways in which the fringes formed by the diffraction grating differ from those formed by the double slits.

[2]

[Total: 10]

[Section B Total: 40]

[Turn over

Section C

In this section, 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. In this section four marks are available for the quality of written communication.

11 Read this short passage carefully.

> "Fundamental particles such as photons and electrons have their own way of behaving, quite unlike the behaviour of everyday objects. This so-called quantum behaviour can be explained using simple rules."

In this question, you are to choose, and write about, one particular example of a phenomenon in which quantum behaviour is significant.

(a) State the quantum phenomenon you have chosen.

[1]

(b) Show, with the aid of a suitably labelled diagram, the arrangement of apparatus that could be used to observe this quantum phenomenon.

[4]

(c) Describe what can be observed.

[4]

(d) Write a detailed explanation of the observations you have described, using your knowledge of the physics of quantum behaviour.

[4]

[Total: 13]

For Examiner's Use

12 In this question, you are to choose and describe a method of producing and observing standing waves.

(a) Draw a labelled diagram to show the equipment needed to produce standing waves in the system of your choice, and how it would be arranged.

[3]

(b) Describe how you could produce standing waves using the equipment you have described.

[3]

For Examiner's Use

(c) Describe what could be observed with this apparatus.

[3]

(d) Explain the observations you have described in terms of the physics of standing waves.

[4]

[Total: 13]

Quality of Written Communication [4]

[Section C Total: 30]