RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE **2861**

PHYSICS B (ADVANCING PHYSICS)

Understanding Processes

THURSDAY 22 MAY 2008

Afternoon
Time: 1 hour 30 minutes

Candidates answer on the question paper
Additional materials (enclosed): None

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

CUP/T43053

Candidate Forename | Candidate Surname

Centre Number | Candidate Number

INSTRUCTIONS TO CANDIDATES

- Write your name, Centre Number and Candidate Number in the boxes above.
- 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.
- Answer **all** the questions.
- Do **not** write in the bar code.
- Write your answer to each question in the space provided.
- 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	22	
B	40	
C	28	
Total	90	

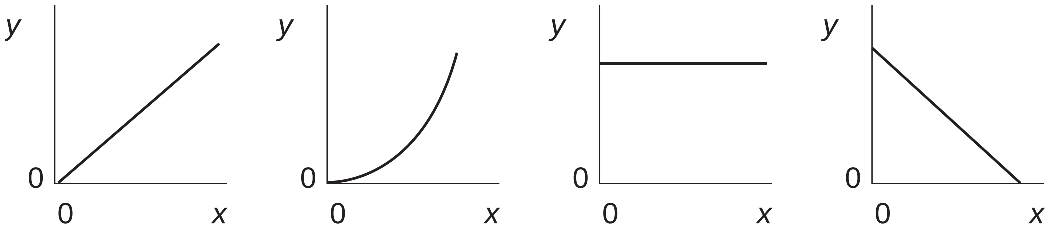
This document consists of **24** printed pages.

Answer **all** the questions.

Section A

1 A moving car can be brought to rest by the application of a constant decelerating force ***F***.

Fig. 1.1 shows four graphs that relate to the motion of the car.



A **B** **C** **D**

Fig. 1.1

Which graph, **A**, **B**, **C** or **D** in Fig. 1.1, best shows the relationship between the two quantities given in each case below, as the constant force ***F*** is applied?

(a) y-axis: the **speed** of the car

x-axis: the **time**

answer .... [1]

(b) y-axis: the **stopping distance** of the car

x-axis: the **initial kinetic energy** of the car

answer .... [1]

(c) y-axis: the instantaneous **kinetic energy** of the car

x-axis: the **distance** travelled by the car

answer .... [1]

2 **(a)** A diffraction grating is labelled 300 lines mm^{-1}.

Show that the spacing d between the lines on the grating is 3.3×10^{-6} m.

[1]

(b) Interference of light can be demonstrated by shining a beam of laser light through the diffraction grating as shown in Fig. 2.1. An interference pattern is produced on the screen.

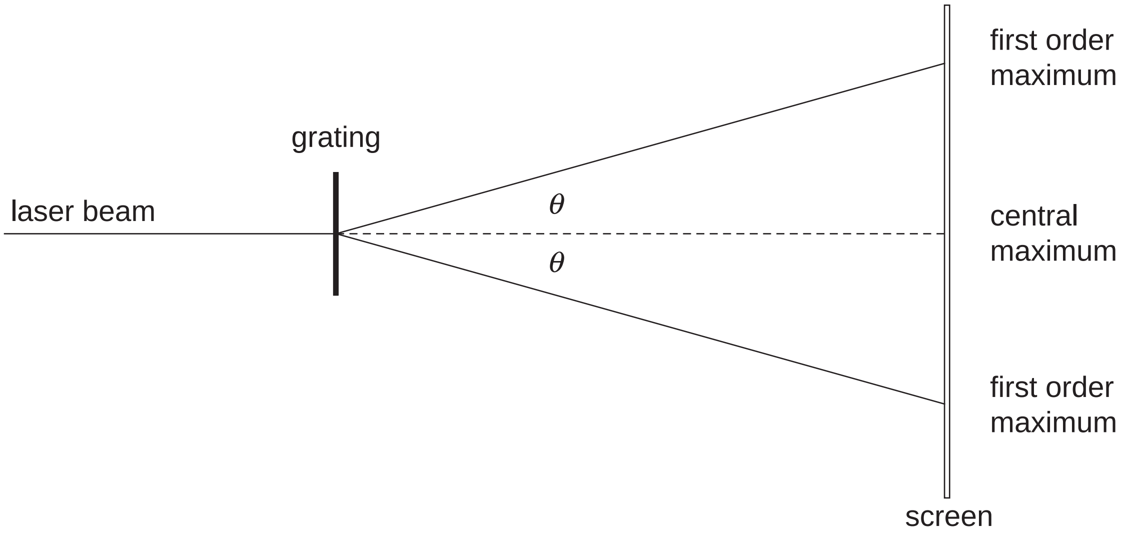


Fig. 2.1

The first order maximum in the interference pattern is observed where angle $\theta = 11^{o}$.

