33144601

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
Advanced Subsidiary GCE

PHYSICS B (ADVANCING PHYSICS)

Understanding Processes

2861

Monday **14 JUNE 2004** Afternoon 1 hour 30 minutes

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

Candidate Name

Centre Number

Candidate Number

TIME 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

- Write your name, Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Write your answers in the spaces provided on the question paper.
  DO NOT ANSWER IN PENCIL. **DO NOT** WRITE IN THE BARCODE. **DO NOT** WRITE IN THE GREY AREAS BETWEEN THE PAGES.
- 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	**41**	
C	**29**	
TOTAL	**90**	

This question paper consists of 20 printed pages.

SP (SLM/SLM) S74622/5.3

[Turn over

Section A

Answer **all** the questions.

For Examiner's Use

1 Here is a list of numbers.

500   5 5×10^{-2} 5×10^{-4}

Select from the list the number which is the best estimate for

(a) the diameter of a hair in **m**

diameter = ...m

(b) the wavelength of visible light in **nm**.

wavelength = ...nm

[2]

2 Photons from a source reach the point **X** on the screen by the two possible paths shown in Fig. 2.1. The resultant phasor amplitude at **X** for these two paths is 3.0.
At another point **Y** on the same screen (Fig. 2.2), the resultant phasor amplitude is 1.5.

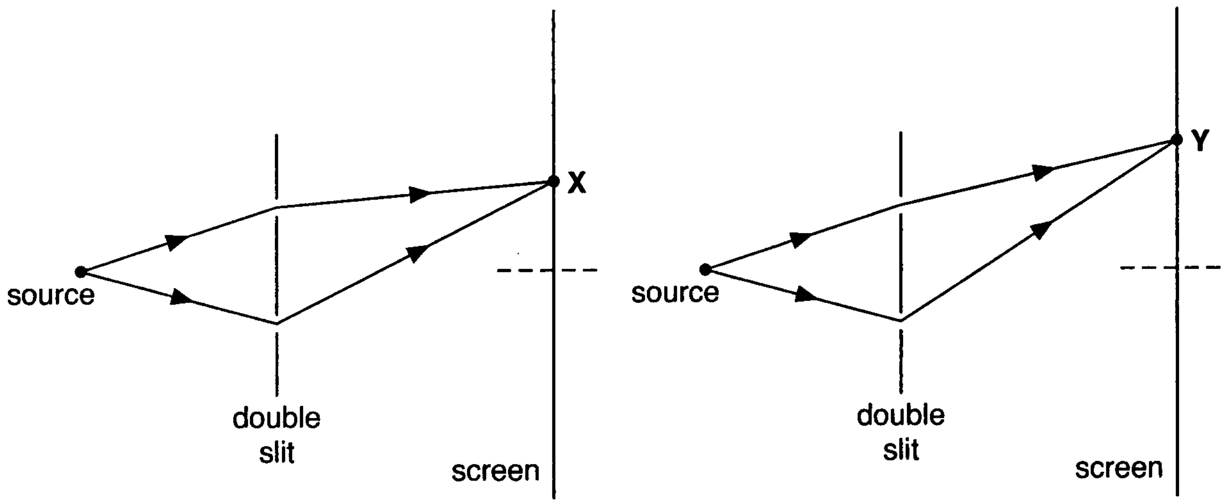


Fig. 2.1   **Fig. 2.2**

Calculate the ratio, $P = \dfrac{\text{probability of photons arriving at point } \mathbf{X}}{\text{probability of photons arriving at point } \mathbf{Y}}$

P = ...[2]

For Examiner's Use

3 A car travels a distance s in a time t with constant acceleration a. In this time, the velocity of the car increases from an initial velocity u to a final velocity v.

