THIS IS A LEGACY SPECIFICATION

OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE

PHYSICS B (ADVANCING PHYSICS) 2861

Understanding Processes

CUP/T56009

Candidates answer on the question paper

OCR Supplied Materials:
- Data, Formulae and Relationships Booklet

Other Materials Required:
- Electronic Calculator
- Ruler (cm/mm)
- Protractor

Tuesday 13 January 2009
Afternoon

Duration: 1 hour 30 minutes

2861

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided

INFORMATION FOR CANDIDATES

- The number of marks 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.
- This document consists of **24** pages. Any blank pages are indicated.

FOR EXAMINER'S USE		
Section	**Max**	**Mark**
A	**21**	
B	**40**	
C	**29**	
TOTAL	**90**	

Answer **all** the questions.

Section A

1 Here is a list of four numbers

0.0003 0.03 3 300

Write down the number that is the best estimate of

(a) the speed of sound in air

answer ..... m s^{-1} **[1]**

(b) the wavelength of a radio wave of frequency 100 MHz

answer ..... m **[1]**

(c) the diameter of a human hair.

answer ..... m **[1]**

2 In Acapulco, Mexico, a common sport is to dive into the sea from a cliff 28 m above the water surface.

Calculate the maximum velocity a diver could reach just before entering the water. State any assumption that you make.

acceleration due to gravity = 9.8 m s^{-2}

working

maximum velocity = ... m s^{-1}

assumption

[3]

3 Fig. 3.1 shows a man running with an umbrella through the rain.

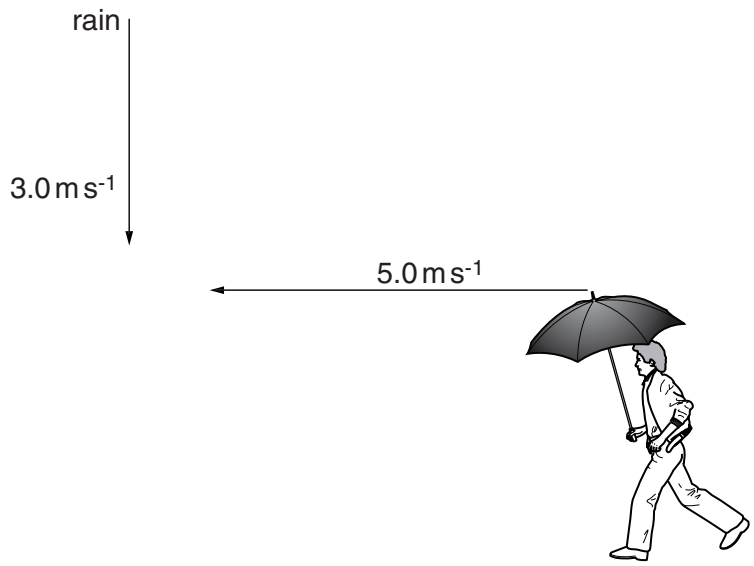

Fig. 3.1

The rain is falling vertically at a speed of $3.0\,m\,s^{-1}$ and the horizontal speed of the man is $5.0\,m\,s^{-1}$, as shown.

By scale drawing, or by some other method of your choosing, show that the velocity of the rain relative to the umbrella is $5.8\,m\,s^{-1}$ at an angle of about 60° to the vertical.

[3]

4 Photons of light from a vapour lamp are emitted at only two wavelengths λ_1 and λ_2.

(a) Show that the difference in photon energy ΔE can be given by the equation

$$\Delta E = hc\left(\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right)$$

where h is the Planck constant and c is the speed of light in air.

[1]

(b) The two wavelengths present in the light are 589.6 nm and 589.0 nm.

Calculate the difference ΔE in photon energy.