Calculate the wavelength λ of the light.

λ = ...m [2]

3 In 1966 John Stapp became the fastest man on Earth.
He was propelled along a track on a vehicle that reached a top speed of 1011 km h^{-1}.

(a) Show that the vehicle travels almost 300 m in 1 second at this speed.
Show your working.

[2]

(b) The vehicle was brought to rest from top speed in 1.4 s.

Show that the average deceleration was about 20*g*.
acceleration due to gravity g = 9.8 m s^{-2}

[2]

4 A swimming duck leaves a series of transverse waves in its wake as shown in Fig. 4.1.

© iStockphoto.com / Kaare Linderoth

Fig. 4.1

It is suggested that the wavelength λ of the waves produced by the duck is related to the speed v at which the duck swims through the water by the expression:

$$\lambda = k\,v^2 \quad \text{where } k \text{ is a constant.}$$

Some measurements are shown in the table.

λ / *m*	v / m s^{-1}
0.06	0.10
0.23	0.20
0.53	0.30

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

test proposed	test carried out

[2]

(b) State your conclusion.

[1]

5 Photon energies for different colours of visible light are shown in the table.

colour	photon energy/10^{-19} J
red	3.1
green	
blue	4.4

(a) The wavelength of the green light is 550 nm.

Complete the table by calculating the photon energy for green light.

$h = 6.6 \times 10^{-34}$ J s
$c = 3.0 \times 10^{8}$ m s^{-1}
1 nm = 10^{-9} m

Show your working in the space below.

[2]

(b)

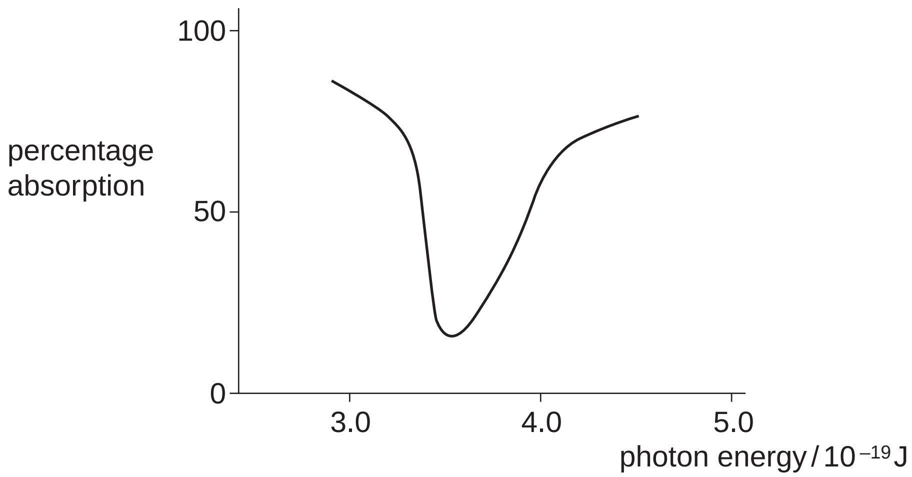


Fig. 5.1

The graph (Fig. 5.1) shows the relative amount of light absorbed by a leaf for different photon energies.

Use the graph and table to explain why the leaf appears green in **white** light.

[2]

6 Here is a list of quantities you may know about a moving object:

A its velocity

B its mass

C its acceleration

D the resultant force acting on it.

(a) Select from the list the quantity that is equal to the rate of change of one of the others.

answer .... [1]

(b) Select from the list the quantity that **cannot** be calculated if at one instant you know the values of the other three, but have no other information.

answer .... [1]

