OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE UNIT **2861**

PHYSICS B (ADVANCING PHYSICS)

Understanding Processes

FRIDAY 8 JUNE 2007 Morning

Time: 1 hour 30 minutes

Additional materials:
- Data, Formulae and Relationships Booklet
- Electronic calculator
- Ruler (cm/mm)

Candidate Name

Centre Number

Candidate Number

INSTRUCTIONS TO CANDIDATES

- Write your name, Centre Number and Candidate Number in the boxes above.
- Answer **all** the questions.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Do **not** write in the bar code.
- Do **not** write outside the box bordering each page.
- WRITE YOUR ANSWER TO EACH QUESTION IN THE SPACE PROVIDED. ANSWERS WRITTEN ELSEWHERE WILL NOT BE MARKED.
- Show clearly the working in all calculations and give answers to only a justifiable number of significant figures.

INFORMATION FOR CANDIDATES

- The number of marks for each question is given in brackets [ ] at the end of each question or part question.
- The total number of marks for this paper is 90.
- You are advised to spend about 20 minutes on Section A, 40 minutes on Section B and 30 minutes on Section C.
- 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	**41**	
C	**29**	
Total	**90**	

This document consists of **21** printed pages and **3** blank pages.

Answer **all** the questions.

Section A

1

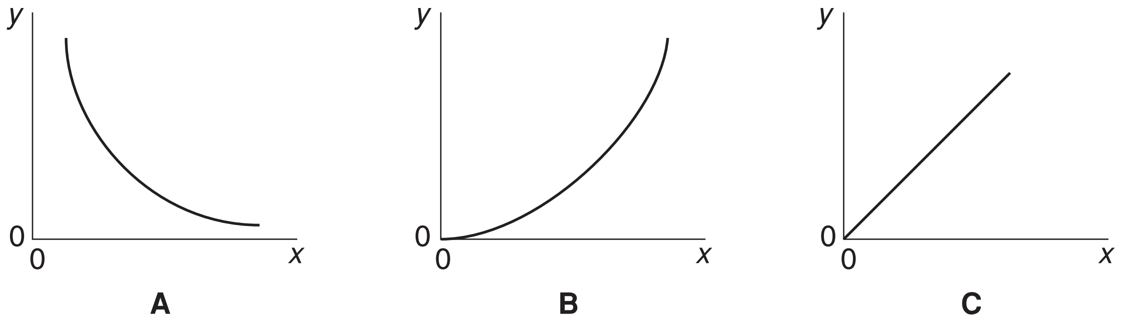


Fig. 1.1

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 **energy** of a photon of electromagnetic radiation

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

answer .... [1]

(b) *y*-axis: the **kinetic energy** of a moving object

x-axis: the **speed** of the object

answer .... [1]

2 Here is a list of four numbers.

5 50 500 5000

Write down the number that is the **best** estimate of

(a) the wavelength of green light, in nanometres

wavelength = ... nm [1]

(b) the speed 1400 $m\ s^{-1}$, converted to kilometres per hour.

speed = ... $km\ h^{-1}$ [1]

3 Arrows have been drawn on two discs **A** and **B**.

The discs are being illuminated in a darkened room by a light that flashes at a fixed frequency.

A and **B** rotate anticlockwise at different constant rates.

(a) During a single flash the discs appear as shown in Fig. 3.1.

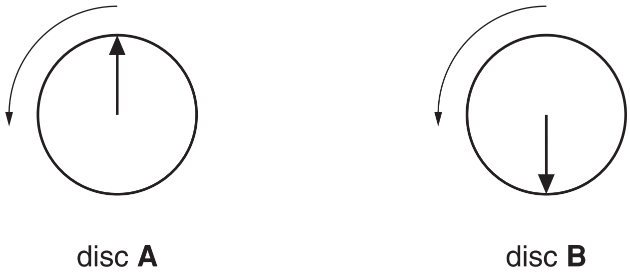


Fig. 3.1

State the phase difference between the arrows shown.

phase difference = ... [1]

(b) In the next flash the discs appear as shown in Fig. 3.2.