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

ΔE = ... J **[2]**

5 Fig. 5.1 shows the Space Shuttle on the launch pad. At time $t = 0$ the rockets are fired and the launch commences.

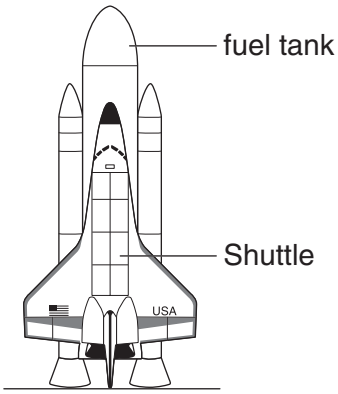

Fig. 5.1

Fig. 5.2 shows how the upward force exerted by the rockets and the total weight of the Shuttle change during the first 20 seconds of a launch.

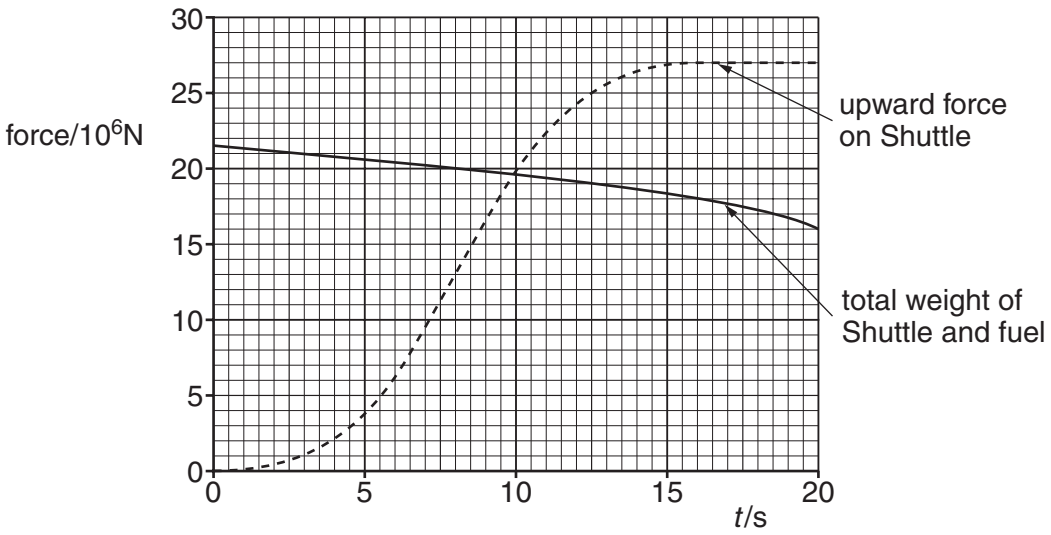

Fig. 5.2

(a) Using data from Fig. 5.2, calculate the **resultant** force acting on the Shuttle at $t = 20$ s.

resultant force = ... N **[1]**

(b) Show that the acceleration of the Shuttle at $t = 20\,s$ after launch is about $7\,m\,s^{-2}$.
gravitational field strength = $9.8\,N\,kg^{-1}$

[2]

6 Light from a lamp submerged on the bottom of a pond reaches your eye after passing through the surface of the water. Some possible paths for photons are shown in Fig. 6.1.