7 Fig. 7.1 shows two sinusoidal waveforms **P** and **Q**.

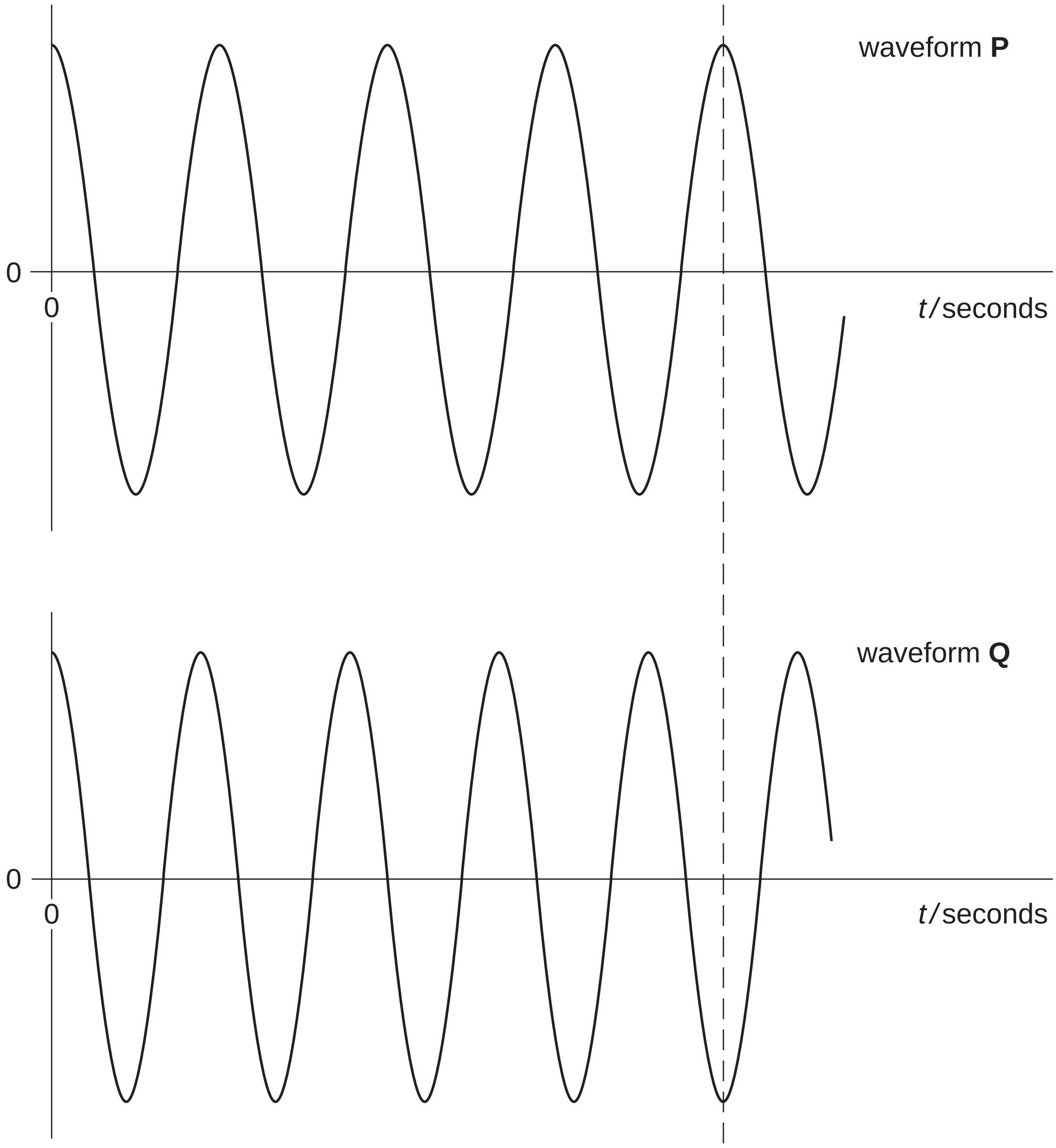


Fig. 7.1

(a) The period of waveform **P** is 9 seconds.

Calculate the period of waveform **Q**.

period = ... seconds [2]

(b) At $t = 0$ on Fig. 7.1, the waves are in phase.

At what time t will the waves next be in phase?

