OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary GCE

PHYSICS B (ADVANCING PHYSICS) 2861

Understanding Processes

Friday **10 JUNE 2005** Morning 1 hour 30 minutes

Candidates answer on the question paper.
Additional materials:
Data, Formulae and Relationships Booklet
Electronic calculator
Ruler (cm/mm)

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 the questions 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 available 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	**42**	
C	**28**	
TOTAL	**90**	

This question paper consists of 20 printed pages.

Section A

Answer **all** the questions.

1

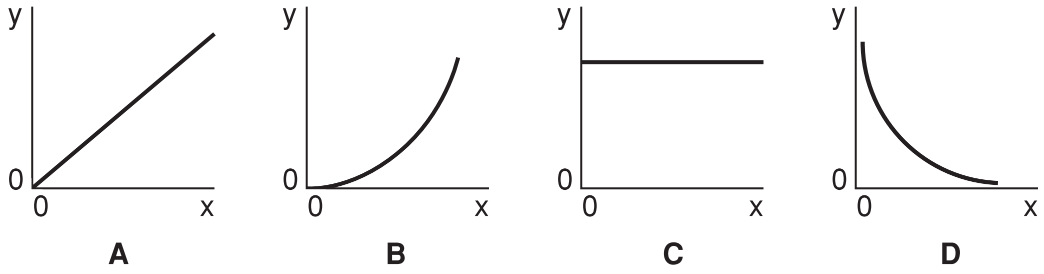


Fig. 1.1

Which graph, **A**, **B**, **C** or **D** 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 **speed** of an electromagnetic wave in air

x-axis: the **wavelength** of the electromagnetic wave

answer ....

(b) y-axis: the **kinetic energy** of a cricket ball

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

answer ....

(c) y-axis: the **time** to run a 100 m race

x-axis: the **average speed** of the runner

answer ....

[3]

2 Interference of light can be demonstrated by shining a coherent beam of yellow light through two narrow slits onto a screen, as shown in Fig. 2.1.

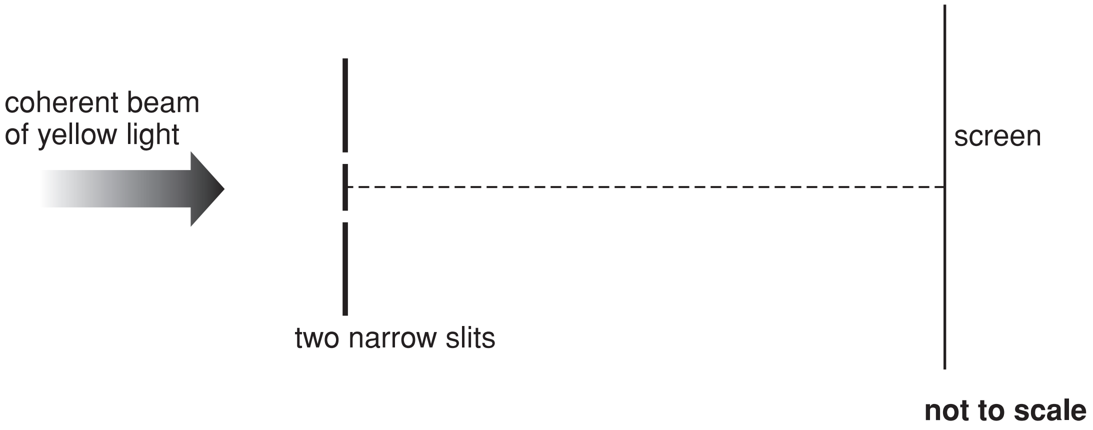


Fig. 2.1

(a) Describe the pattern of light seen on the screen.