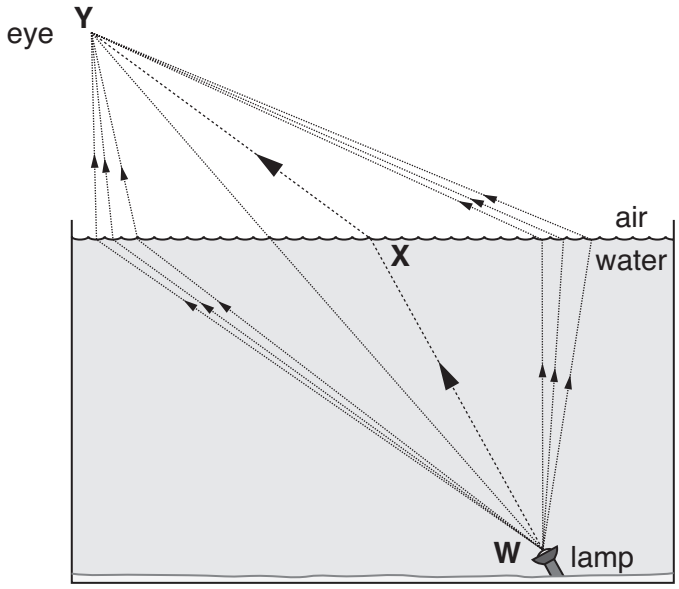

Fig. 6.1

Photons could reach your eye by many possible paths. The **observed** path of a ray of light is the path **WXY**.

(a) Write down the letter (**A**, **B** or **C**) of the statement which correctly completes the sentence below.

The paths close to the one labelled **WXY** in Fig. 6.1 are important because …

A … the phasors associated with these paths are opposite in phase at **Y** to those for all other paths.

B … when the phasors associated with these paths at **Y** are placed tip to tail they tend to line up.

C … when the phasors associated with these paths at **Y** are placed tip to tail they tend to curl up.

answer …… **[1]**

(b) Explain why a photon can take less time to travel from **W** to **Y** by the path **WXY**, than by the direct straight path, even though the geometrical distance is greater.

[2]

7 Fig. 7.1 shows how **displacement** varies with **position** for two sinusoidal waveforms **A** and **B,** at the same instant in time.

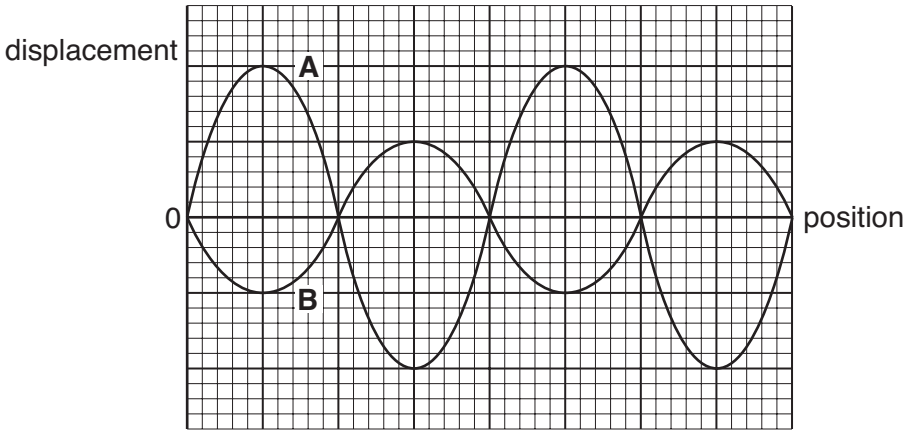

Fig. 7.1

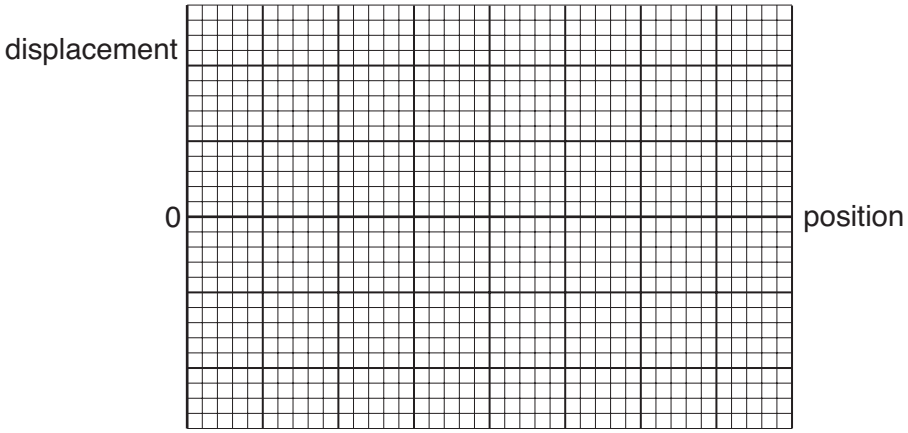

Fig. 7.2

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

phase difference = …… **[1]**

(b) Add the waves together by superposition.