$t =$ .... seconds [1]

[Section A Total: 22]

Section B

8 This question is about waves on a stretched wire.

(a)

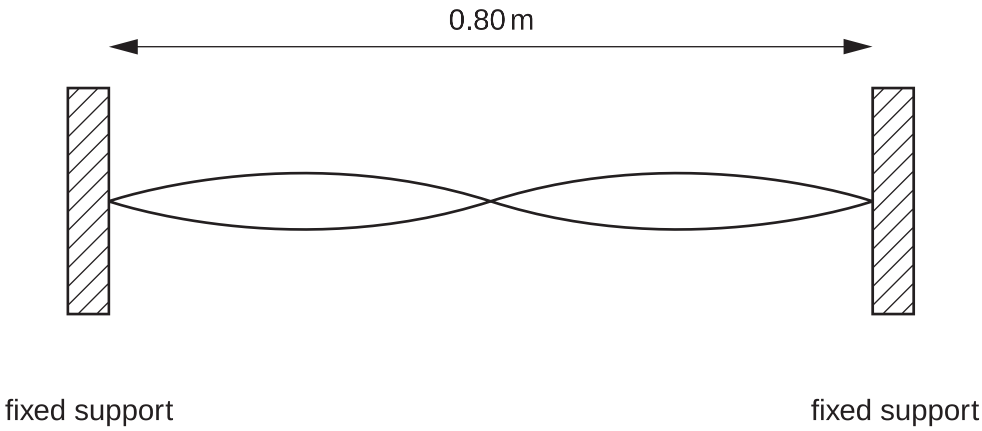


Fig. 8.1

A steel wire of length 0.80 m is stretched between fixed supports as shown in Fig. 8.1. When the wire is plucked, the wire vibrates and a standing wave is produced as shown.

(i) State the wavelength of this standing wave.

wavelength = ... m [1]

(ii) The frequency of vibration of the wire is 320 Hz.
Calculate the speed of transverse waves on the wire.

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

(iii) On Fig. 8.1, label the positions of a displacement node and a displacement antinode with the letters **N** and **A** respectively. [1]

(iv) By considering the motion of transverse waves on the wire, explain how a standing wave is produced.

[3]

(b) The amplitude of the standing wave decreases as the energy stored in the vibrating wire is dissipated.

(i) Suggest where the stored energy goes.

[1]

(ii)

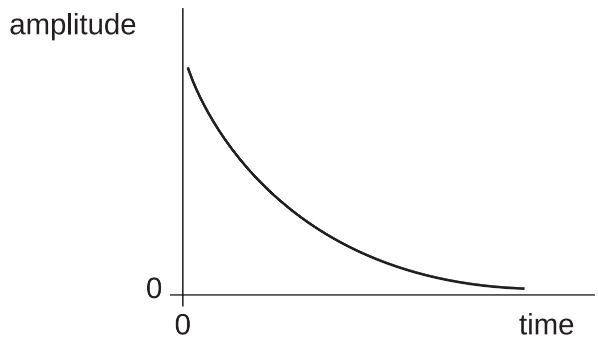


Fig. 8.2

Fig. 8.2 shows how the amplitude of the standing wave decreases with time.
The amplitude decreases by a factor of 0.75 every 200 vibrations of the wire.

Show that in 5 seconds the amplitude of this standing wave decreases to about 10% of its original value.

frequency of vibration of the wire = 320 Hz

[3]

[Total: 11]