The equations below model the motion.

$$s = \frac{(u + v)t}{2} \qquad \textbf{equation 1}$$

$$v = u + at \qquad \textbf{equation 2}$$

(a) Rearrange each of these equations to make t the subject of the equation.

equation 1

$t =$ ....

equation 2

$t =$ .... [2]

(b) Equate the two expressions for t and hence show that

$$v^2 = u^2 + 2as.$$

[1]

4

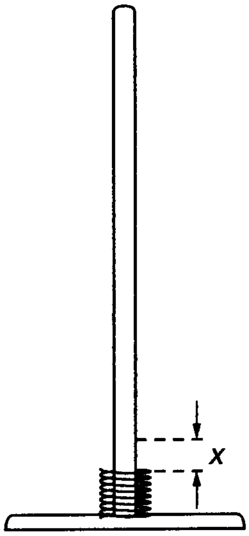


Fig. 4.1(a)

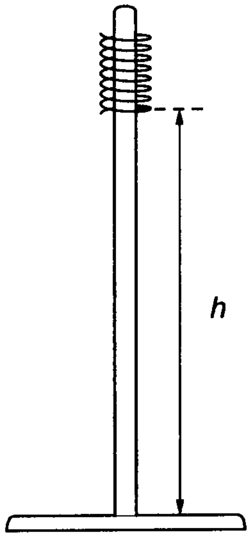


Fig. 4.1(b)

For Examiner's Use

In Fig. 4.1(a), an open-wound spring is compressed a distance x. When released, the spring rises by a height h as shown in Fig. 4.1(b). The maximum possible value of h is given by

$$h = 500x^2.$$

On Fig. 4.2, the point for $x = 0.02$ m is already plotted.

Plot **three** further points and draw the graph to show how h varies with x.

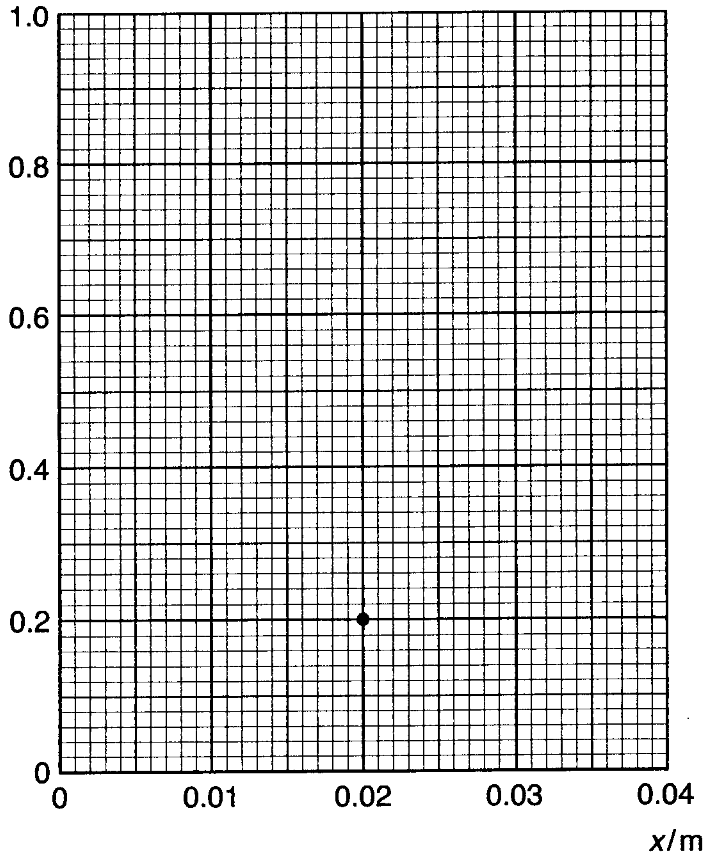


Fig. 4.2

[3]

For Examiner's Use

5 A metal surface is illuminated with light. An electron in the metal surface requires a minimum amount of energy to escape from the surface.

The frequency of the light is changed and the maximum kinetic energy of the electrons emitted is measured for each frequency.

Fig. 5.1 shows a graph drawn using the measurements.

