THIS IS A NEW SPECIFICATION

OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE

PHYSICS B (ADVANCING PHYSICS)

G492

Unit G492: Understanding Processes / Experimentation and Data Handling

Candidates answer on the question paper

OCR Supplied Materials:
- Insert (Advance Notice Article for this question paper) (inserted)
- Data, Formulae and Relationships Booklet

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

Thursday 21 May 2009
Afternoon

Duration: 1 hour 45 minutes

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 **100**.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
- 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.
- Where you see this icon you will be awarded marks for the quality of written communication in your answer.
  This means, for example, you should
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- This document consists of **24** pages. Any blank pages are indicated.
- The questions in Section C are based on the material in the Insert.

FOR EXAMINER'S USE		
Section	**Max.**	**Mark**
A	**20**	
B	**40**	
C	**40**	
TOTAL	**100**	

Turn over

Answer **all** the questions.

Section A

1 Here is a list of physical quantities.

force kinetic energy mass power velocity

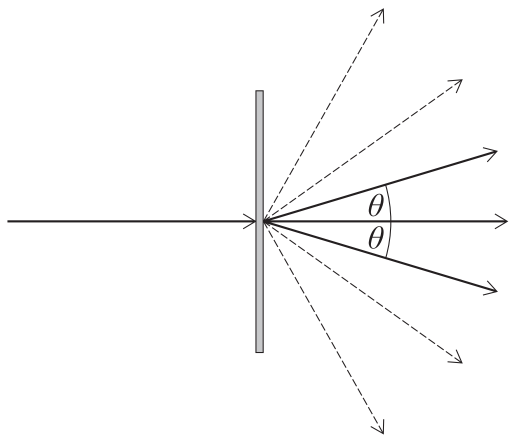
(a) Which one can be measured in $J\,s^{-1}$?

....

(b) Which of the quantities are vectors?

.... **[3]**

2 Light of a single wavelength is incident on a diffraction grating with grating spacing 2.0×10^{-6} m. The angle θ of the first-order maximum in the diffraction pattern is 17°.



Calculate the wavelength of the light.

wavelength = ... m **[2]**

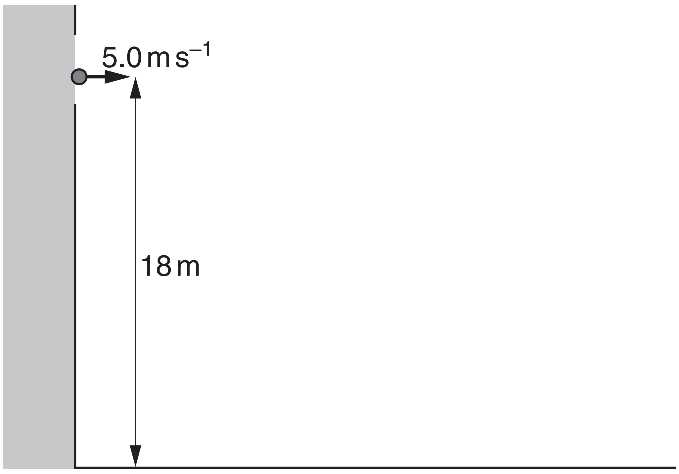
3 A bee of mass 120 mg flies at a speed of $3.0\,m\,s^{-1}$.

Calculate its kinetic energy.

kinetic energy = ... J **[2]**

4 A ball is thrown out of a window 18 m above the ground.

It is thrown horizontally at $5.0\,m\,s^{-1}$.



(a) Show that it takes about 2 seconds to reach the ground.

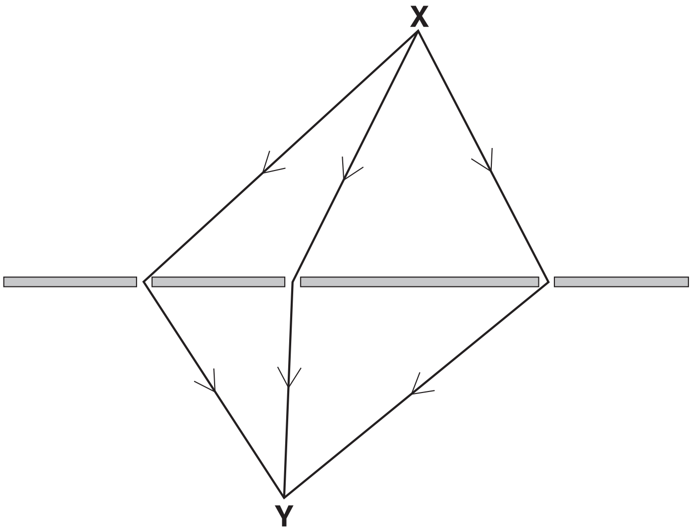
$g = 9.8\,m\,s^{-2}$

[2]

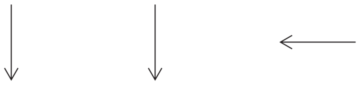
(b) Calculate the distance from the bottom of the building to the place where the ball hits the ground.

distance = ... m **[1]**

5 A photon travels from **X** to **Y**. Three of the possible paths are shown below.



The phasors for these three paths are shown below. Each has the same amplitude A.