[2]

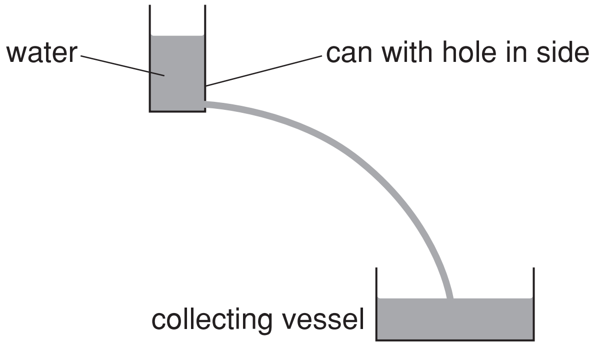
(b) The beam of yellow light is then replaced by a coherent beam of blue light.

Describe how the **pattern** on the screen changes.

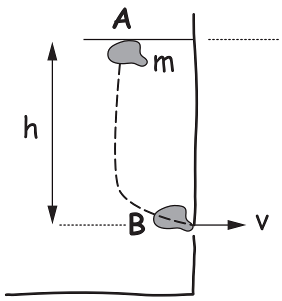
[1]

3 A student is investigating the flow of water from a hole in the side of a can.

The apparatus is shown below.



Here is an extract from the student's notes.



Estimating the speed of water v flowing from the hole.

Imagine a small mass m of water moving down under gravity from near the top of the water at **A** to the hole at **B**. We can write:

$mgh = \frac{1}{2}mv^2$ 1

so $v = \sqrt{2gh}$ 2

(a) State what equation 1 says about energy changes in the system.

[1]

(b) State how equation 2 predicts that the speed of water flowing from the can decreases with time.

[2]

4 Surfers try to ride big waves as they come in towards the shore.

An image has been removed due to third party copyright restrictions

Details:

An image of a beach with some large waves

Fig. 4.1

A surfer waits at point P some distance off shore (Fig. 4.1). Two wave trains A and B travelling towards the beach superimpose to produce a resultant wave.

Rotating phasors for the two waves, A and B, are shown in Fig. 4.2.

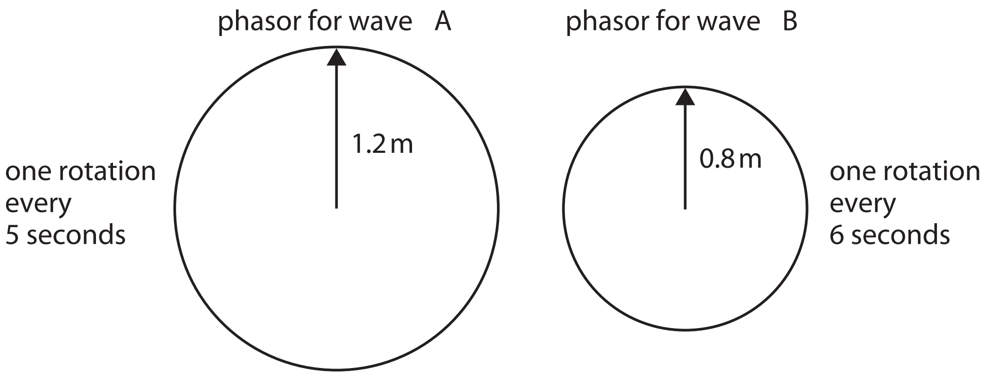


Fig. 4.2

(a) Wave A has an amplitude of 1.2 m while wave B has an amplitude of 0.8 m.

State the maximum and minimum amplitudes of the resultant wave.

maximum amplitude = ………………… m minimum amplitude = ………………… m [2]

(b) Explain why a wave of maximum amplitude travels in towards the shore every 30 seconds.

[2]

[Turn over

5 To cook a boiled egg to perfection is a difficult thing to achieve. The cooking time required depends on the size of the egg.

It is suggested that the cooking time *t* is related to the mass *m* of the egg by the expression:

$$t^3 = k\, m^2$$

where *t* is the cooking time, *m* is the mass of the egg and k is a constant.