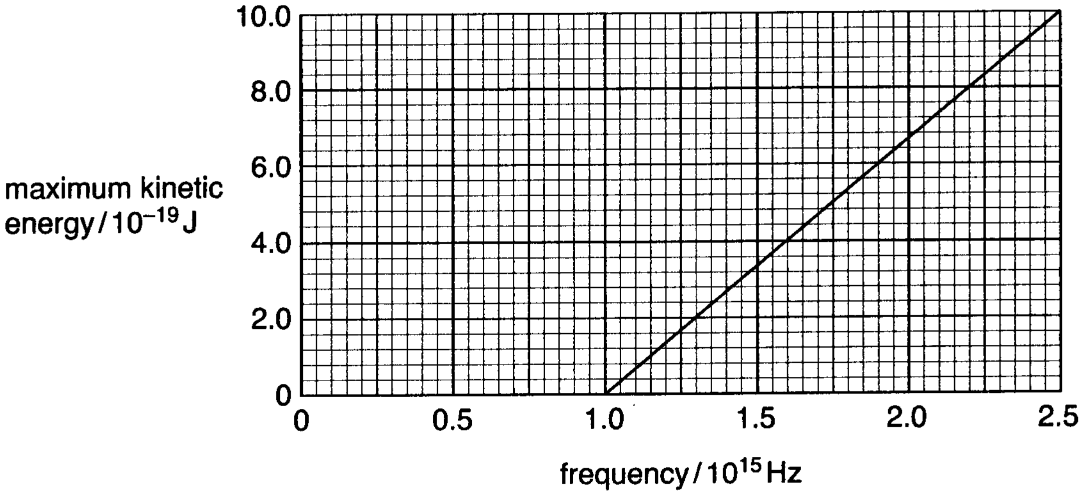


Fig. 5.1

(a) Use the graph to determine the **minimum** frequency of light required for an electron to escape from the metal surface.

frequency = ... Hz [1]

(b) Explain how the graph suggests that a minimum amount of **energy** is required for an electron to escape from the metal.

[2]

(c) Calculate the gradient of the graph.

gradient = ... J s [1]

6 Fig. 6.1 shows the distance–time graph for an underground train travelling between two stations.

For Examiner's Use

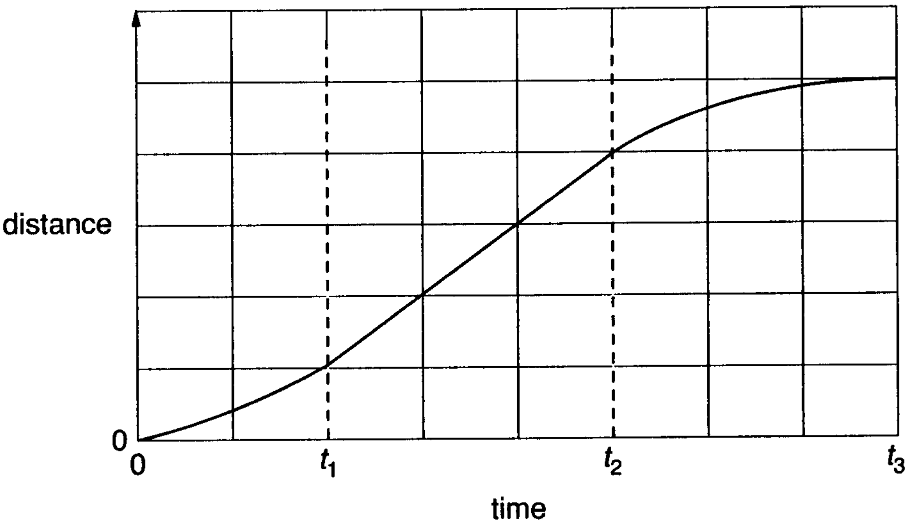


Fig. 6.1

On Fig. 6.2, sketch a graph to show how the **speed** of the train varies with time t during the journey.
The train starts from rest at $t = 0$.