9 This question is about the motion of a sphere in a viscous liquid.

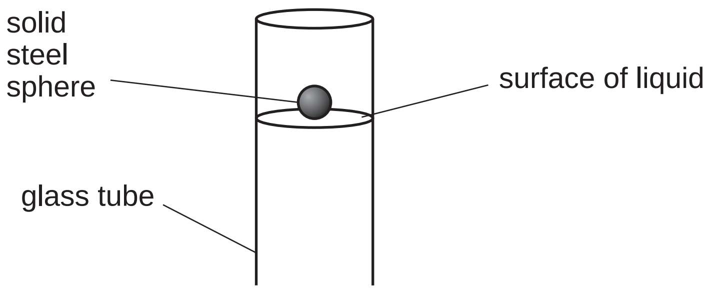


Fig. 9.1

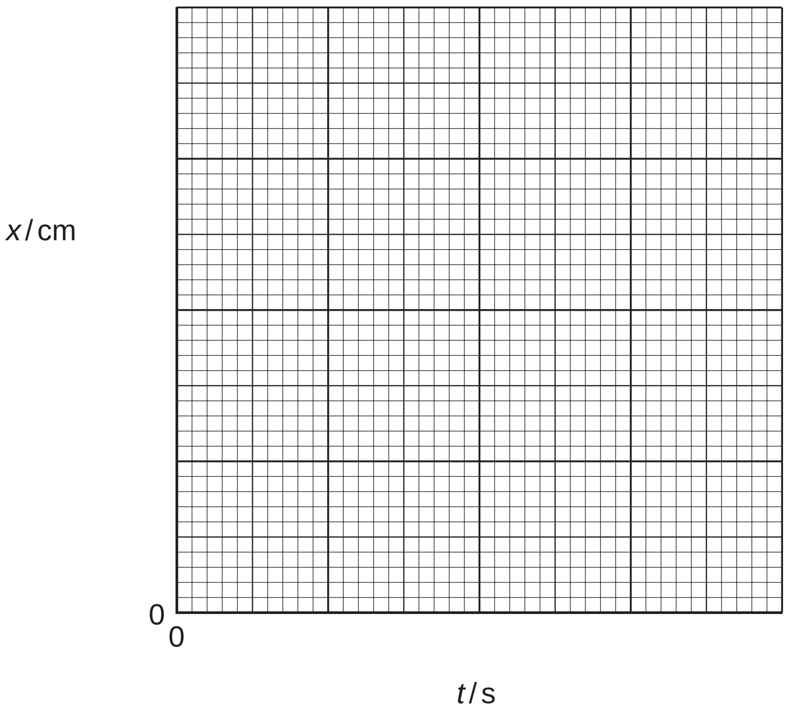
(a) A solid steel sphere is released from rest at the surface of a transparent liquid in a cylindrical glass tube, as shown in Fig. 9.1

The time t taken for the sphere to fall to different distances x below the surface of the liquid is recorded in Fig. 9.2.

x /cm	0	20	40	60	80	100	120
t /s	0.0	1.6	2.4	3.0	3.4	3.8	4.2

Fig. 9.2

(i) On the axes below, draw a graph to show how the distance x travelled by the sphere varies with time t from the moment of release (t = 0).



[3]

(ii) Describe the motion of the sphere between t = 0 and t = 4 s. Make your reasoning clear.

[3]

(b) A student attempts to use the data in Fig. 9.2 to obtain an estimate of the speed v of the falling sphere at different distances x below the liquid surface.
The data are processed as shown in Fig. 9.3.

x/cm	t /s	Δx /cm	Δt /s	$v = \Delta x / \Delta t$ /cm s^{-1}
0	0	-	-	-
20	1.6	(40 – 0) = 40	(2.4 – 0) = 2.4	40 / 2.4 = 17
40	2.4	(60 – 20) = 40	(3.0 – 1.6) = 1.4	40 / 1.4 = 29
60	3.0	(80 – 40) = 40	(3.4 – 2.4) = 1.0	40 / 1.0 = 40
80	3.4	(100 – 60) = 40	(3.8 – 3.0) = 0.8	40 / 0.8 = 50
100	3.8	(120 – 80) = 40	(4.2 – 3.4) = 0.8	40 / 0.8 = 50
120	4.2	-	-	-

Fig. 9.3

(i) Explain what the student has done to get a value for the speed v of the sphere at x = 100 cm.

[2]

(ii) Explain why calculating the value of v in this way gives a good estimate of the speed of the sphere at depth 100 cm, but gives an inaccurate estimate for the speed at depth 40 cm.

[2]

[Total: 10]

10 This question is about a bouncing ball.

(a) A ball, possessing no initial spin, bounces off a flat, horizontal surface.

The ball, travelling at 5.0 m s^{-1}, meets the surface at 30^{o} to the vertical.
It rebounds in the same plane at 3.5 m s^{-1} and at the same angle as it hit the surface, as shown in Fig. 10.1.

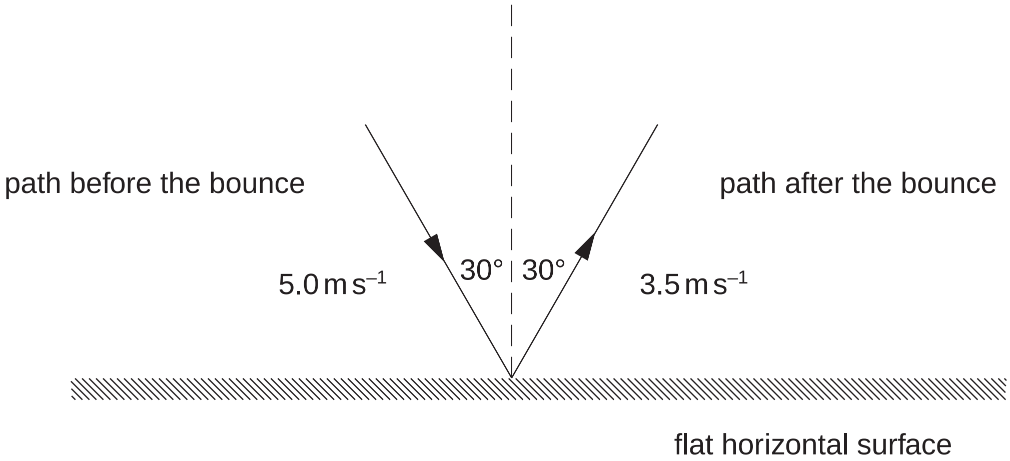


Fig. 10.1

The table, Fig. 10.2, shows the horizontal and vertical components of velocity just before and after the bounce.

