OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary GCE

PHYSICS B (ADVANCING PHYSICS) 2861

Understanding Processes

Friday **31 MAY 2002** Afternoon 1 hour 30 minutes

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

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 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 round answers to only a justifiable number of significant figures.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [ ] at the end of each question or part question.
- 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.
- You are advised to spend about 20 minutes on Section A, 40 minutes on Section B and 30 minutes on Section C.
- You will be awarded marks for the quality of written communication where an answer requires a piece of extended writing.

FOR EXAMINER'S USE		
Section	**Max.**	**Mark**
A	**20**	
B	**40**	
C	**30**	
TOTAL	**90**	

This question paper consists of 22 printed pages and 2 blank pages.

[Turn over

Section A

1 Fig. 1.1 shows a standing wave in a pipe, closed at one end.

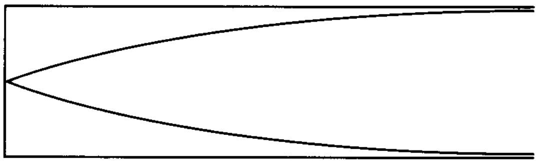


Fig. 1.1

(a) The frequency of the sound producing the standing wave is 170 Hz.

Calculate the wavelength.

velocity of sound in air = 340 m s^{-1}.

wavelength = ... m

(b) Calculate the length of the pipe.

length of the pipe = ... m

[3]

For Examiner's Use

2 Fig. 2.1 shows a racing car fitted with a *spoiler*. When air flows over the spoiler a downward force is produced on the rear of the car.

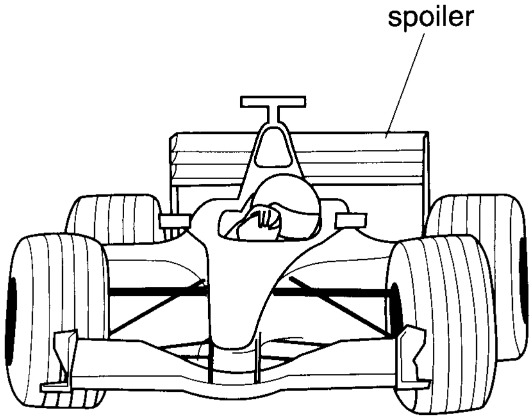


Fig. 2.1

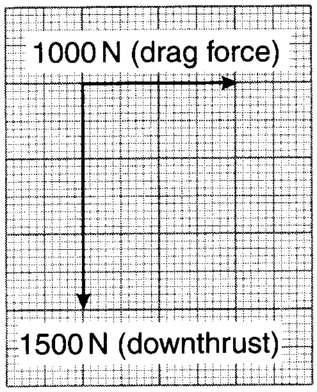


Fig. 2.2

Fig. 2.2 shows the magnitude and direction of the forces acting on the spoiler when the car is travelling at speed. The forces are drawn to a scale of 1 cm to 500 N.

Find the magnitude of the resultant force acting on the spoiler. Show how you get your answer.

resultant force = ... N [2]

[Turn over

3 **(a)** Calculate the energy of a photon of light of frequency $f = 6.0 \times 10^{14}$ Hz.

The Planck constant $h = 6.6 \times 10^{-34}$ J s.

energy = ... J

[2]

(b) A light-sensitive cell on the retina at the back of the eye will respond when 1.1×10^{-18} J of light energy falls on it.