On the grid Fig. 7.2, sketch the resultant wave produced. **[2]**

[Section A Total: 21]

Section B

8 This question is about standing waves on a nylon rope.

(a) A nylon rope is 65.0 m long and has a mass of 12 kg.

Show that the mass per unit length of the **unstretched** rope is about 0.2 kg m^{-1}.

[1]

(b) The rope is securely tied to a fixed support at the top of a vertical shaft as shown in Fig. 8.1.

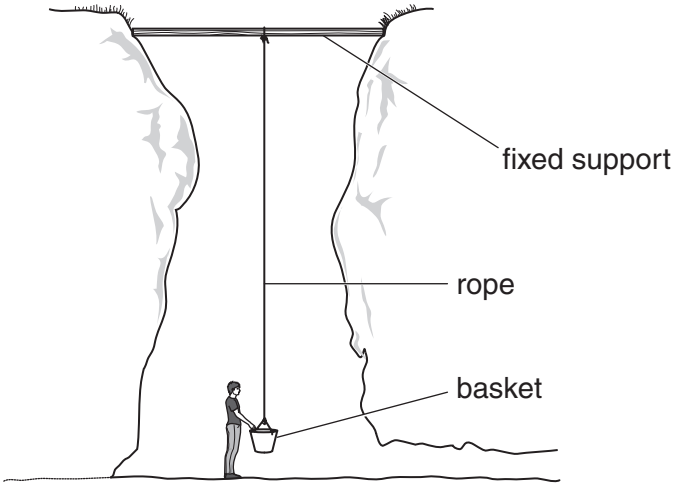

Fig. 8.1

A basket containing rock samples is attached to the bottom of the rope. The mass of the rope hanging below the fixed support is 11 kg, and the mass of the basket and rock samples is 19 kg.

Show that the total downward force exerted on the fixed support at the top of the shaft is about 300 N.

g = 9.8 N kg^{-1}

[1]

(c) The man at the bottom of the shaft moves the rope continuously from side to side to produce a standing wave on the rope.

Explain how a standing wave can be formed on the rope.

[3]

(d) Fig. 8.2 shows the standing wave produced on the rope.

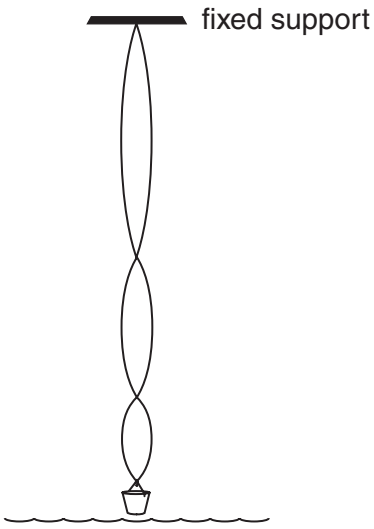

Fig. 8.2

(i) On Fig. 8.2 label the positions of one node and one antinode with the letters **N** and **A** respectively. **[1]**

(ii) Explain how you can tell that the speed of the wave shown in Fig. 8.2 must be increasing as the wave travels up the rope.

[2]

Question 8 continues on next page

(iii) The speed v of the wave on the rope is given by the equation

$$v = \sqrt{\frac{T}{\mu}}$$

where T is the tension in the rope and μ is the mass **per unit length**.

Use the equation to explain why the speed of the wave increases as it travels up the rope.

[2]

[Total: 10]

9 This question is about a method of finding the wavelength of light from a sodium vapour lamp.

(a) Yellow light from a sodium vapour lamp falls on a pair of narrow slits, as shown in Fig. 9.1.