(a) Show, by drawing or otherwise, that the amplitude of the resultant phasor, A_{res}, is more than $2A$ and less than $3A$.

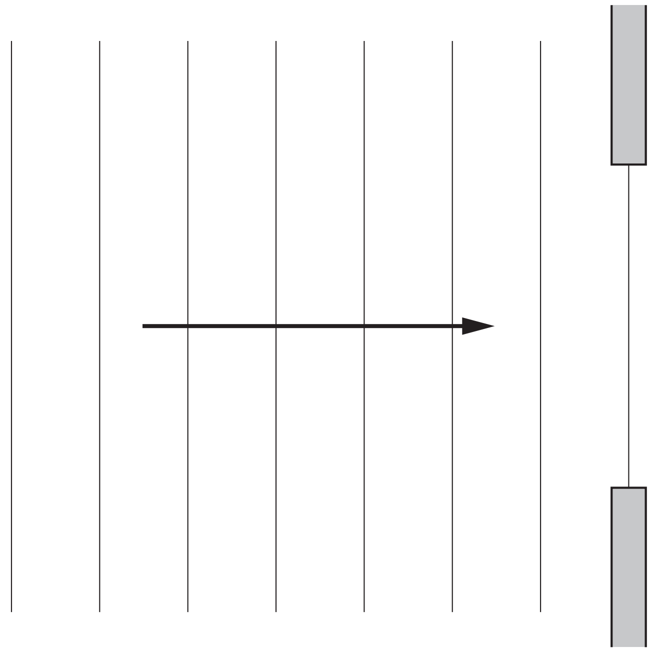
[2]

(b) The probability P of the photon arriving at **Y** depends on the amplitude of the resultant phasor, A_{res}.

State the relationship between the probability P and the amplitude A_{res}.

.... **[1]**

6 Waves travel towards a narrow opening as shown in the diagram.



(a) Draw **four** wavefronts on the right-hand side of the diagram to show the effect of the opening on the waves.

[2]

(b) Describe the difference in the pattern you would see if the narrow opening is made smaller.

[1]

7 It is thought that some climate changes are linked with large-scale ocean waves.

One type is the Rossby wave. These are transverse waves which make the ocean surface rise and fall.

Rossby ocean waves are difficult to observe, and have only recently been recorded.

Here are some data about a typical Rossby wave:

vertical amplitude of motion of ocean surface = 10 cm
wavelength = 500 km
speed = $8\,\text{cm}\,\text{s}^{-1}$

(a) Show that the frequency of this Rossby wave is very small.

[2]

(b) Suggest and explain why Rossby ocean waves are difficult to observe.

[2]

[Section A Total: 20]

Section B

8 This question is about an early musical instrument called the tromba marina. Although it is a stringed instrument, it makes a sound rather like a trumpet.

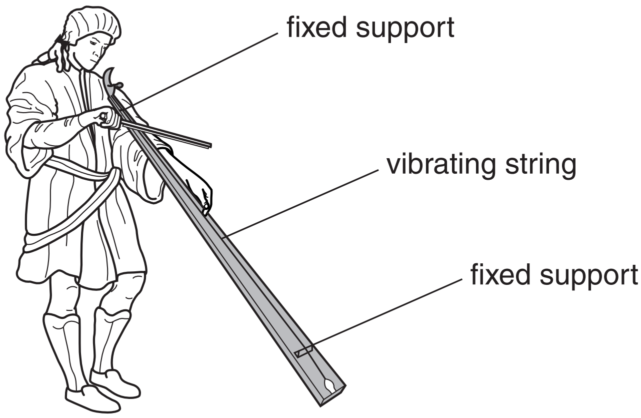


Fig. 8.1

The tromba marina has a single string stretched between fixed supports.

The string is made to vibrate by a bow in the player's right hand, and the player makes different notes by lightly touching different points on the string with his left hand.

(a) The movement of the bow sends transverse waves along the string in both directions. The waves reflect from each end of the string, continually bouncing to and fro. If the string is viewed from the side when the instrument is playing its lowest note, a standing wave pattern is seen (Fig. 8.2).

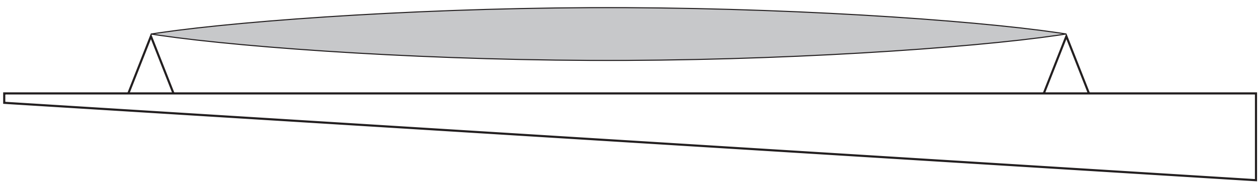


Fig. 8.2

(i) Use the letters **N** and **A** to label node(s) and antinode(s) in Fig. 8.2.

[1]

(ii) Use the principle of superposition of waves to explain why the string vibrates to and fro with large amplitude at the centre.

[2]

(b) The length of the string is 1.9 m. The frequency of the lowest note produced is 32 Hz.

