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Thursday 8 June 2017 – Afternoon

AS GCE PHYSICS B (ADVANCING PHYSICS)

G492/01 Understanding Processes / Experimentation and Data Handling

Candidates answer on the Question Paper.

OCR supplied materials:
- Insert (Advance Notice for this question paper) (inserted)
- Data, Formulae and Relationships Booklet (sent with general stationery)

Other materials required:
- Electronic calculator
- Protractor
- Ruler (cm / mm)

Duration: 2 hours

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- The Insert will be found inside this document.
- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the barcodes.

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 **28** pages. Any blank pages are indicated.

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POST-EXAMINATION CORRECTION

Thursday 8 June 2017 – Afternoon

AS GCE Physics B (Advancing Physics)

G492/01 Understanding Processes / Experimentation and Data Handling

The following is a correction to the published examination paper to make it more suitable for practice material.

Page 9, question 8b(i), 19 must be changed to -19.

Page 24, question 13d, in the table heading in the third column 10^6 should be changed to10^{-6}.

Any enquiry about this notice should be referred to the Customer Contact Centre on 01223 553 998 or general.qualifications@ocr.org.uk

Jun17/post-exam correction

Answer **all** the questions.

SECTION A

1 Here is a list of physical quantities.

force **kinetic energy** **mass** **power** **velocity**

(a) Which quantity can be measured in $kg\,m\,s^{-2}$?

.... **[1]**

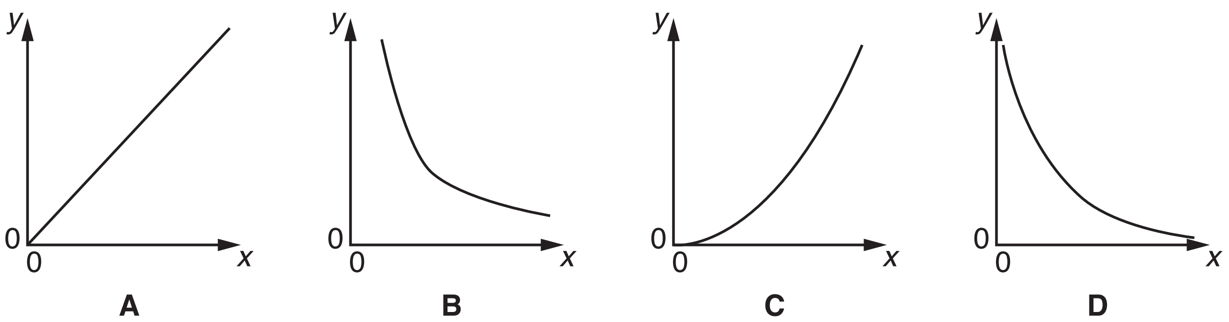
(b) Which of the quantities are vectors?

.... and .... **[1]**

(c) Choose **two** of the quantities from the list to complete the following equation.

.... = force × .... **[1]**

2



Which graph, **A**, **B**, **C** or **D**, is obtained when the *y* and *x* axes represent the two quantities given in each case below?

(a) *y*-axis: the potential energy gained when an object is lifted under gravity
x-axis: the vertical height though which it is lifted