(a) The cooking times for three different sized eggs are shown in the table below.

egg	*m* / g	*t* / s
quail	4	50
hen	50	270
ostrich	1640	2760

Propose and carry out a test to check if these data support this relationship.

proposed test	*test carried out*

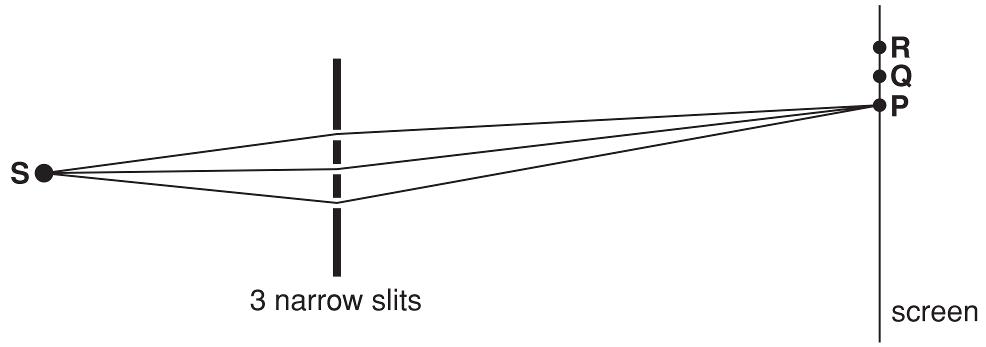
[2]

(b) State your conclusion.

[1]

For Examiner's Use

6 This question is about calculating the probability of photons arriving at different points on a screen.



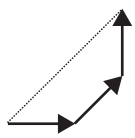
not to scale

Fig. 6.1

Photons travel from a source **S**, through three very narrow slits, to fall on a distant screen, as shown in Fig. 6.1.
The diagram shows three possible paths by which a photon could reach the region around **P**.

The phasors associated with the three paths shown are considered at three different points **P**, **Q** and **R** on the screen. See the table below.

Each phasor is represented by an arrow 1.0 cm long.

position	phasor diagram	resultant phasor amplitude	relative probability of arrival of photon
P		3.0	
Q			5.8
R		1.0	1.0

(a) Complete the table by filling in each blank space with the missing drawing or number. [3]

(b) Sketch below a phasor diagram to show how it is possible for the three phasors to add to give a relative probability of zero.

[1]

[Section A Total: 20]

[Turn over

Section B

7 This question is about a use of light emitting diodes (LEDs).

(a) An array of LEDs used in modern traffic lights emits red light of wavelength 6.5×10^{-7} m.

(i) Show that the energy of a photon of the red light is about 3×10^{-19} J.

$h = 6.6 \times 10^{-34}$ J s
$c = 3.0 \times 10^{8}$ m s^{-1}

[2]

(ii) Each LED emits photons at a rate of 5.0×10^{17} s^{-1}.

Show that the power **output** from the LED in the form of red light is 0.15 W.

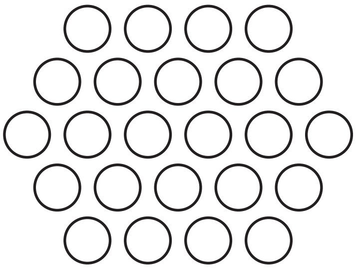
[1]

(iii) Only 79% of the energy supplied to the LED appears in the red light emerging.

Calculate the power **input** required to operate one red LED.

[2]

(iv) The red light in the modern traffic light consists of an array of 105 red LEDs connected in parallel. Part of the array is shown below.



Complete the table below.

number of red LEDs	power input required / W	power output in red light / W
1		0.15
105		

[1]

(b) In a traditional traffic light, red light is produced by placing a tungsten filament lamp behind a red filter. The rating of the lamp is 200 W.

Only 0.5% of the input power to the lamp appears in the red light emerging.