(i) Write down the wavelength of the waves on the string.

wavelength = ... m **[1]**

(ii) The frequency of the lowest note produced by the string is given by the equation

$$f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$$

where L is the length of the string, T is the tension in the string and μ the mass of one metre of the string.

Show that the tension in the string is about 120 N.

mass of one metre of the string = 8.0 g

[3]

(c) By touching the string lightly at different points, the player can produce notes of frequencies 64 Hz, 96 Hz, 128 Hz and further higher notes.

(i) When the player lightly touches a point one-third of the way along the string, the note of frequency 96 Hz is produced.

Draw on Fig. 8.3 the standing wave pattern seen on the string when this note is produced.

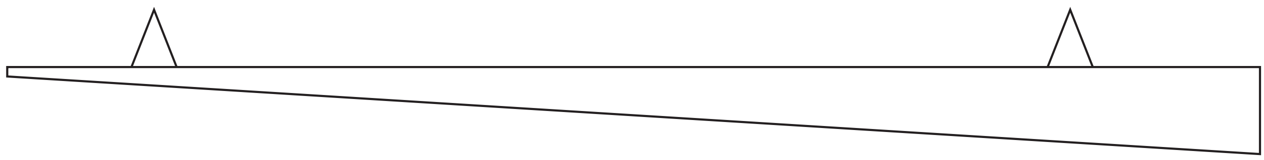


Fig. 8.3

[1]

(ii) Although the instrument is very long, the player does not need to reach more than half-way down the string to produce any of these notes. Explain clearly why this is the case.

[2]

[Total: 10]

9 This question is about the LEDs (light-emitting diodes), used in some torches.

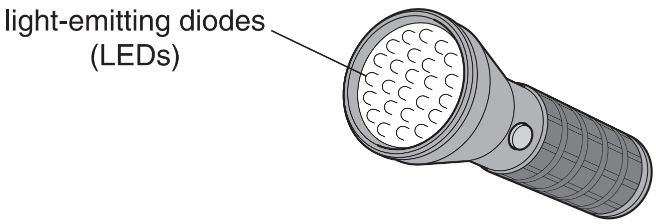


Fig. 9.1

(a) The LEDs used in the torch emit blue light. The energy of the photons comes from electrons passing through the LED.

(i) The wavelength of the blue light is 470 nm.

Show that the energy of a photon from the LED is about 4×10^{-19} J.

speed of light, $c = 3.0 \times 10^{8}\ \mathrm{m\,s^{-1}}$

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

[2]

(ii) LEDs need to be connected to a certain minimum voltage before they emit light. A blue LED needs a higher voltage than a longer wavelength red LED.

Explain why a blue LED needs a higher voltage than a red LED.

Your answer should use the quantum nature of light to explain this effect.

[2]

(iii) There is a current of 20 mA in a LED emitting blue light.
Show that this corresponds to 1.3×10^{17} electrons per second passing through the LED.

electron charge, $e = -1.6 \times 10^{-19}$ C

[1]

(iv) Calculate the total energy per second of the blue light emitted by the LED.

energy per second = ... W **[2]**

(b) An LED torch is modified to emit light which appears white.

To do this, the blue LEDs are given a fluorescent chemical coating. The coating absorbs some of the blue light and emits other colours of the spectrum.

Fig. 9.2 shows the spectrum of light from these modified LEDs.

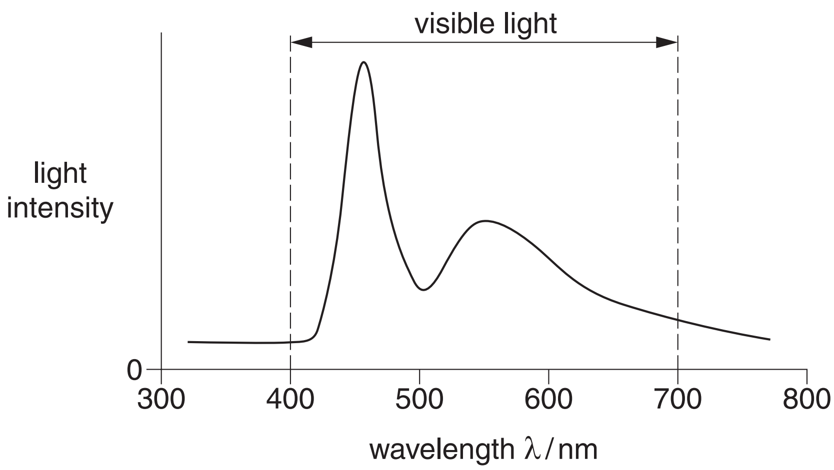


Fig. 9.2

(i) Draw a ring around the part of this spectrum which shows you that a blue LED is the basis for this device.

[1]

(ii) Explain how the spectrum of Fig. 9.2 shows that the light given out by the LED can appear white.

[1]

(iii) The fluorescent coating can emit red photons, having absorbed blue photons. Explain why it cannot emit blue photons, having absorbed red photons.

[2]

[Total: 11]

10 This question is about trains on the London underground rail system.

(a) Fig. 10.1 shows two maps of the same part of the London underground.

Fig. 10.1A is part of the 'traditional' tube map that is used by travellers every day.
Fig. 10.1B shows the actual positions of the stations and rail track.