.... **[1]**

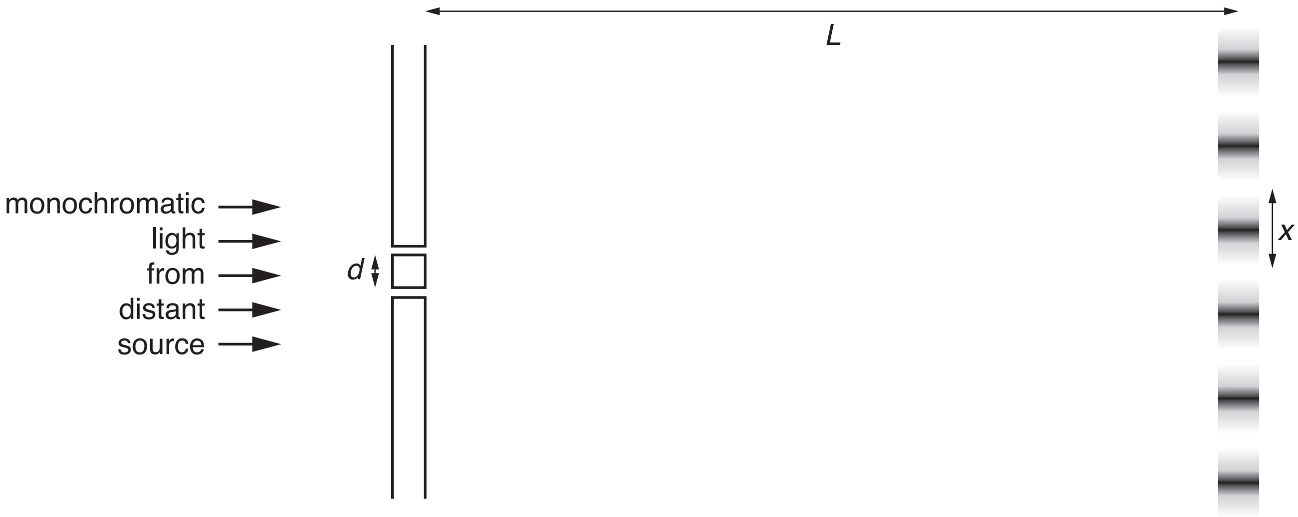
(b) *y*-axis: the velocity of an object falling from rest in a vacuum under gravity
x-axis: the time for which it has fallen

.... **[1]**

(c) *y*-axis: the frequency of light in a vacuum
x-axis: the wavelength of the light

.... **[1]**

3 Monochromatic light (light of one wavelength only) from a distant source falls upon two narrow slits separated by a distance $d = 0.65\,\text{mm}$.
A pattern of bright and dark bands, called fringes, each separated by a distance x, is seen on a screen a distance L away.

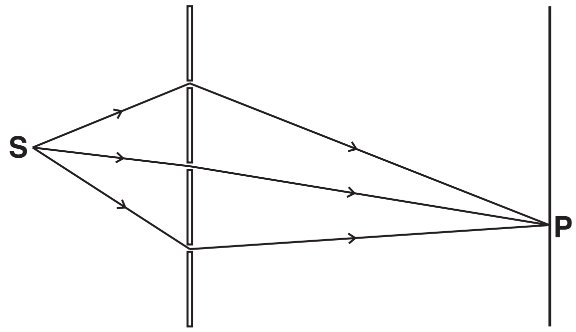


Light of wavelength $\lambda = 630\,\text{nm}$ is used and the screen is at a distance $L = 3.2\,\text{m}$ from the two slits.

Calculate the separation of the fringes x.

x = ... m **[3]**

4 The diagram shows three different paths for a photon travelling from a source **S** to a point **P** on a distant screen.

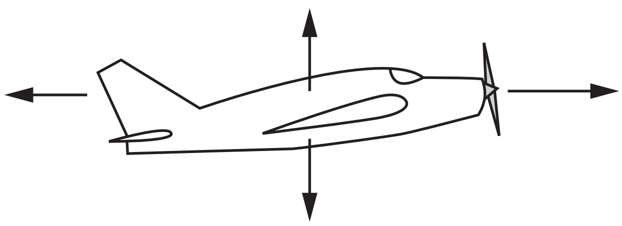


At **P**, the phasor for each path has the same amplitude as shown by this arrow:

Draw a diagram to show a combination of the three phasors which would give zero light intensity at **P**.

[2]