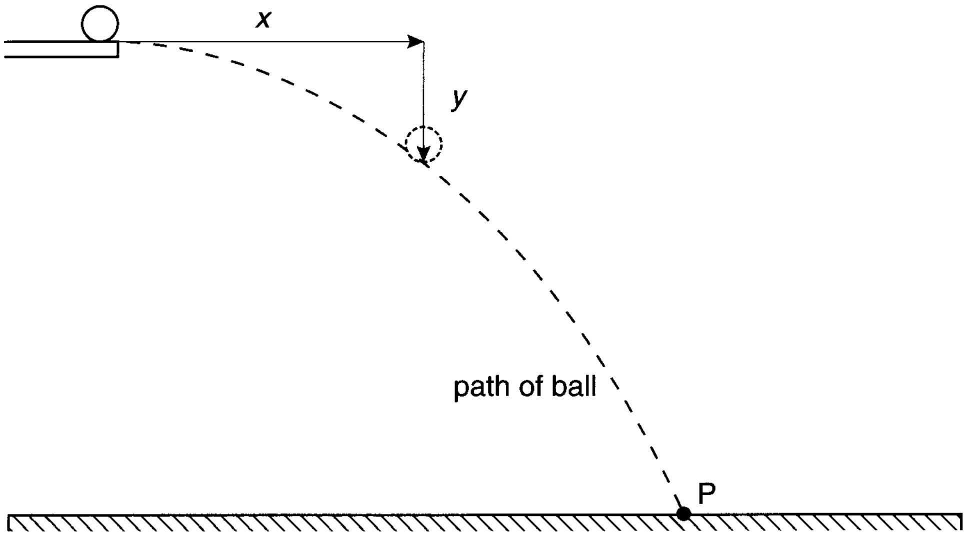
How many photons of light, frequency $f = 6.0 \times 10^{14}$ Hz, are required to trigger the response of a single cell?

number of photons = ...

[2]

For Examiner's Use

4 A heavy ball rolls off a shelf with an initial horizontal velocity v, and lands at point P some time later, as shown below.



The horizontal and vertical displacement of the ball from the edge of the shelf, at any time t during the flight, can be calculated as follows:

horizontal displacement $x = vt$ vertical displacement $y = \frac{1}{2}gt^2$,

where g is the acceleration due to gravity.

Show that the equation describing the path of the ball is given by:

$$y = \frac{gx^2}{2v^2}$$

[2]

[Turn over

5 Two loudspeakers, A and B, produce sound waves from the same signal generator. Point P is equidistant from A and B (Fig. 5.1).

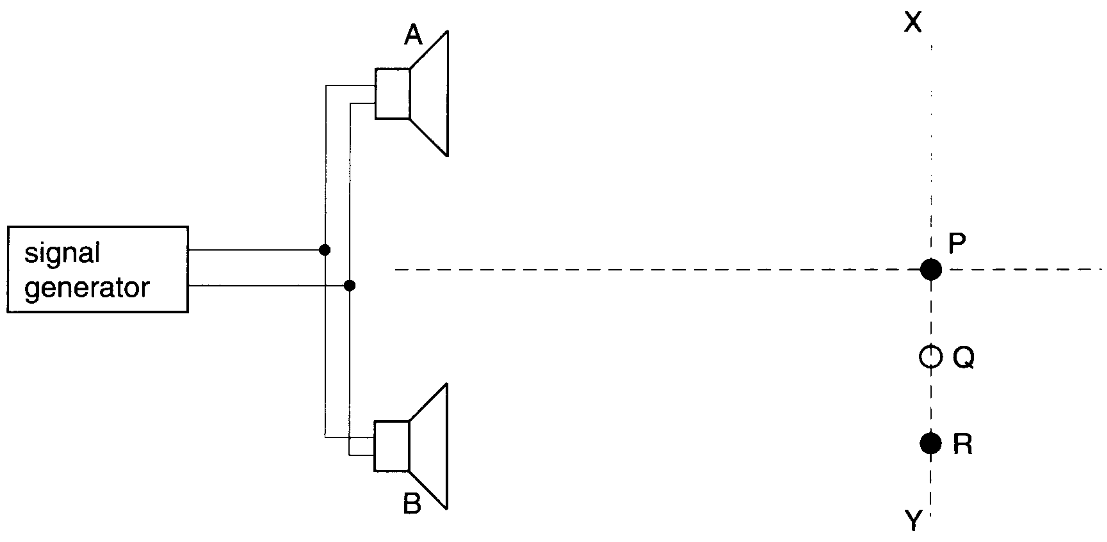


Fig. 5.1

An observer, walking along the line XY, hears the loudness of the sound rise and fall. Strong signals are heard at P and R, but no signal at Q. The wavelength of the sound is 0.3 m.

(a) What is the path difference (QA – QB)?

path difference ....

[1]

(b) The separation of the speakers is decreased as shown in Fig. 5.2.