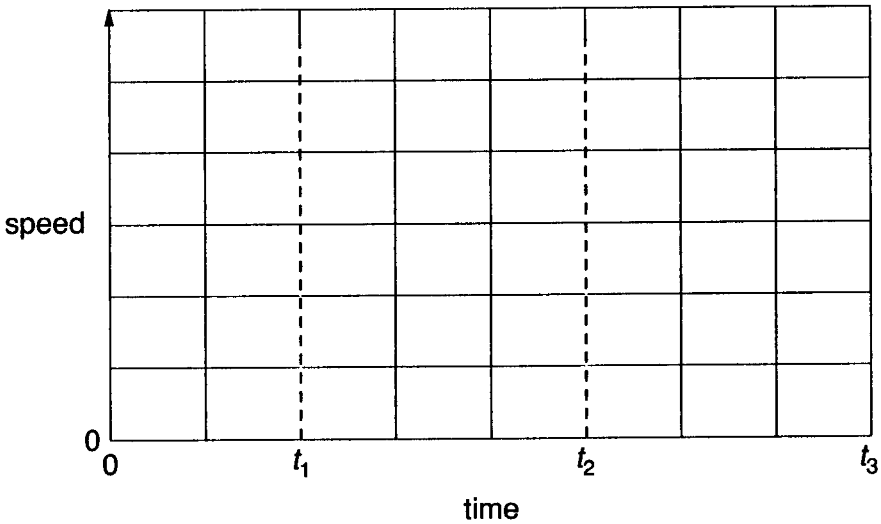


Fig. 6.2

[3]

7 Fig. 7.1 shows a graph of two oscillations **A** and **B**.

For Examiner's Use

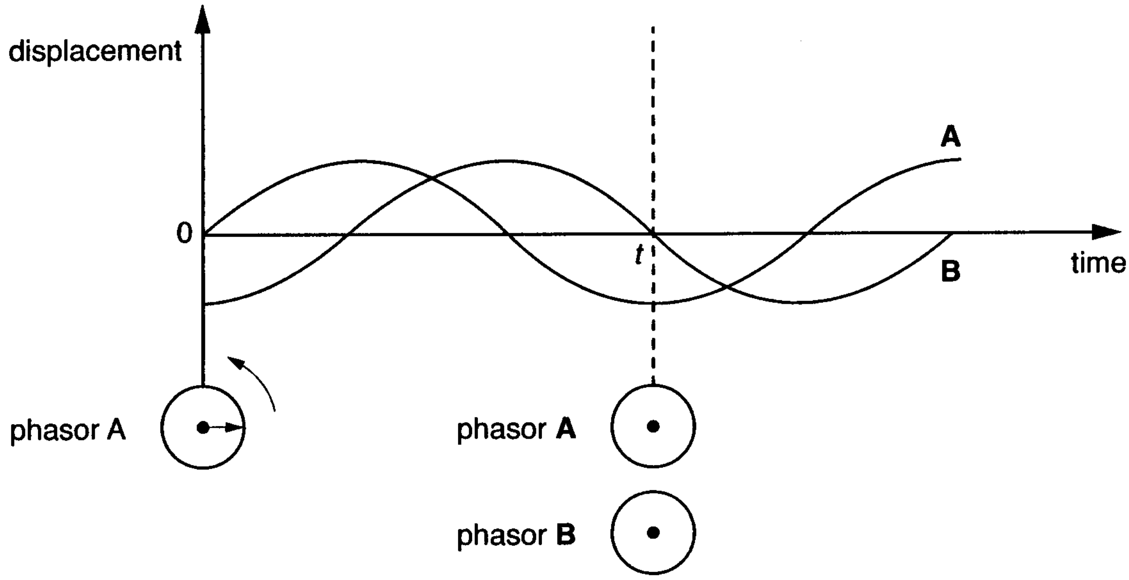


Fig. 7.1

(a) State the phase difference between the two oscillations **A** and **B**.

phase difference = ...[1]

(b) Draw, in the circles provided on Fig. 7.1, phasors to represent **A** and **B** at time *t*. Assume that the phasors rotate in an anticlockwise direction. [2]

[Section A Total: 20]

Section B

For Examiner's Use

8 This question is about an investigation of standing waves in a pipe.

(a) Sound waves are sent into a long pipe containing water, from a loudspeaker positioned above the pipe. The waves are reflected by the water surface. The water level is lowered until a standing wave is set up in the air in the pipe (Fig. 8.1). A loud note is heard. The water level is then lowered further until a loud sound is again obtained from the air in the pipe (Fig. 8.2).