	before the bounce	**after** the bounce
horizontal component of velocity / m s^{-1}	2.5	1.8
vertical component of velocity / m s^{-1}	4.3	–3.0

Fig. 10.2

(i) Show how the horizontal and vertical components of velocity **before** the bounce are calculated.

[2]

(ii) Explain the significance of the minus sign in the value of the vertical component of velocity after the bounce.

[2]

(iii) The vertical and horizontal forces acting on the ball during the impact are shown in Fig. 10.3.

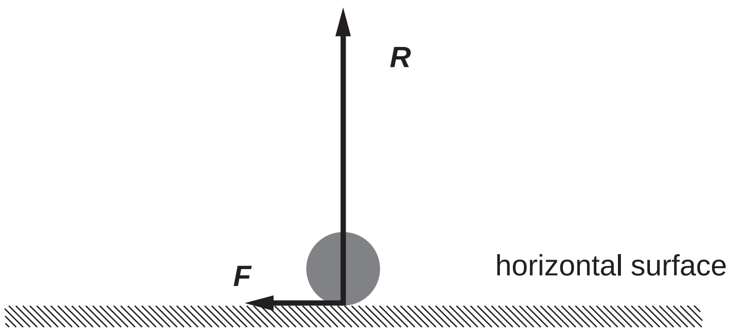


Fig. 10.3

The average upward force ***R*** changes the vertical component of velocity. The frictional force ***F*** of the ground on the ball changes the horizontal component of velocity.

Use information in the table, Fig. 10.2, to show that the average frictional force F = 6.4 N.

mass of ball = 0.046 kg
impact time = 5.0×10^{-3} s

[3]

Question 10 continues on next page.

(b) A ball which possesses back spin can bounce off the surface more sharply. This effect can be seen for example in a drop shot in tennis.
Given enough spin, the ball can be made to bounce back almost to its original path as shown in Fig. 10.4(a).

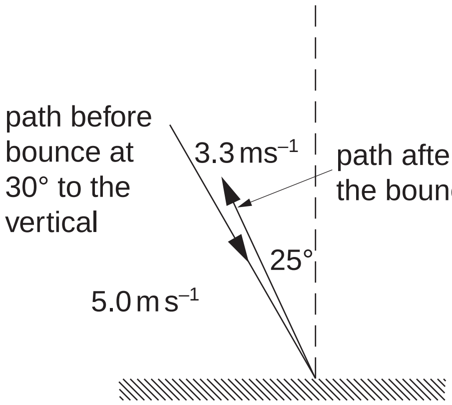


Fig. 10.4(a)

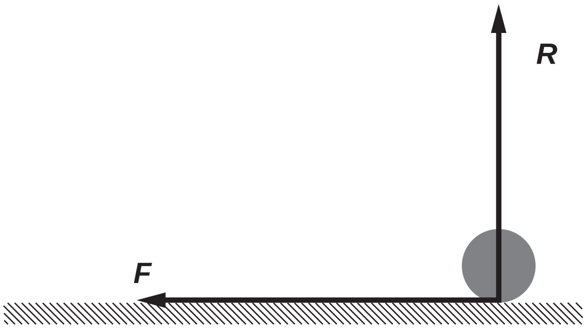


Fig. 10.4(b)

In this bounce, ***R*** is unchanged but the spinning ball experiences a greater frictional force ***F***, as shown in Fig. 10.4(b).

Calculate the change in the horizontal component of velocity and use this to show that the average frictional force ***F*** is more than five times greater than the value in **(a)(iii)**.
Assume the impact time remains unchanged at 5.0×10^{-3} s.

[3]

[Total: 10]

11 This question is about the quantum behaviour of photons.

(a) Light is emitted from a laser and a bright spot of light is produced at point **H** on a screen, as shown in Fig.11.1.