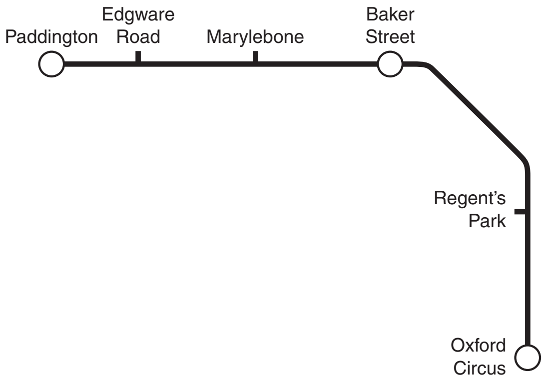


Fig. 10.1A

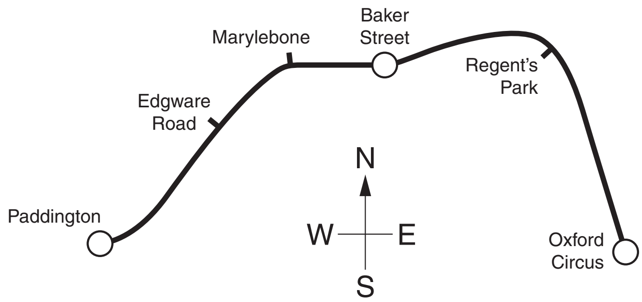


Fig. 10.1B

Fig. 10.1

(i) The average speed of the train between stations is fairly constant. Explain how a passenger travelling from Paddington to Marylebone could tell that Edgware Road is actually closer to Marylebone (Fig. 10.1B) than to Paddington (Fig. 10.1A).

[1]

(ii) Fig. 10.1A shows that the track between Baker Street and Regent's Park consists of three straight line segments joined by quite sharp curves.

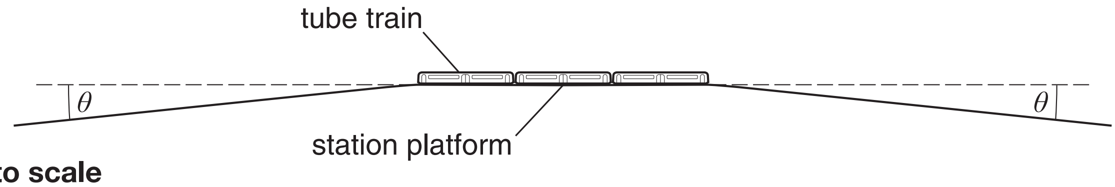
A passenger, who is not able to see out of the window, is travelling between these stations at a steady speed. Suggest and explain how she could tell that the continuous curve of Fig. 10.1B is actually the correct arrangement.

[2]

(iii) Suggest why the 'traditional' tube map of Fig. 10.1A has remained popular since its design by Harry Beck in 1933, even though it is not an accurate representation of the positions of the stations and the directions of the lines.

[1]

(b) Many of the stations on the London underground rail system are higher than the track either side of the station (Fig. 10.2).



not to scale

Fig. 10.2

(i) The angle θ between the track and the horizontal on each side of this station platform is 1°.

Show that the component of the train's weight acting parallel to the track when approaching or leaving the station is about one-fiftieth of its weight.

You may draw a vector diagram to help your answer.

[2]

(ii) Describe the effect of this force on the motion of the train when approaching, and when leaving, the station.

[2]

(iii) At each station the train has to stop and then start again. Explain why the arrangement of Fig. 10.2 wastes less energy, as compared with having the station on a perfectly level track.

[2]

[Total: 10]

11 This question is about satellite observations of the level of the oceans.

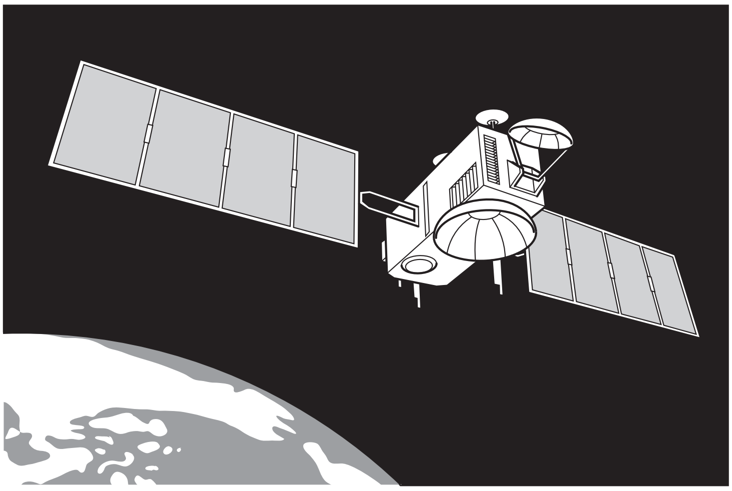


Fig. 11.1

The satellite Jason-1 observes water levels by reflecting microwaves off the ocean surfaces.

(a) The satellite orbits at a height of 1.3×10^6 m above the Earth's surface and completes an orbit in 1.9 hours (6800 s).

radius of the Earth = 6.4×10^6 m

(i) Show that the satellite is moving at a speed of about 7 km s^{-1}.