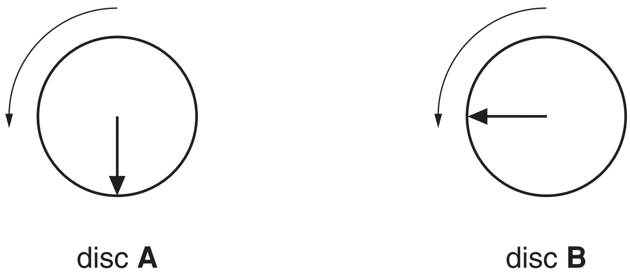


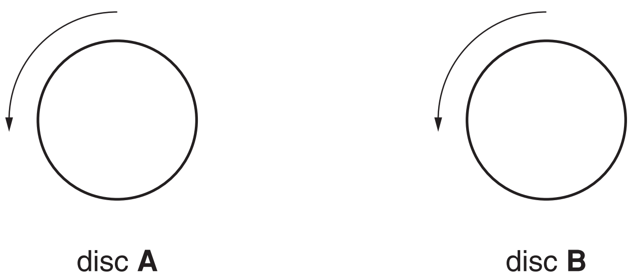
Fig. 3.2

State the phase difference between the arrows now.

phase difference = ... [1]

(c) Neither disc makes a complete rotation between successive flashes of the light.

Complete the diagram below to show the appearance of the discs in the next flash in the sequence.



[1]

4 A large mirror of weight 48 N is suspended in equilibrium from two wires as shown in Fig. 4.1.

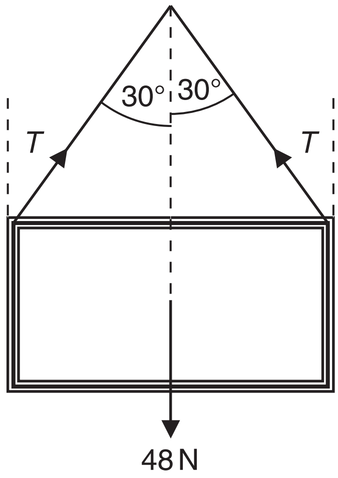


Fig. 4.1

Each wire hangs at an angle of 30° to the vertical as shown. The lines of action of the forces acting on the mirror are shown on the diagram.

To calculate the tension *T* in the wires, a student writes down the following:

For equilibrium	$T\cos 30° + T\cos 30° = 48$	line 1
so	$2T\cos 30° = 48$	line 2
	i.e $T = \dfrac{48}{2\cos 30°}$	line 3

(a) Give a physical justification for the equation in line 1.

[1]

(b) Complete the calculation, starting from line 3, to find the tension *T* in the wires.

T = ... N [1]

(c) Explain why the tension *T* in the wires will be greater if shorter wires are used to hang the mirror.

[1]

5 Wind turbines are designed to harness energy from the wind.

The power generated by a wind turbine varies with the speed of the wind.

The power *P* produced by a turbine is measured at three different wind speeds *v*.

The results are shown below.

P / kW	v / m s^{-1}
600	4.5
2470	7.2
4450	8.8

Theory suggests that the relationship between *P* and *v* is given by the expression:

$$P = k\,v^3 \quad \text{where k is a constant.}$$

(a) Propose and carry out an arithmetical test on these results to see whether they fit the relationship.

test proposed	test carried out

[2]

(b) Conclusion:

[1]

6 A sports car is travelling at a constant speed of $24\,m\,s^{-1}$ along a level road against resistive forces totalling 5.2 kN.

(a) Calculate the power developed by the engine of the sports car.

power = ... W [2]

(b) The kinetic energy of the sports car is 2.8×10^5 J. The driver takes his foot off the accelerator and applies the brakes to bring the car safely to rest in a distance of 40 m.

Calculate the average decelerating force on the car.

force = ... N [2]

7

Fig. 7.1

Two boats **X** and **Y** are travelling towards each other along the centre of a canal in still water. The speeds of the boats are 0.7 m s^{-1} and 1.2 m s^{-1} respectively, as shown in Fig. 7.1.

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

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

(b) The boats are 57 m apart at the instant shown in Fig. 7.1.

Calculate the time before the boats would collide if avoiding action is not taken.

time = ... s [2]

[Section A Total: 20]

Section B

8 This question is about standing waves in air.

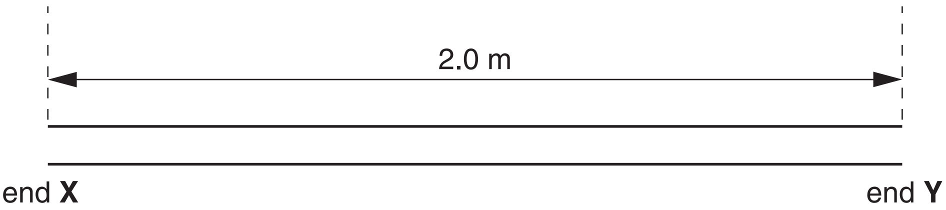


Fig. 8.1

(a) Fig. 8.1 shows a narrow pipe 2.0 m long and open at both ends.