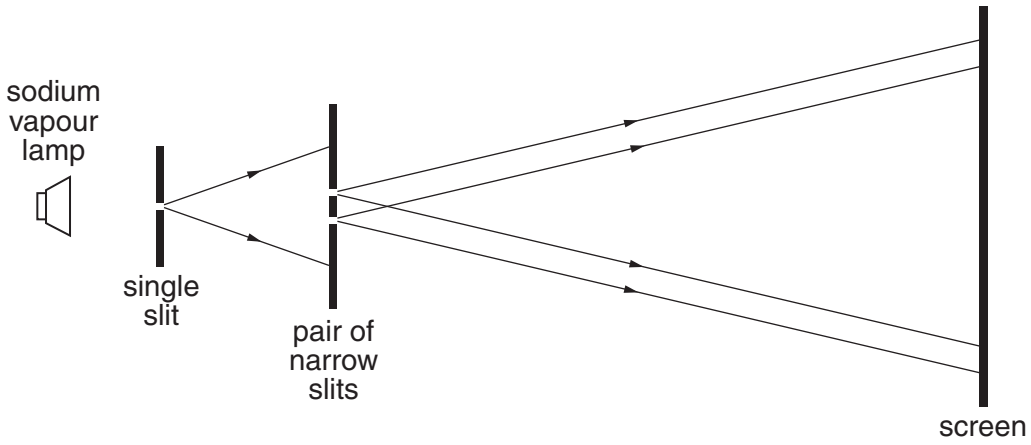

Fig. 9.1

The light passes through the slits and a pattern of regularly spaced bright and dark lines, called **fringes**, is obtained on the screen beyond the slits.

Using the idea of **superposition** explain the existence of

(i) the **dark** lines in the pattern

(ii) the **bright** lines in the pattern.

[3]

Question 9 continues on next page

(b) Fig. 9.2 shows the central part of the fringe pattern produced on the screen beyond the slits.

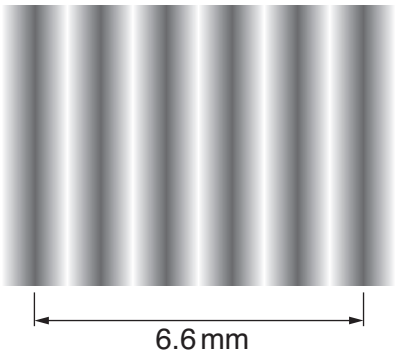

Fig. 9.2

(i) Calculate the spacing, in metres, between the bright fringes.

spacing = ... m **[1]**

(ii) The separation of the slits is 0.40 mm and the distance from the slits to the screen is 0.90 m.

Show that the wavelength of the light λ is about 600 nm.

[3]

(c) One of the slits is now covered up.

Describe and explain how the pattern of light on the screen now differs from that shown in Fig. 9.2.

[2]

[Total: 9]

10 This question is about a motorcycle moving along a straight horizontal road in still air.

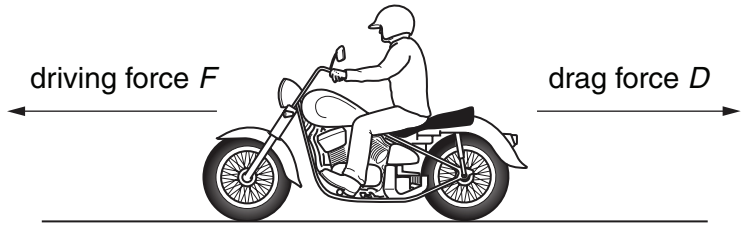

Fig. 10.1

(a) Fig. 10.1 shows the horizontal forces acting on the moving motorcycle.
The useful output power of the engine produces the driving force *F*.

(i) State the source of the drag force *D* acting on the motorcycle.