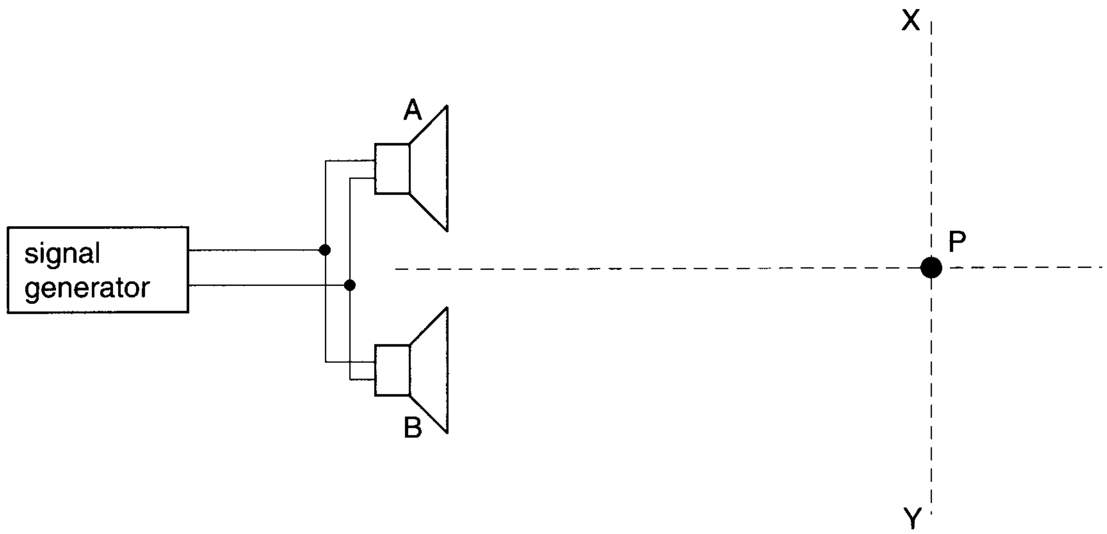


Fig. 5.2

State and explain how the spacing of P, Q and R changes when the separation of the speakers is decreased.

[2]

For Examiner's Use

6 A coin falls from rest, under gravity, down a deep well. The coin hits the bottom of the well 4.0 s later.

(a) Calculate the depth of the well.

acceleration due to gravity = $9.8\,\mathrm{m\,s^{-2}}$.

depth = ... m

[2]

(b) In fact, the depth of the well is known to be 70 m.

Suggest a reason for the difference in the values.

[2]

7 In a double slit experiment an interference pattern is produced on a distant screen.

Photons from the source reach the screen at point X by the two possible paths shown in Fig. 7.1. The resultant phasor amplitude at X for these two paths is 2.0. Similarly, at another point Y on the same screen (Fig. 7.2) the resultant phasor amplitude is 0.5.

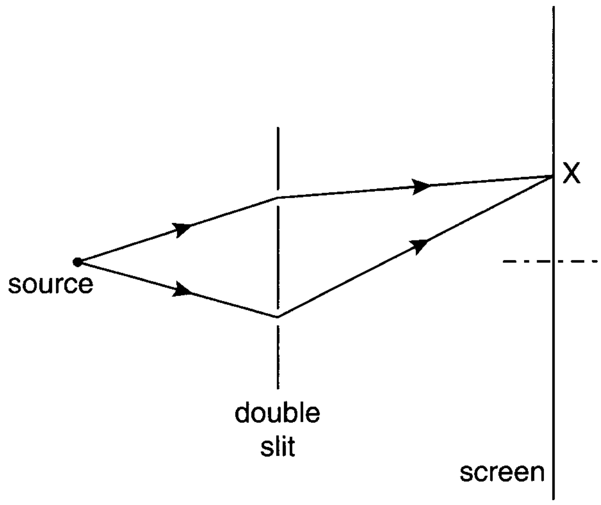


Fig. 7.1

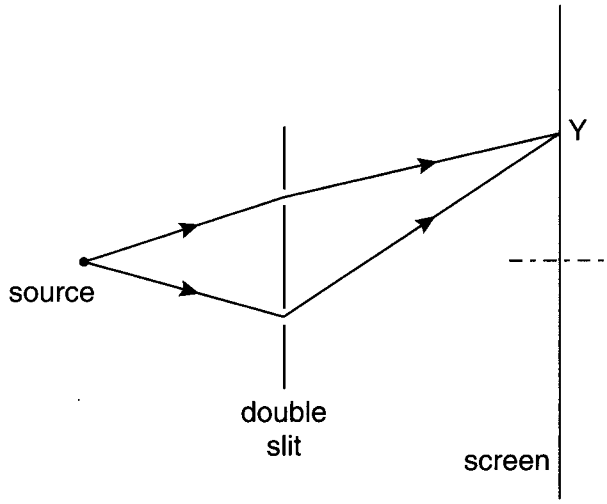


Fig. 7.2

Calculate the ratio:

$$\frac{\text{probability of photons arriving at point X}}{\text{probability of photons arriving at point Y}}$$

ratio = ... [2]