When air is blown across one end of the pipe standing waves can be produced in the pipe and sound produced.

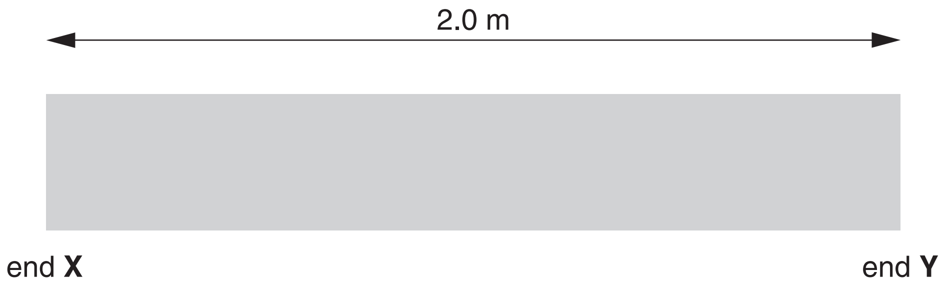


Fig. 8.2

(i) On Fig. 8.2, draw a sketch to represent the **fundamental** standing wave in this narrow pipe. Label the positions of any displacement nodes and antinodes with the letters **N** and **A** respectively.
The shaded area represents the region of space inside the pipe. [2]

(ii) State the wavelength of the fundamental note produced by the pipe.

wavelength = ... m [1]

(iii) The speed of sound in air v in metres per second depends on the temperature of the air θ in °C according to the equation

$v = v_0 + k\theta$ where v_0 is 331 m s^{-1}
and k is 0.61 m s^{-1} °C^{-1}.

Calculate the speed of sound in the pipe when the air inside it is at 10 °C.

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

(iv) Hence calculate the frequency of the fundamental note produced by the pipe at 10 °C.

frequency = ... Hz [2]

(b) The air inside the pipe is heated and the frequency of the fundamental note produced by the pipe is found to have increased by 5%.

(i) Calculate the new fundamental frequency.

frequency = ... Hz [2]

(ii) Calculate the temperature of the air in the pipe.

temperature = ... °C [2]

[Total: 11]

9 **(a)** Electromagnetic radiation of wavelength 9.2×10^{-8} m is incident on a metal surface in a vacuum.

(i) Show that the energy of a photon of this radiation is about 2.2×10^{-18} J.

speed of electromagnetic radiation = 3.0×10^{8} m s^{-1}
the Planck constant $h = 6.6 \times 10^{-34}$ J s

[2]

(ii) When a single photon is absorbed, the energy of the photon can release an electron from the metal. The minimum energy required to release an electron from the metal surface is 4.0×10^{-19} J.

Explain why electrons emerge from the metal with kinetic energies up to a maximum of 1.8×10^{-18} J.

[2]

(iii) Show that the speed of an electron of kinetic energy 1.8×10^{-18} J is 2.0×10^{6} m s^{-1}.

mass of electron = 9.1×10^{-31} kg

[2]

(b) **(i)** 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 an electron travelling at $2.0 \times 10^6\,\mathrm{m\,s^{-1}}$.

wavelength = ... m [2]

(ii) Suggest why a stream of these electrons directed at a thin foil sample in which the interatomic spacing is 4.0×10^{-10} m could produce a diffraction pattern on the far side of the foil.

[2]

[Total: 10]

10 This question is about skydiving.

(a) A skydiver falls from a stationary balloon high above the surface of the Earth.
Air resistance can be neglected at this height since the density of the air is low.

Show that the time taken for the falling skydiver to accelerate to the speed of sound after leaving the balloon is more than 30 s.

speed of sound = 330 m s^{-1}
acceleration due to gravity = 9.8 m s^{-2}

[3]

(b) As the skydiver descends towards the Earth the density of the air increases.

Fig. 10.1 shows how the velocity of the skydiver changes with time as he falls towards Earth, before opening his parachute.