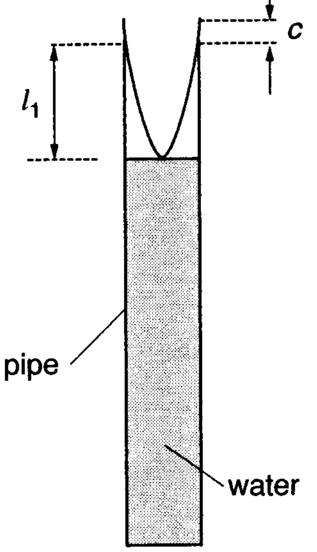


Fig. 8.1

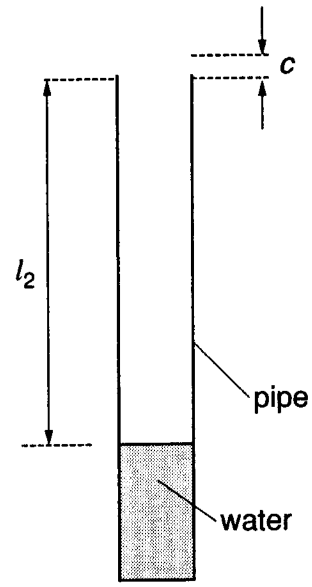


Fig. 8.2

The air at the open end of the pipe is free to move and this means that the displacement antinode of the standing wave is actually a small distance *c* beyond the open end. This distance is called the end correction.

A student writes down the following equations relating to the two situations shown.

$$l_1 + c = \frac{\lambda}{4} \qquad l_2 + c = \frac{3\lambda}{4}$$

(i) Draw the standing wave in the pipe shown in Fig. 8.2 which corresponds to the equation $l_2 + c = \frac{3\lambda}{4}$.

On your diagram, label the positions of any displacement nodes and antinodes with the letters **N** and **A** respectively. [2]

(ii) Use the two equations to show that $l_2 - l_1 = \frac{\lambda}{2}$.

[1]

For Examiner's Use

(iii) The following results were recorded in this experiment.

frequency of sound = 500 Hz l_1 = 0.170 m l_2 = 0.506 m

Calculate

1. the wavelength λ of the sound wave

λ = ...m [2]

2. the speed of sound v in the pipe.

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

(b) The student repeats the experiment, but sets the frequency of the sound from the speaker at 5000 Hz.

Suggest and explain why these results are likely to give a far less accurate value for the speed of sound v than those obtained in the first experiment.

[3]

[Total: 10]

For Examiner's Use

9 This question is about an orange light-emitting diode (LED).

Light emerging from the orange LED passes through a diffraction grating and the pattern of coloured dots, shown in Fig. 9.1, is produced on a screen beyond the grating.
Fig. 9.2 shows the intensity distribution in the pattern.