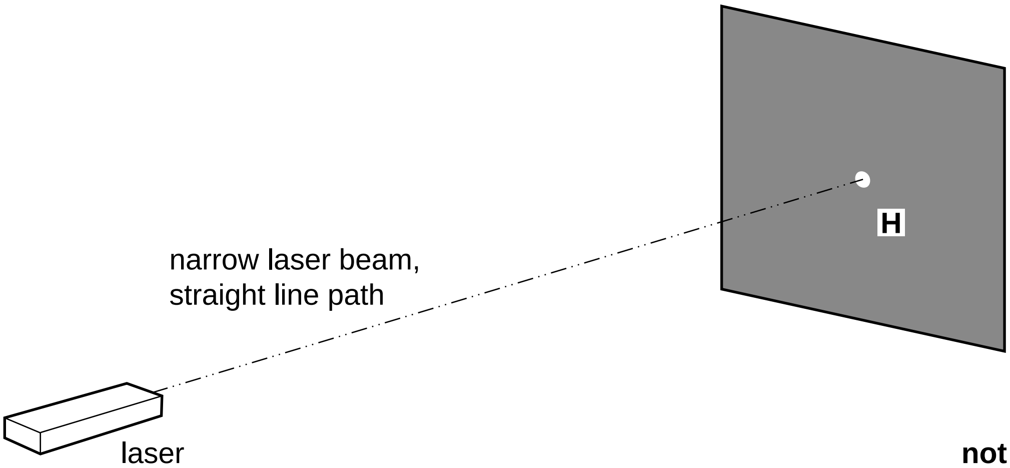


Fig. 11.1

Any photon from the laser could reach **H** by many paths, but the important paths are those close to the straight line path shown.

(i) For a set of paths close to the straight line path, the difference between the path lengths is almost zero. The phasors associated with these paths are almost in phase at **H**, and the resultant phasor amplitude for these paths will be large.

Using a ruler, draw a diagram showing how six phasors that are almost in-phase can be combined to produce the resultant phasor amplitude.

[2]

(ii) For another set of paths from the laser to **H** the difference between path lengths is larger. This means that the phase varies significantly from one path to the next.

Using a ruler, draw a diagram showing how six phasors that are significantly out of phase combine to produce a smaller resultant phasor amplitude than in **(a)(i)**.

[2]

Question 11 continues on next page.

(iii) Explain **why** the resultant phasor amplitudes you have drawn above suggest that paths close to the direct path from the laser to **H** contribute most to the intensity at **H**.

[2]

(b)

Fig. 11.2

Fig. 11.2 shows what happens when the beam is passed through a very small circular hole in an opaque barrier. The beam spreads out producing a pattern of bright and dark rings on the screen.

(i) State the physical process responsible for the **spreading** of the beam.

....[1]

(ii) Photons travel from the laser, through the small hole, to fall on the screen. Fig. 11.3 shows four possible paths by which a photon could reach a point **F** on the screen.