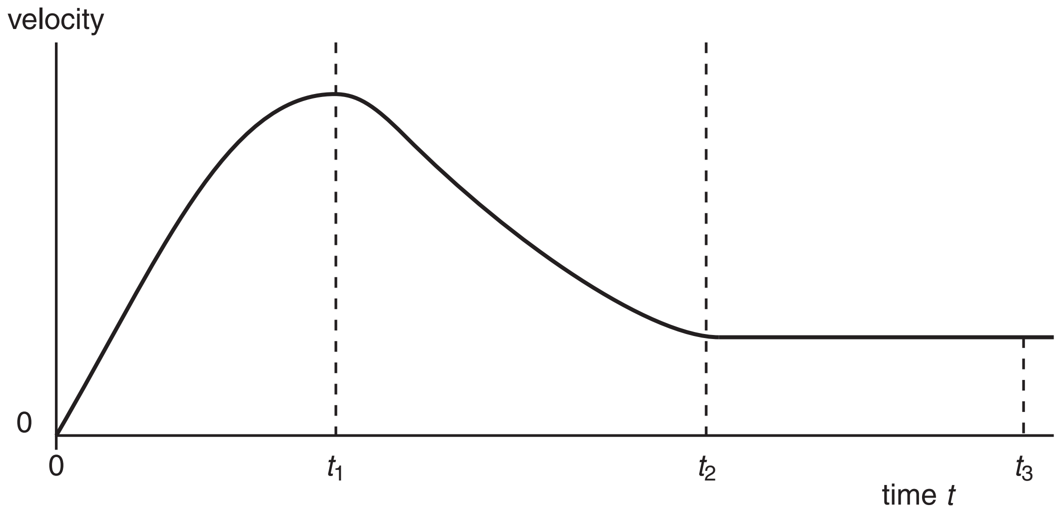


Fig. 10.1

(i) Complete the following statements.

1 The area under a velocity-time graph represents

....

2 The gradient of a velocity-time graph at any time represents

.... [2]

(ii) The graph shows three distinct stages of the skydiver's descent.

Using information from the graph, describe the motion of the skydiver in each of the time intervals shown on the graph.

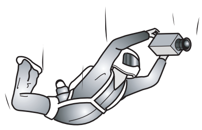
$t = 0$ to $t = t_1$

$t = t_1$ to $t = t_2$

$t = t_2$ to $t = t_3$

[3]

(c) A camera man, in freefall alongside the skydiver, films every moment of the skydiver's descent.



camera man

skydiver

At $t = t_3$ the skydiver finally opens his parachute. The camera man continues in freefall. The film of the event shows the skydiver apparently accelerating upwards.

Explain this observation.

[2]

[Total : 10]