[1]

(ii) The motorcycle is travelling at a constant velocity along a level road and the useful output power of the engine *P* is 9.5 horsepower.

Show that the useful output power of the engine *P* is about 7000 W.

1 horsepower is equivalent to 750 W.

[1]

(iii) The motion of the motorcycle depends on the relative magnitudes of the drag force *D* and the driving force *F*.

Complete the table below.

description of motion	conditions required
the motorcycle travels at constant velocity	the drag force *D* is equal and opposite to the driving force *F*
the motorcycle accelerates	
	the drag force *D* is greater than the driving force *F*

[2]

Question 10 continues on next page

(b) The work W done by the engine is given by the expression $W = Fs$, where F is the driving force and s is the distance moved by the motorcycle in the direction of F.

The useful power output P of the engine equals the work done per second.

Use this information to show that useful output power P of the engine is given by the expression

$$P = Fv$$

when the motorcycle is travelling at constant velocity v.

[1]

(c) The drag force D acting on the motorcycle travelling in still air at a velocity v can be calculated using the equation

$$D = \tfrac{1}{2} k\rho A v^2$$

where ρ is the density of the air, A is the frontal area of the motorcycle and k is a constant depending on its shape.

(i) Show that the velocity v reached by the motorcycle is related to the output power P of the engine by the expression

$$v^3 = \frac{2P}{k\rho A}$$

[2]

(ii) Calculate the factor by which the output power P of the engine would have to increase for the speed of the motorcycle to double.

[1]

(iii) A 'fairing' can be fitted to the front of a motorcycle to make it more streamlined.

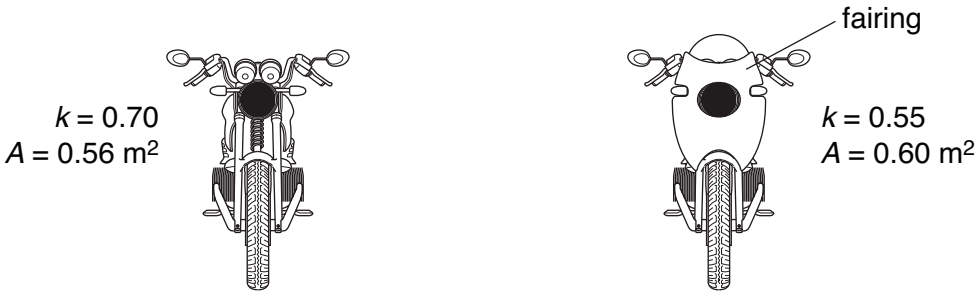

Fig. 10.2

Using information given in Fig. 10.2, explain why the fairing is likely to reduce fuel consumption.

[2]

[Total: 10]

11 In Einstein's explanation of the photoelectric effect, a photon incident on a metal surface must have at least a minimum energy to release an electron from the surface. This minimum energy is called the work function of the metal.

A photocell generates an electric current using the photoelectric effect.

(a) An electron current is generated within the photocell shown in Fig. 11.1 when photons of light of wavelength 5.0×10^{-7} m are incident on the metal surface of the photocathode.

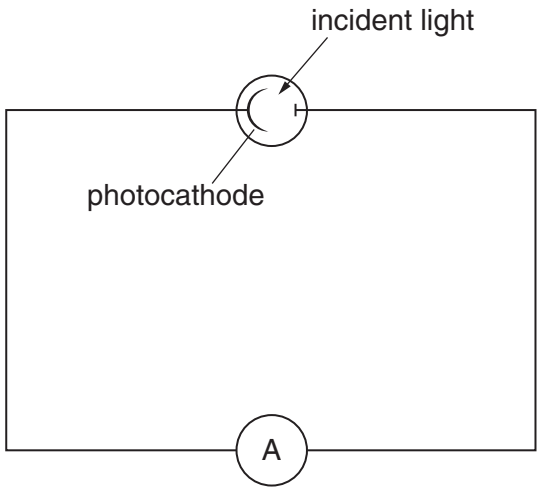

Fig. 11.1

(i) Show that a single photon of this light has energy of about 4×10^{-19} J.