[3]

(ii) Calculate the distance moved by the satellite in the time it takes for a pulse of electromagnetic radiation to go from the satellite to the ocean surface and back again.

speed of electromagnetic radiation, $c = 3.0 \times 10^8$ m s^{-1}

distance = ... m **[2]**

(b) By diffraction, the microwaves leaving Jason spread out as shown in Fig. 11.2.

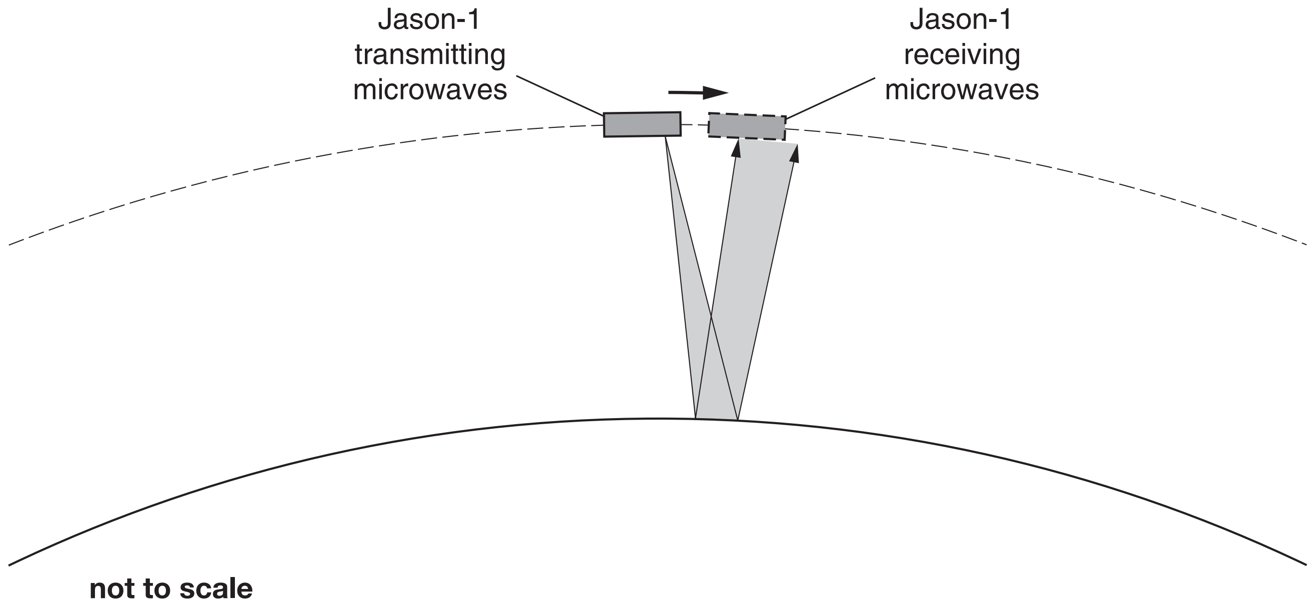


Fig. 11.2

The spreading out due to diffraction has both advantages and disadvantages in measuring the mean height of the ocean surface.

Suggest and explain **one** advantage and **one** disadvantage.

You should ensure that your explanation is clear, with correct spelling and punctuation.

[4]

[Total: 9]

[Section B Total: 40]

Section C

The questions in this section are based on the material in the insert.

12 This question is about the article *Plot and look*.
An experiment investigates the horizontal distance travelled by a marble fired from a launcher.
The launcher is a tube containing a spring which can be compressed by different amounts.

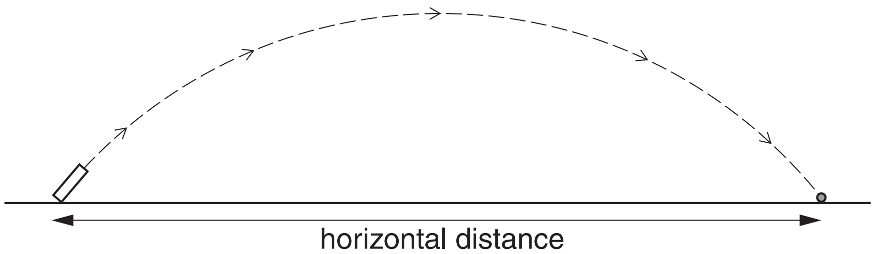
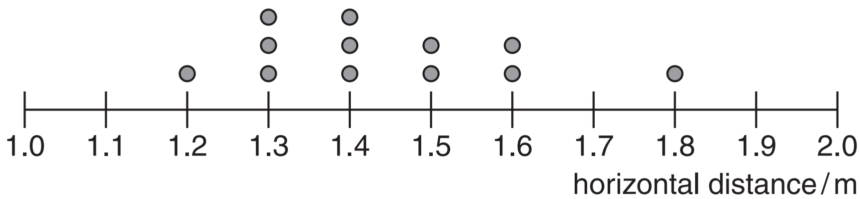


Fig. 12.1

The following dot plot shows a set of results for a marble fired at an angle of 60° with a particular compression of the spring in the launcher.