11 This question is about wave behaviour.

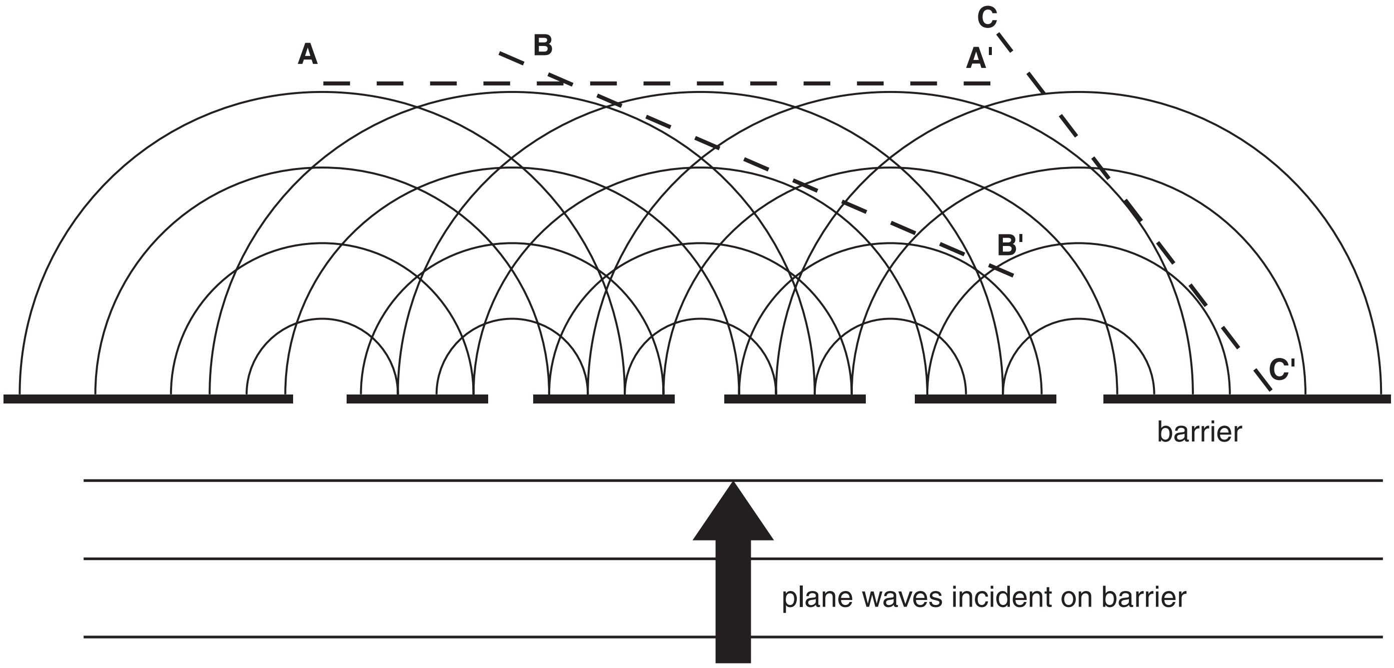


Fig. 11.1

(a) Fig. 11.1 shows what can be observed in a ripple tank when **plane** water waves pass through equally spaced slits in a barrier.

(i) State the physical process that causes waves emerging from the slits to be semi-circular in shape.

.... [1]

(ii) As waves from the different slits pass through each other in the region beyond the slits, wave superposition occurs.

Explain what is meant by *wave superposition*.

[2]

(b) (i) The construction lines **AA'**, **BB'** and **CC'**, drawn on Fig. 11.1, represent plane wavefronts that travel away from the barrier in different directions. Much of the energy from the incident waves goes in these particular directions.

Suggest why the amplitude of the resultant waves along these wavefronts is particularly large.

[1]

(ii) Using a ruler, draw arrows on Fig. 11.1 showing the directions in which each of the wavefronts **AA'**, **BB'** and **CC'** are travelling. [1]

(iii) Wavefronts **BB'** and **CC'** carry energy in directions at angles $\theta_1 = 24°$ and $\theta_2 = 53°$, respectively, to the direction of the incident plane waves.

Show the angles 24° and 53° on Fig. 11.1. Draw any construction lines necessary. [1]

Question continued on next page.

(c) The phenomenon observed with water waves in a ripple tank is a useful way of visualising how an interference pattern is produced when light passes through a grating. Wavefronts similar to **BB'** and **CC'** shown in Fig. 11.1 would carry light energy to the first and second order maxima in the interference pattern.

Light of wavelength 5.0×10^{-7} m is incident on a grating with 800 lines per mm.

Show that the first order and second order maxima in the interference pattern would be produced at angles of 24° and 53° respectively, to the straight through direction.

[4]

[Total: 10]

[Section B Total: 41]

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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 written communication.

12 In this question you are to choose and write about a method of measuring the distance to some remote, inaccessible object. The distance measurement you choose should be one that you can justify as being a useful, or important, one to make.

(a) State the distance measurement you have chosen.

[1]

(b) Explain why you consider this distance measurement to be useful, or important, to make.

[1]

(c) Draw a diagram to show the arrangement of equipment that would be needed to make the measurement. Label the important parts of the diagram.

[4]

(d) Explain how the method works and state what data are collected.

[3]

(e) Show how the distance to the remote object is calculated from the data collected.

[3]

[Total: 12]

13 "Electrons in atoms and the light that those atoms can emit are seemingly quite different. But electrons and photons are both quantum objects and their behaviour can be explained by the same rules of quantum behaviour."

In this question you are to choose and write about a phenomenon that can be explained in terms of quantum behaviour.

(a) State the quantum phenomenon you have chosen to write about.

[1]

(b) Draw a **labelled** diagram of the arrangement of apparatus that could be used to observe the quantum phenomenon.

[4]

(c) Describe what could be observed with this apparatus. Your description may include a diagram.

[4]

(d) Use ideas of quantum physics to explain the observations described in **(c)** above. Use equations where appropriate in your explanation.

[4]

[Total: 13]

Quality of Written Communication [4]

[Section C Total: 29]

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