For Examiner's Use

Section B

8 A skydiver of mass 75 kg jumps from an aircraft that is in level flight at a great height above the earth's surface.

(a) Calculate the gravitational pull of the earth on the skydiver as he falls from the aircraft.

Assume that $g = 9.8\,\text{N}\,\text{kg}^{-1}$ at this height.

gravitational pull = ... N

[2]

(b) **(i)** Initially, the skydiver falls faster and faster, accelerating downwards.

Explain, in terms of the **forces** acting, why the downward acceleration of the skydiver *decreases* as his vertical speed *increases*.

[3]

(ii) Only a few seconds after leaving the aircraft the skydiver is falling towards the earth at a steady maximum speed of about $50\,\text{m}\,\text{s}^{-1}$ (over 100 miles an hour).

Explain why he reaches a *steady* speed.

[1]

For Examiner's Use

(c) To land safely the skydiver opens his parachute. When he does this, his vertical speed decreases *rapidly* from 50 $m\,s^{-1}$ to about 5 $m\,s^{-1}$. He then falls to the earth at a steady speed of about 5 $m\,s^{-1}$.

Explain, in terms of the forces acting, why he

(i) decelerates rapidly when the parachute opens

[2]

(ii) falls with a smaller steady speed than before the parachute was opened.

[2]

[Total : 10]

For Examiner's Use

9 This question is about the motion of a skateboarder on ramps of different shape.

Fig. 9.1 shows two ramps, A and B, which are used for skateboarding.

The ramps are the same length and 3.0 m high.

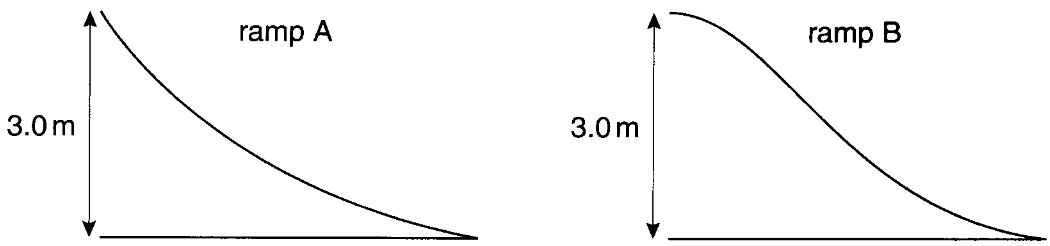


Fig. 9.1

(a) A skateboarder starts from rest at the top of each ramp.

Describe the motion of the skateboarder as he descends

ramp A

ramp B.

[4]

For Examiner's Use

(b) The speed-time graphs for the motion down each ramp are shown in Fig. 9.2.