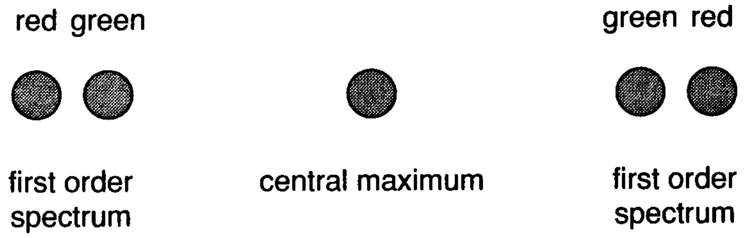


Fig. 9.1

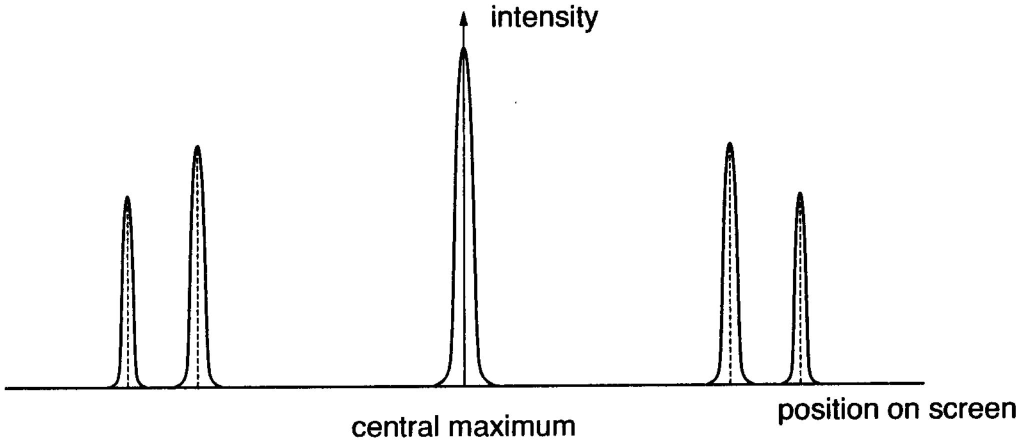


Fig. 9.2

(a) **(i)** State **two** ways in which the central maximum differs in **appearance** from the first order spectrum either side of the central maximum.

[2]

(ii) What does the presence of just two dots, green and red, in the first order spectrum, tell you about the light waves coming from the LED?

[1]

For Examiner's Use

(iii) Explain why the green dots are closer than the red dots to the central maximum of the diffraction pattern.

[2]

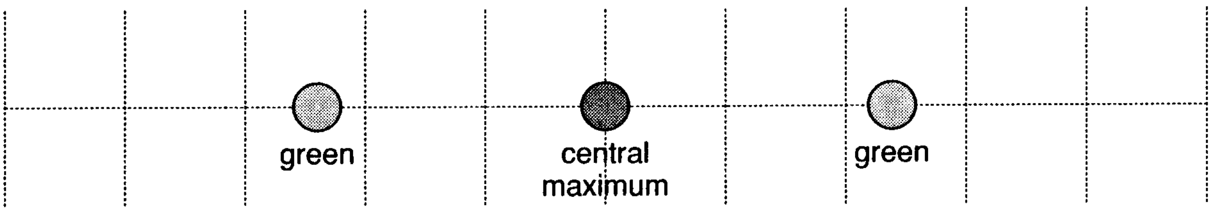
(iv) Give **one** reason why the intensity of the central maximum is greater than the intensity of either the green or red dots in the first order spectrum.

[1]

(b) The diffraction grating is removed and replaced by another with **twice** the number of lines per mm.

(i) In Fig. 9.3, the positions of the central maximum and the green dots in the first order spectrum of the **original** pattern are shown.

Draw on this diagram the positions of the green dots in the first order spectrum produced by the grating with twice the number of lines per mm.



[2]

Fig. 9.3

(ii) Explain your reasoning.

[2]

[Total: 10]

For Examiner's Use

10 This question is about the mathematical modelling of a golf shot.

(a) A golf professional demonstrates how to play an approach shot to a green. When struck, the golf ball follows the path shown from **W**, reaching its greatest vertical height *h* at **X**, and pitches onto the front of the green at **Y** as shown in Fig. 10.1.