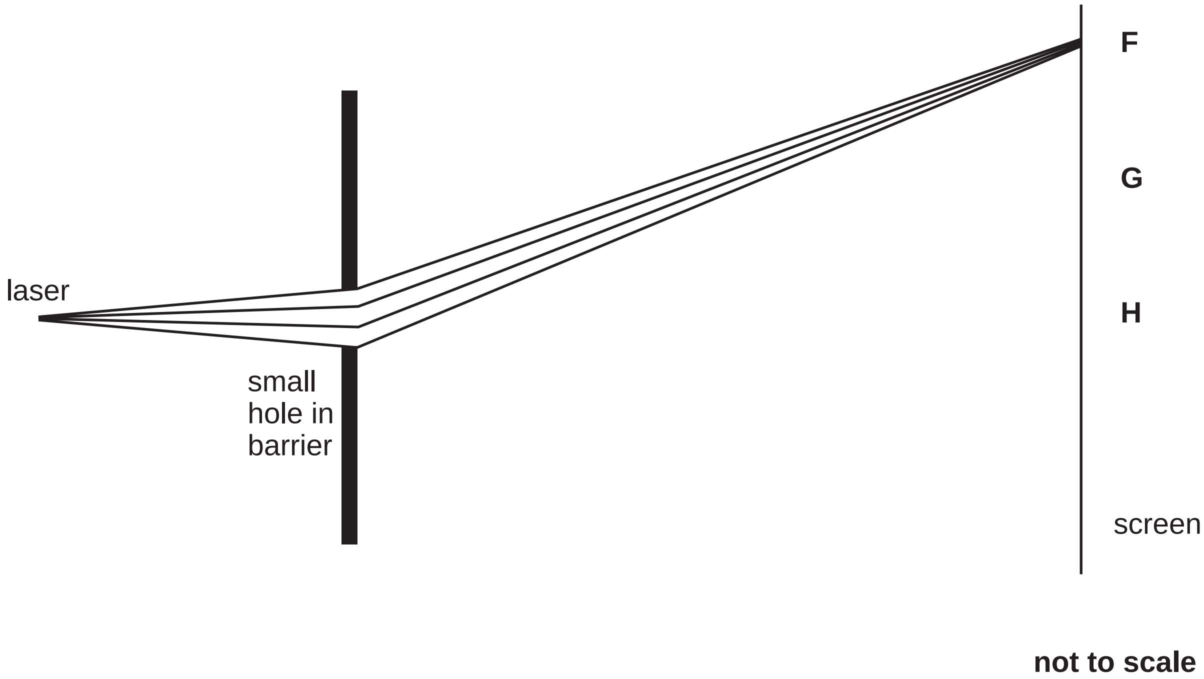


Fig. 11.3

The phasors associated with the four paths shown are combined at point **F**, and for four similar paths at points **G** and **H**. The intensity of light arriving at these points on the screen can then be compared. Some of the results are shown in the table below.

point	resultant phasor amplitude	relative probability of arrival of a photon	light intensity / W m^{-2}
H		0.16	32
G	0	0	0
F	1		2

Using your knowledge of the relationships between these quantities, complete the table by filling in each blank space with the missing number.

[2]

[Total: 9]

[Section B Total: 40]

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, one particular example of the superposition of waves.

(a) **(i)** State the superposition effect you have chosen.

[1]

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

wavelength = ... unit ....

wavelength = ... unit ....

[2]

(b) Show, with the aid of a suitably labelled diagram, the arrangement of apparatus or physical situation required to produce the superposition effect.

[3]

(c) Describe **three** observations that can be made, and explain them using the principle of superposition.
You may find it useful to draw diagrams to help in your description.

[6]

[Total: 12]

13 In this question you are to describe how to make an accurate measurement of the acceleration of a trolley moving down a ramp.

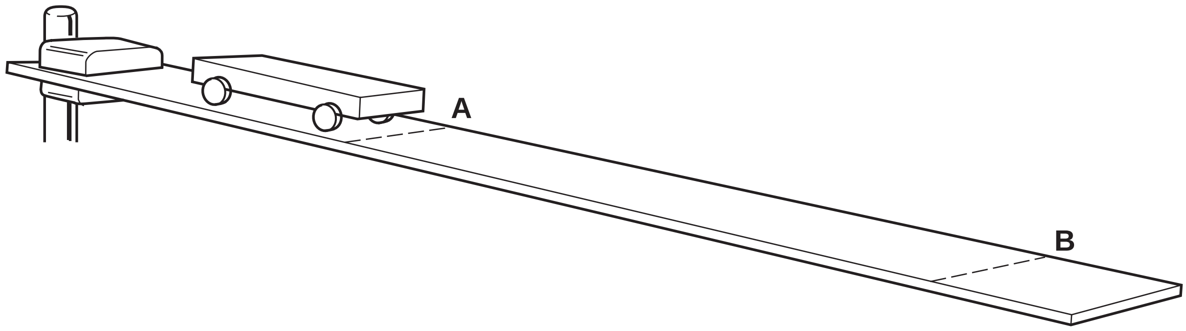


Fig. 13.1

One end of the ramp is firmly supported above the bench in the position shown in Fig. 13.1. The trolley is released from rest at **A** and accelerates down the ramp through **B**.

(a) State the quantities that would need to be measured in order to be able to calculate the average acceleration of the trolley between **A** and **B**.

[2]

(b) Describe and explain how you would make accurate measurements of the quantities you stated in **(a)**.

[4]

(c) Show how the quantities would be used to find a value for the average acceleration.

[2]

(d) (i) State **two** different factors that can introduce uncertainty into the measurement of the acceleration by this method.

1.

2.

[2]

(ii) Explain how the uncertainty might be reduced.

[2]

[Total : 12]

Quality of Written Communication [4]

[Section C Total: 28]

END OF QUESTION PAPER

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