(a) (i) Calculate the mean and spread of the data values **leaving out** the result of 1.8 m.

horizontal distance = ... ± .... m **[2]**

(ii) Use the answer to **(i)** to show that the value of 1.8 m is probably not an outlier.

[1]

(b) Explain why including the value of 1.8 m makes little difference to the mean value, but it does considerably change the spread.

[2]

(c) Suggest and explain one thing the experimenter might have done to give the slightly high reading of 1.8 m.

[2]

[Total: 7]

13 This question is about the article *How can you measure the diameter of an extremely thin wire in a school laboratory?*
The practical problem given to the students was to determine the radius r of extremely thin steel wire by an **indirect** method.

(a) It is difficult to obtain a precise value, with small uncertainty, of the diameter of a thin steel wire by measurement with a micrometer. The steel wire is only about 10^{-4} m in diameter and the smallest scale division on a micrometer is $\frac{1}{100}$ mm.

Using this information, explain why making a **direct** measurement of the diameter of the wire using a micrometer is likely to give a value with a large uncertainty.

[2]

(b) Each of the **indirect** methods described in the insert relies on an equation.

Show how the equation $m = \pi r^2 \rho x$, used in **Method 2**, follows from the definition of density as mass per unit volume.

[2]

(c) The results obtained using **Method 1** are recorded below.

The student has estimated the uncertainty in each measurement, as shown in data set 1.

data set 1

$x = 180 \pm 0.5\,\text{cm}$
$\Delta x = 2.6 \pm 0.1\,\text{mm}$
$F = 1.60 \pm 0.01\,\text{N}$

(i) Show that these data, when used in the equation $\frac{F}{\pi r^2} = E\frac{\Delta x}{x}$, lead to a calculator value of $4.098 \times 10^{-5}\,\text{m}$ for the radius r.

Young modulus of steel, $E = 2.1 \times 10^{11}\,\text{Pa}$

[2]

(ii) Explain why the value for r obtained from these results should not be given to more than **two** significant figures.

[2]

(iii) It is suggested that the measurement of the length x could easily be done with smaller uncertainty of $\pm$ 0.1 cm, and that this would improve the measurement. Explain why this suggestion is **not** very sensible.

[1]

(iv) Calculate the **percentage** uncertainty in the value of r caused by the uncertainty in the measurement of the extension Δx. Give your answer to an appropriate number of significant figures.

percentage uncertainty = ... % **[4]**

(d) In **Method 2** the student took a length $x = 1.80\,\text{m}$ of the wire.
The mass m of this length of wire was measured on a top-pan balance.

The results are recorded in data set 2.

data set 2

$x = 180 \pm 0.5\,\text{cm}$
$m = 0.072 \pm 0.001\,\text{g}$

The density of the steel $\rho = 7.8 \times 10^3\,\text{kg}\,\text{m}^{-3}$
These results lead to a calculator value of $4.040 \times 10^{-5}\,\text{m}$ for the radius r.

The two methods to determine the radius r of the steel wire yield slightly different results, as shown in the table below.

Method 1	**Method 2**
$r = 4.1 \times 10^{-6}\,\text{m}$	$r = 4.0 \times 10^{-6}\,\text{m}$

(i) By considering data set 1 and data set 2, state with reasons which method has given the value of r with the smaller uncertainty.

[2]

(ii) One suggestion for improving these experiments is to use a greater length of wire.
Choose **one** of the two methods and explain whether increasing the length to $x = 10\,\text{m}$ could improve the measurement. Comment on its practicality.

[2]

[Total: 17]

14 **(a)** This question is about the article *Galileo, gravity and projectiles*.
Explain why 'Measurement of short time intervals was difficult in 1606, when Galileo did this experiment, but measurement of distance was easy.'

[2]

(b) **(i)** Show that a 0.025 kg ball rolling down the ramp through a vertical height of 1.0 m will gain a little under 0.25 J of total kinetic energy.

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

[1]

(ii) Show that a 0.025 kg ball which is **not** rolling must be travelling at over $4\,\text{m}\,\text{s}^{-1}$ to have 0.25 J of kinetic energy.

[1]

(iii) For the **rolling** ball, the correct kinetic energy equation is

$$\textbf{total}\text{ kinetic energy} = \frac{7}{10}\,mv^2.$$

Use this equation to calculate the velocity v of the rolling ball as it leaves the table and to check the statement in the insert that 'the horizontal velocity of the ball as it leaves the table is less than you might calculate for an object sliding down the ramp without rolling'.

[3]

(iv) If Galileo had used a **flat** 0.025 kg mass sliding down the ramp, the sliding mass would have left the table slower than the rolling ball, **not** faster. Explain why.

[2]

(c) Using the mathematics of projectiles and the equations of motion – which Galileo did much to create – it can be shown that $D^2 \propto H$. See Fig. 2 in the Insert.

(i) Complete this table.

H / m	D / m	D^2 / m^2
1.00	1.50	2.25
0.83	1.34	1.80
0.80	1.33	1.77
0.65	1.17	
0.30	0.80	

[1]

(ii) Complete the graph of Fig. 14.1 and plot a best-fit straight line.