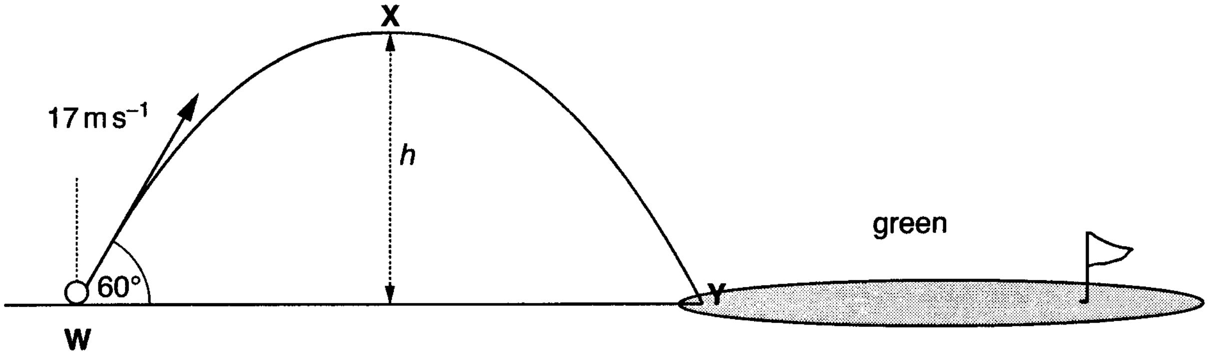


Fig. 10.1

(i) The ball leaves the ground at 17 m s^{-1} at an angle of 60° to the horizontal.

Show that the initial vertical component of velocity v_y of the ball is 14.7 m s^{-1}.

[1]

(ii) At the highest point **X**, the vertical component of velocity $v_y = 0$.

Explain why the vertical component of velocity has changed.

[1]

(iii) The ball takes 1.5 s to reach its maximum height.

Calculate the maximum vertical height *h* reached by this ball.
$g = 9.8$ m s^{-2}

h = ... m [3]

For Examiner's Use

(b) The golf professional plays a second shot from the same position **W** using a different golf club. Again the ball pitches onto the front of the green at the same point **Y**, but the path through the air followed by this ball is quite different, as shown in Fig. 10.2.

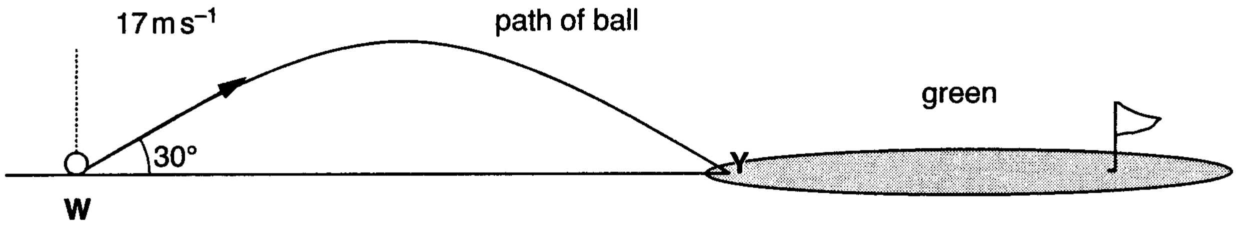


Fig. 10.2

This ball leaves the ground at 17 m s^{-1} as in the first shot, but at an angle of only 30° to the horizontal.

(i) State and explain how the time of flight for this ball travelling from **W** to **Y** compares with that of the first ball.

[2]

(ii) Explain why the horizontal range **WY** can be the same for each shot even though the times of flight are different.

[2]

(iii) Suggest and explain which of the two balls might be expected to travel further across the green after pitching onto it at **Y**.

[2]

[Total: 11]