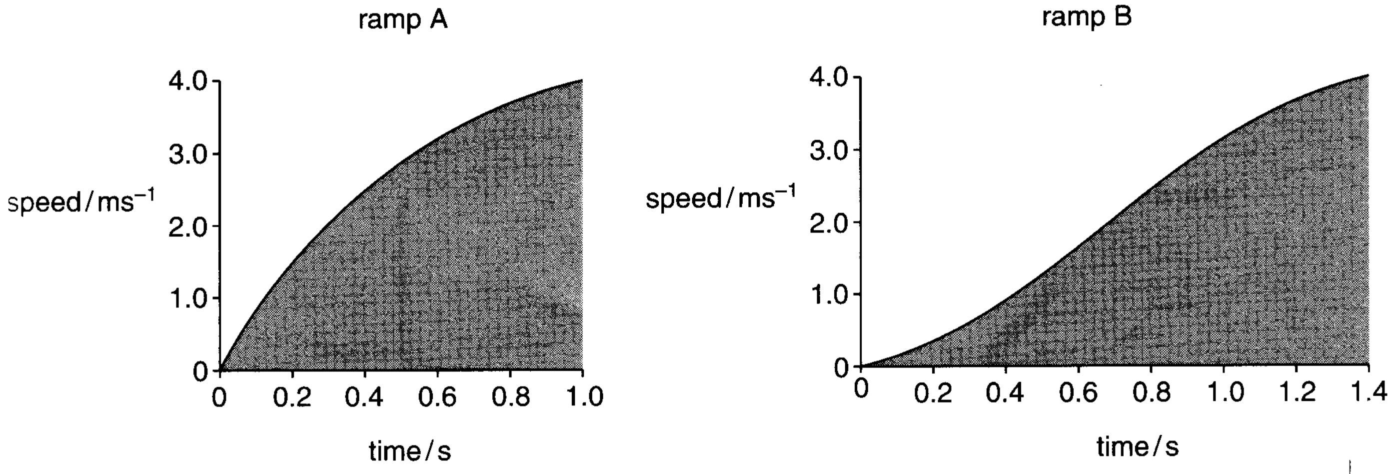


Fig.9.2

Explain why

(i) the shaded areas under the two graphs must be equal

[2]

(ii) the time taken to descend ramp B is greater than for ramp A.

[3]

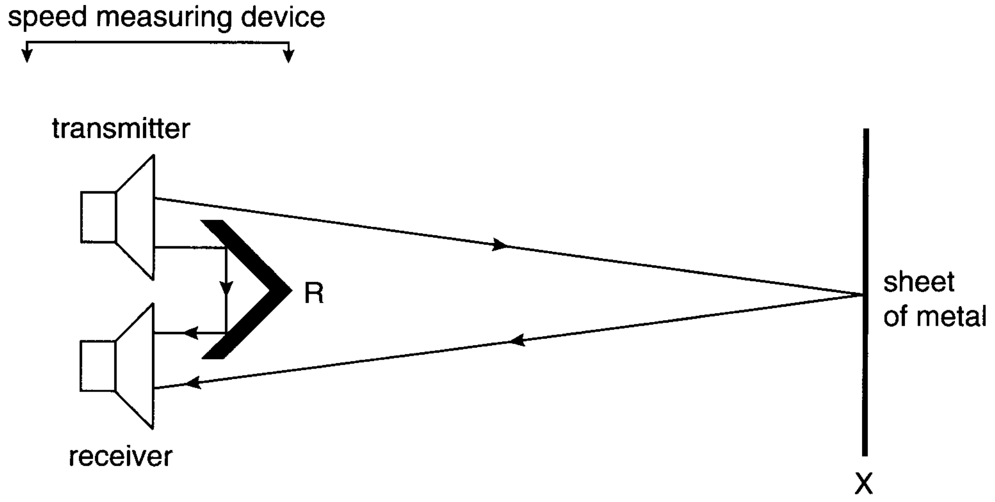
[Total : 9]

[Turn over

For Examiner's Use

10 This question is about a speed measuring device.

The device is shown in the diagram below.



A beam of radiowaves is emitted from the transmitter. Part of the transmitted signal is reflected directly back to the receiver by the reflector R, and part is reflected back from a sheet of metal X, positioned as shown. Waves entering the receiver are combined to give a resultant output.

(a) The sheet X is positioned such that the output of the receiver is a **maximum**.

State the relative phase of the two waves combining at the receiver.

[1]

For Examiner's Use

(b) The wavelength of the radiowaves is 30 mm. When the metal sheet is moved 7.5 mm towards the receiver the output of the receiver decreases to a **minimum**.

Explain why

(i) the receiver signal decreases

[2]

(ii) the minimum is not necessarily zero.

[2]

(c) The signal is now directed at a car which is moving directly towards the receiver at a steady speed. The output of the receiver rises and falls at a frequency 2.0 kHz.

(i) Calculate the period T of the fluctuating signal.

[2]

(ii) Show that the speed of approach of the car is $30\,m\,s^{-1}$.

[3]

[Total : 10]

11 This question is about the emission of electrons from a metal surface.

A thin, square specimen of metal, dimensions 4.2×10^{-2} m x 4.2×10^{-2} m, is placed on the bench. The specimen is uniformly illuminated from above by a beam of electromagnetic radiation of frequency 6.0×10^{15} Hz, as shown in Fig. 11.1.