Complete the table below for the tungsten filament lamp in the traditional traffic light.

power input required / W	power output in red light / W
200	

[1]

(c) State **two** advantages of replacing the lamp with the array of LEDs in a traffic light.

first advantage

second advantage

[2]

[Total: 9]

8 This question is about the vibrations of a guitar string.

(a) Fig. 8.1 represents the fundamental vibration for a guitar string, fixed at points **A** and **B**. The length of the string is 0.64 m.

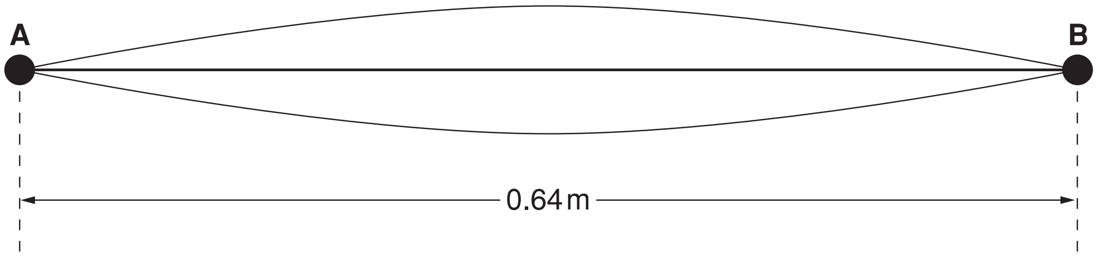


Fig. 8.1

(i) State the wavelength λ of this standing wave.

λ = ... m [1]

(ii) When the string is plucked, a note of frequency 330 Hz is produced.

Calculate the speed v at which waves travel along the string.

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

(iii) Explain why the wave on the string is a **standing** wave.

[3]

For Examiner's Use

(b) A guitarist places a finger on the string at C, one quarter of the way along its length. The string is plucked and the finger removed.
Fig. 8.2 shows how the part of the string AC is vibrating.

Fig. 8.2

(i) Complete the diagram to show how the string vibrates between B and C. [1]

(ii) Calculate the frequency of the note produced now.

frequency = ... Hz [2]

(c) Fig. 8.3 shows a guitar. Metal rods, called frets, are embedded in the neck of the guitar. The frets become closer together towards the bridge as shown.

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Details:

An image of a guitar with the following labels:
End Fret, 1st Fret, 5th Fret and the bridge. The distance between the end fret and the bridge is labelled 'x' and the distance between the 1st fret and the bridge is labelled 17/18x.

Fig. 8.3

Each fret is positioned so that its distance from the bridge is seventeen eighteenths ($\frac{17}{18}$) of the distance from the previous fret to the bridge.

Show that the position of the fifth fret is three quarters of the way along the string from the bridge.

[2]

[Total: 11]

[Turn over

9 This question is about using a gravel bed to stop a runaway lorry.

Fig. 9.1 shows an escape lane positioned on the bend of a steep hill.