11 This question is about **relative** and **resultant** velocities.

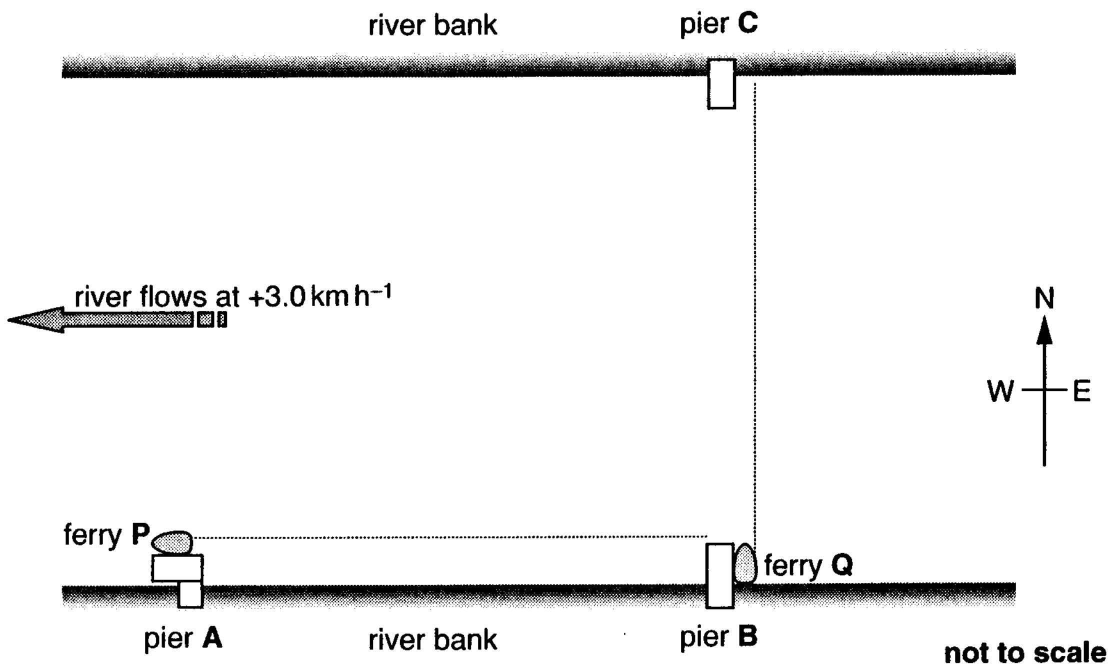


Fig. 11.1

Fig. 11.1 shows part of a wide river on which there are three piers. The river flows from east to west at a constant velocity of +3.0 km h^{-1} as shown.

(a) Ferry **P** travels from pier **A** to pier **B**, and then back again. The ferry travels at a speed of 5.0 km h^{-1} through still water.

(i) Calculate the **velocity** of the ferry relative to the river bank as it sails

1. from **A** to **B**

velocity = ... km h^{-1}

2. from **B** to **A**.

velocity = ... km h^{-1} [2]

(ii) Piers **A** and **B** are 2.0 km apart.

Show that the total sailing time for a return journey for ferry **P**, sailing from pier **A** to **B** and back again to **A**, is 1.25 hours.
Ignore the time taken for the boat to turn around at pier **B**.

[2]

For Examiner's Use

(b) There is another pier **C** directly across the river from pier B, as shown in Fig. 11.1.

A second ferry **Q** travels between piers **B** and **C** which are 2.0 km apart. This ferry also travels at a speed of 5.0 km h^{-1} through still water.

(i) By scale drawing, or some other method of your choosing, show that ferry **Q** must sail in a direction 37 degrees east of north in order to travel due north across the river, from pier **B** to pier **C**.

[2]

(ii) Show that the resultant velocity of this ferry relative to the river bank is 4.0 km h^{-1} due north.

[2]

(c) Ferry **Q** sets off from pier **B** on an outward bound journey to **C** at the **same time** as ferry **P** sets off from pier **A** towards pier **B**.

Show that the bearing of ferry **Q** from ferry **P** is about 27 degrees east of north, when **Q** just reaches pier **C**.

[2]

[Total: 10]

[Section B Total: 41]

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

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

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

[1]

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

[3]

For Examiner's Use

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

[4]

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

[4]

[Total: 12]

For Examiner's Use

13 In this question, you are to choose, and write about, **one** particular example of wave superposition.

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

[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 physical situation required to produce the superposition effect.

[3]

For Examiner's Use

(c) State how the effect could be produced.

[1]

(d) Describe **three** observations that could be made, and explain these observations using the principles of superposition.

[6]

[Total: 13]

Quality of Written Communication [4]

[Section C Total: 29]

END OF QUESTION PAPER