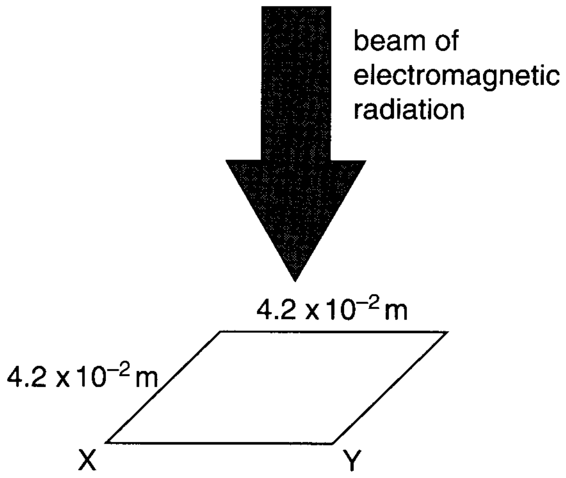


Fig. 11.1

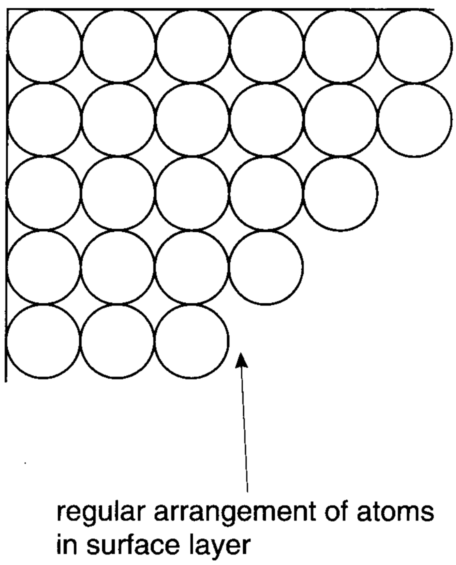


Fig. 11.2

Assume that the atoms in the metal surface are in a simple regular arrangement, as shown in Fig. 11.2.

(a) **(i)** Show that there are 1.5×10^{8} atoms along the edge XY of the specimen in the surface layer.

diameter of an atom = 2.8×10^{-10} m.

[2]

(ii) Show that there are about 2.3×10^{16} atoms in the whole surface.

[2]

For Examiner's Use

(b) **(i)** Every second, 9.0×10^{-7} J of energy is incident on the metal surface. Assume the energy arrives continuously and is completely absorbed by the atoms in the surface layer. Show that, on average, the amount of energy absorbed every second by each atom in the metal surface is 4.0×10^{-23} J.

[2]

(ii) The energy required to remove an electron from an atom of the metal is known to be 3.2×10^{-18} J.

Calculate the time taken for an atom in the metal surface to absorb this energy from the electromagnetic radiation.

time = ... s

[2]

The experimental result is quite different. When electromagnetic radiation falls on the metal surface, some electrons are emitted immediately from the surface. This is one crucial result that indicates that photoelectric emission cannot be explained if the energy is assumed to arrive continuously.

(c) The quantum theory assumes that electromagnetic radiation of frequency f is absorbed in discrete packets of energy (photons), each of energy $E = hf$.

Show that when a photon of electromagnetic radiation, frequency $f = 6.0 \times 10^{15}$ Hz, is absorbed by an atom of the metal, emission of an electron could occur.

[3]

[Total : 11]

For Examiner's Use

Section C

In this section of the paper 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 There are many effects caused by the superposition of waves. In this question you are to write a short account of one example of **wave superposition** that you consider to be of practical importance or of interest in physics.

(a) **(i)** State the example of wave superposition that you have chosen.

[1]

(ii) Say why you consider the example you have chosen to be of practical importance or of interest in physics.

[2]

(b) Draw a labelled diagram to show the arrangement of equipment needed to produce the superposition effect. On the diagram, give an indication of the dimensions involved, and the wavelength of the waves.

[4]

For Examiner's Use

(c) Describe carefully what would be observed.

[4]

(d) Explain the observations you have described using your knowledge of the physics. Write equations where appropriate.

[4]

[Total : 15]

[Turn over