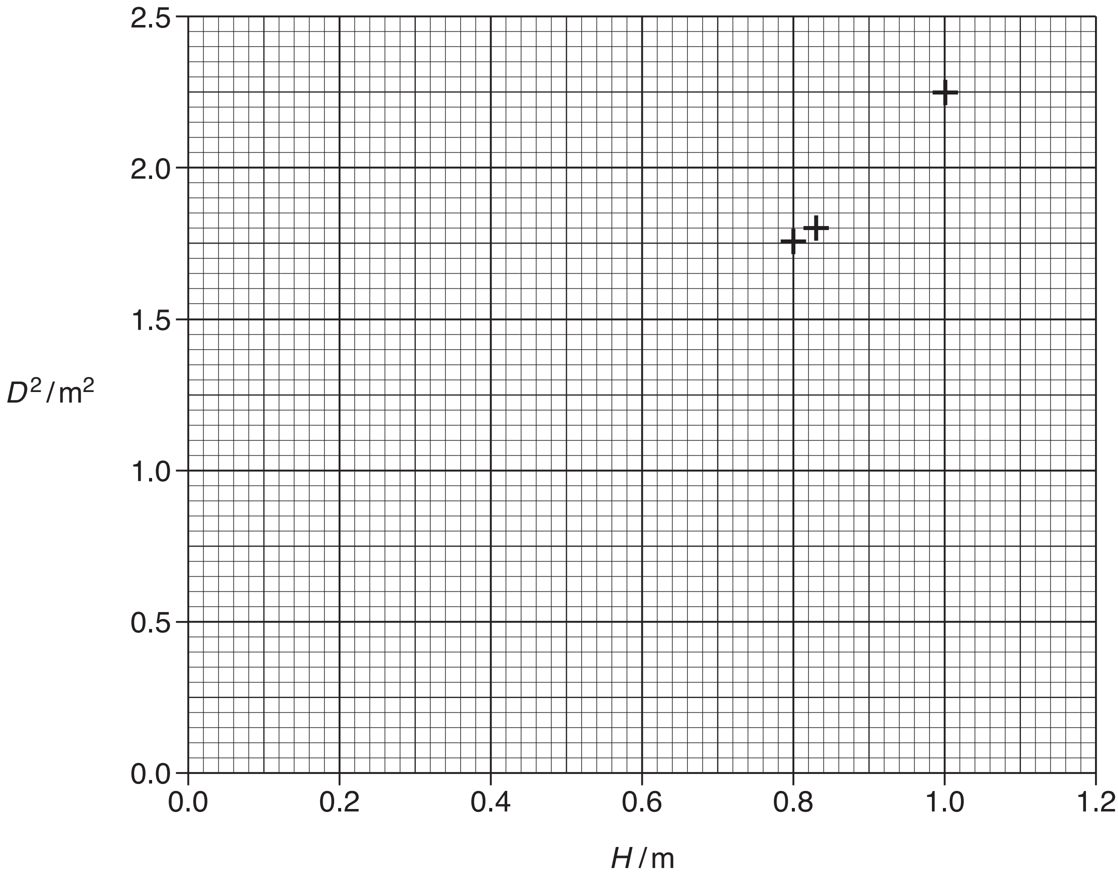


Fig. 14.1

State, with an explanation, whether Galileo's results fit the relationship $D^2 \propto H$.

[3]

(iii) The gradient of the straight line should be $\frac{20}{7}Y$, where Y is the height of Galileo's table shown in Fig. 2 in the Insert.

Calculate the gradient of the straight line, and show that the table height Y is about 0.80 m.

[3]

[Total: 16]

[Section C Total: 40]

END OF QUESTION PAPER

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ADVANCED SUBSIDIARY GCE

PHYSICS B (ADVANCING PHYSICS) G492

Unit G492: Understanding Processes / Experimentation and Data Handling

INSERT

Thursday 21 May 2009
Afternoon

Duration: 1 hour 45 minutes

OCE/T78616

INSTRUCTIONS TO CANDIDATES

- This insert contains the article required to answer the questions in Section C.

INFORMATION FOR CANDIDATES

- This document consists of **8** pages. Any blank pages are indicated.

1. Plot and look

When collecting data which is varying, it is a good idea to make a simple, quick plot of the values. One method is a 'dot plot', which can produce results like those in Fig. 1.

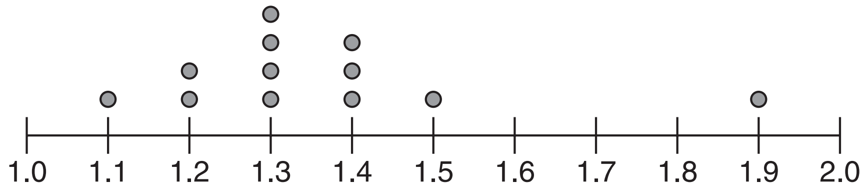

Fig. 1

With a dot plot, you can look at the distribution of values and identify any outliers. Excluding the outlier, you can find the **mean** of the distribution and the **spread**, or uncertainty about the mean, which is half of the range.

This procedure gives a value of 1.3 ± 0.2 for these data. A good rule of thumb is that a value is likely to be an outlier if it lies more than $2 \times$ spread from the mean. Here the outlier is three times the spread from the mean value which seems suspiciously far, but this does not imply that it is definitely an error.