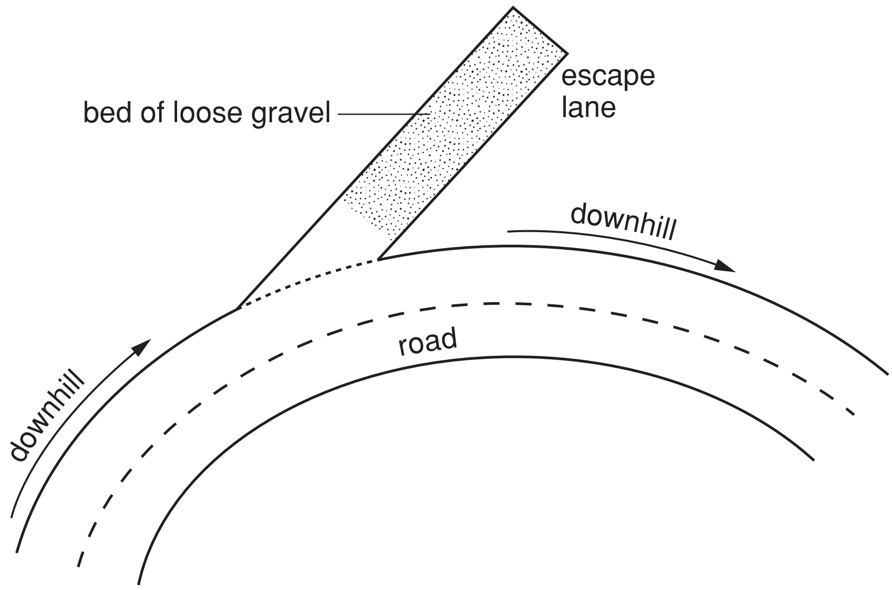

Fig. 9.1

The escape lane provides a safe exit from the hill for any vehicle whose brakes may have failed while descending the hill.

(a) A lorry of mass 8000 kg enters the escape lane at a speed of 20 m s^{-1}.

(i) Show that the kinetic energy of the lorry as it enters the escape lane is 1.6 MJ.

[2]

(ii) The escape lane is horizontal.
The layer of loose gravel provides a resistive force against the wheels of the lorry.
The lorry is brought to rest 50 m along the escape lane.

Show that the average resistive force of the gravel on the lorry is 32 kN.

[2]

(iii) In practice, the resistive force provided by the gravel is unlikely to be constant.

Suggest **one** factor which may cause a change in the resistive force as the lorry decelerates, and explain how this will affect the stopping distance.

[2]

(b) A better design for an escape lane is to give the lane an uphill gradient from its entry point.

(i) By considering the energy changes taking place, explain why a lorry of the same mass and speed as that in **(a)** can now be brought to rest in a shorter distance. Assume the average resistive force from the gravel remains the same.

[2]

(ii) When the lorry of mass 8000 kg enters this escape lane with kinetic energy 1.6 MJ, it rises through a vertical height of 4.5 m before stopping.

Calculate the distance the lorry travels through this gravel bed before stopping. Assume the resistive force remains at 32 kN.

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

distance = ... m [3]

[Total: 11]

10 This question is about a simple model of the physics of the long jump.

A diagram has been removed due to third party copyright restrictions

Details:

A diagram showing three stages of the long jump

Fig. 10.1

Fig. 10.1 shows a long jumper at three different stages, A, B and C, during the jump. The horizontal and vertical components of velocity at each position are shown.

(a) (i) In the model, the horizontal component of velocity v_H is constant at 10 m s^{-1} throughout the jump.

State the assumption that has been made in the model.

[1]

(ii) Without calculation, explain why the vertical component of velocity v_V changes from 3.5 m s^{-1} at A to 0 m s^{-1} at B.

[2]

(b) **(i)** By considering only the **vertical** motion, show that it takes about 0.4 s for the jumper to reach maximum height at **B** after taking off from **A**.

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

[2]

(ii) Hence, calculate the length of the jump.

length of the jump = ...m [2]

(c) Long jumpers can use this model to help them to improve their performance.

Explain why the length of the jump can be increased by

(i) increasing the horizontal component of velocity v_H, keeping v_V the same

[2]

(ii) increasing the vertical component of velocity v_V, keeping v_H the same.

[2]

[Total: 11]

[Section B Total: 42]

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 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]

For Examiner's Use

(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]

12 In this question, you are to choose, and write about, an effect caused by wave superposition.

(a) **(i)** State the nature of the wave being used in your example.

[1]

(ii) Give typical values of the wavelength and speed of these waves.

wavelength = ... unit ....

wave speed = ... unit .... [2]

(b) Draw a suitably labelled diagram to show the arrangement of apparatus, or physical situation, required to produce the effect by wave superposition.

[3]

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(c) Describe **three** features of this situation that could be observed, and explain them using the principle of superposition.

[6]

[Total: 12]

Quality of Written Communication [4]

[Section C Total: 28]

END OF QUESTION PAPER