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

[2]

(ii) The power incident on the metal surface is 0.1 W.

Show that about 2.5×10^{17} photons are incident on the photocathode every second.

[2]

(iii) The electron current produced by the photons in the photocell is 1.2 mA.

Show that only 3% of the photons incident on the photocathode produce electrons which contribute to the current in the circuit.

charge on electron = 1.6×10^{-19} C

[3]

(iv) Suggest and explain **one** reason why the number of electrons released is much smaller than the number of photons incident on the metal surface.

[2]

(b) The source of light is replaced by a more powerful source of light of wavelength 7.0×10^{-7} m. Even though the power incident on the metal surface from this source is 1.0 W, no current is recorded.

Without calculation, explain why there is no current generated in the photocell.

[2]

[Total: 11]

[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 write about a method of measuring the distance to a remote object.

The distance measurement you choose to describe should be one that you can justify as being of particular use, interest, or importance.

(a) State the distance measurement you have chosen.

[1]

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

[1]

(c) Show, with the aid of a labelled diagram, the arrangement of equipment that would be needed to make the measurement.

[3]

(d) Describe how your method works. Make clear the physical principles involved.

[3]

(e) State what data are obtained, and explain how the data can be used to find the distance to the object of interest.

[3]

(f) State **two** factors that may limit the accuracy achieved in this measurement of distance.

[2]

[Total: 13]

13 In this question you are to describe how to measure the average deceleration of a model car as it runs along a carpet and is brought to rest.

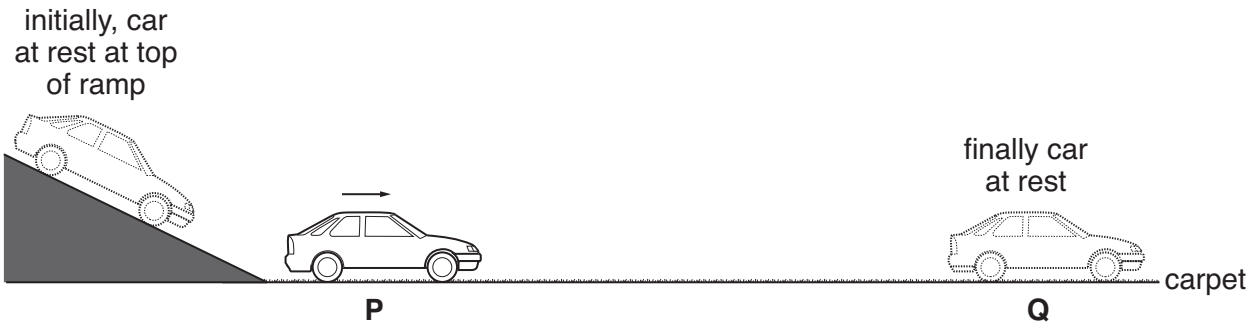

Fig. 13.1

The car is released from the top of a short launching ramp.
The car moves down the ramp and runs onto the horizontal carpet at point **P**.
The car decelerates to rest as it travels between points **P** and **Q** on the carpet, shown in Fig. 13.1.

(a) State the quantities that need to be measured to find the average deceleration of the car on the carpet.

[2]

(b) (i) Describe and explain how you would make the measurements.

You may add to Fig. 13.1 if you wish.

[3]

(ii) Show how the measurements would be used to find a value for the deceleration.

[3]

(c) (i) Suggest **two** different factors that might limit the accuracy of the measurement of the deceleration by this method.

1.

2.

[2]

(ii) Suggest and explain **one** way the accuracy might be improved.

[2]

[Total: 12]

Quality of Written Communication [4]

[Section C Total: 29]

END OF QUESTION PAPER

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