2. How can you measure the diameter of an extremely thin wire in a school laboratory?

You may wish to try out these ideas in the laboratory so that you will know in advance what the difficulties might be, how the experiment works and how the data can be processed.

Making a good measurement of the diameter of extremely thin steel wire by **direct** measurement with a micrometer is not feasible due to the limited resolution of a micrometer.

The diameter of the wire is thought to be about 10^{-4} m.

Two students were given the following practical problem to solve:

> Determine the radius *r* of very thin steel wire by an **indirect** method.
>
> Choose a method which you think can give a better measurement of the radius *r* than can be achieved with a micrometer. Aim to reduce both the uncertainty and any systematic error.

Here is a brief description of the methods chosen by the students.

Method 1:

Measure the extension Δx of a length x of the steel wire under an applied force F.

Calculate the radius r from

$$\frac{F}{\pi r^2} = E\frac{\Delta x}{x}$$

where E is the Young modulus of the steel.

Method 2:

Measure the mass m of a length x of the steel wire.

Calculate the radius r from

$$m = \pi r^2 \rho x$$

where ρ is the density of the steel.

A book of Physical Constants gives the following values for the Young modulus E and density ρ for steel:

$$E = 2.1 \times 10^{11}\ \text{Pa}$$
$$\rho = 7.8 \times 10^{3}\ \text{kg m}^{-3}$$

3. Galileo, gravity and projectiles

It is commonly stated that Galileo dropped heavy and light objects off the Leaning Tower of Pisa. He probably did not do this, but he most certainly did experiments to investigate gravity.
One of his experiments used the arrangement shown in Fig. 2.

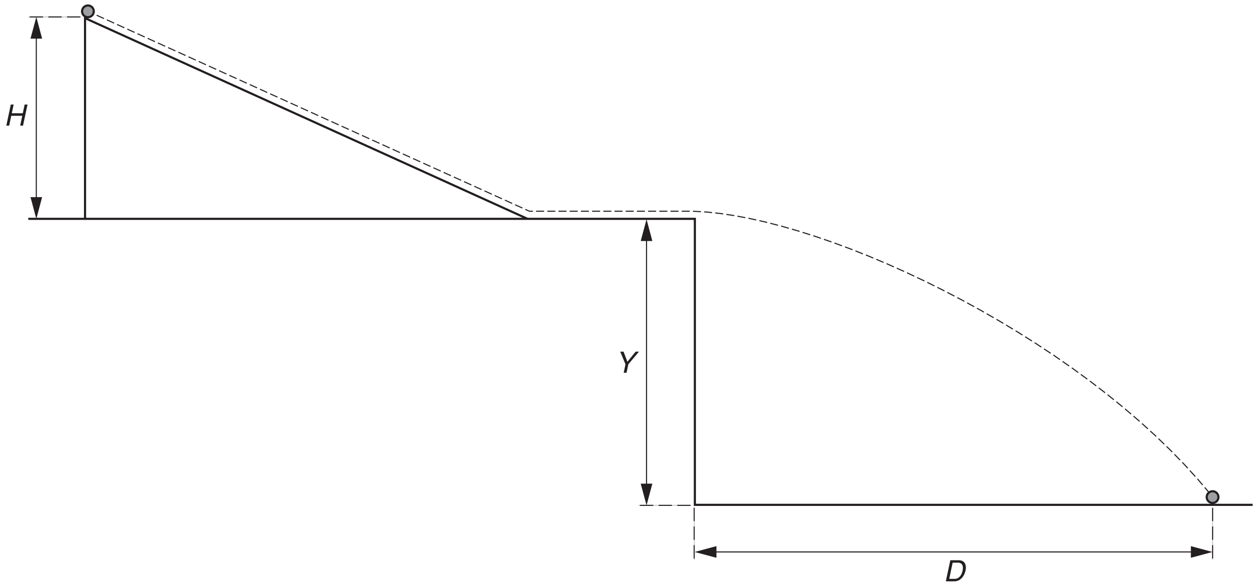

Fig. 2

A solid ball was rolled down a ramp standing on a table, starting at a height *H* above the table. The ball moved for a short distance along the table and then moved through the air, as a projectile, hitting the ground a distance *D* from the bottom of the table.

Measurement of short time intervals was difficult in 1606, when Galileo did this experiment, but measurement of distance was easy. The results he obtained, and published, were:

H / 'points'	*D* / 'points'
1000	1500
828	1340
800	1328
650	1172
300	800

The unit of distance used by Galileo was the 'point' (punto). The 'point' was not a standard unit — there were 'points' of different sizes in different Italian cities. It is thought that in Pisa, where Galileo worked, a 'point' was about 1 mm.

Translation and rotation

For any object moving without rotating, the kinetic energy is given by the familiar equation

$$\text{translational kinetic energy} = \frac{1}{2}mv^2$$

where 'translation' means 'moving from one place to another'.

In Galileo's experiment, the ball is rolling, so it also has **rotational** kinetic energy. For a rolling ball, roughly $\frac{1}{4}$ of the total kinetic energy is rotational kinetic energy and roughly $\frac{3}{4}$ is translational kinetic energy. This means that the horizontal velocity of the ball as it leaves the table is less than you might calculate for an object sliding down the ramp without rolling.

END OF ARTICLE