5 The diagram shows the forces acting on a model plane in flight.

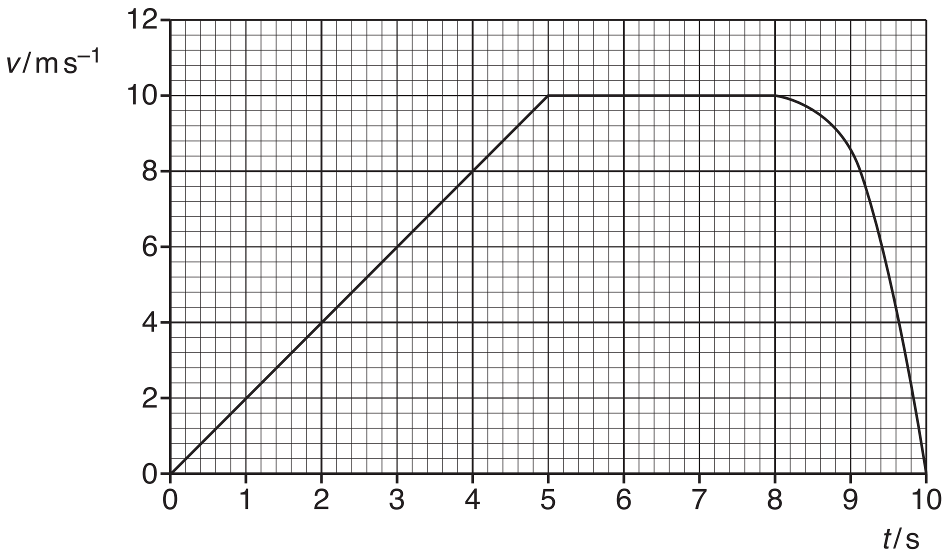


Calculate the magnitude of the acceleration of the plane at the time shown in the diagram.

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

a = ... m s^{-2} **[4]**

6 The velocity-time graph describes the motion of a car.



(a) Calculate the distance travelled by the car in the first 6 seconds.
You should show your working.

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

(b) Use the graph to estimate the deceleration of the car at $t = 8.5$ s.
You should show your working.

deceleration = ... $m\,s^{-2}$ **[3]**

SECTION B

7 This question is about standing waves of sound in a tube.

(a) A small loudspeaker is placed near to the open end of a tube closed at the other end (Fig. 7.1).

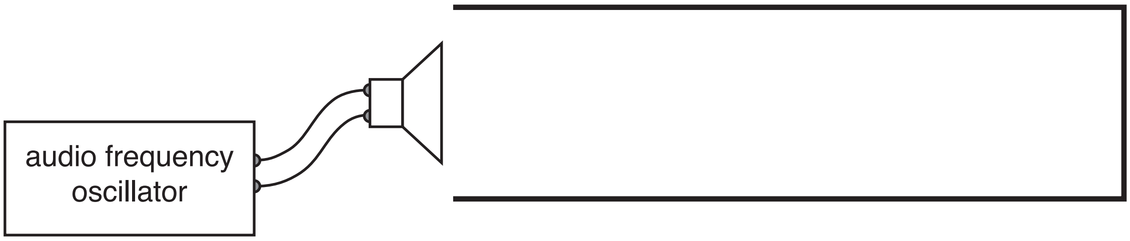


Fig. 7.1

(i) Explain how standing waves are set up in the tube.

....

....

....

.... **[2]**

(ii) State and explain what would be heard as the frequency of the oscillator is increased through the audible range from low frequency to high frequency.

....

.... **[2]**

(b) The speed of sound in the air in the tube is 340 m s^{-1}.
The loudspeaker emits a note of frequency 1.7 kHz.

(i) Calculate the wavelength of the sound wave in the tube.

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

(ii) The tube is 0.25 m long, as shown in Fig. 7.2.
Mark the positions of the nodes and antinodes in Fig. 7.2.
Label each node **N** and each antinode **A**.

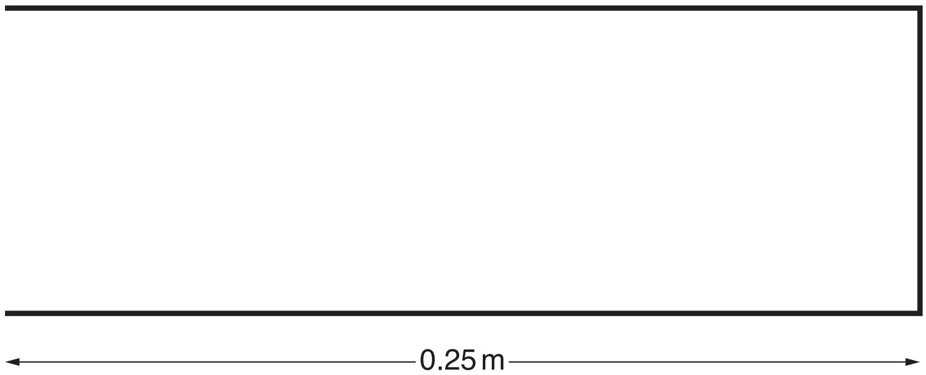


Fig. 7.2

[3]

(c) The air in the tube is replaced with helium gas in which the speed of sound is 920 m s^{-1}.

Calculate the length of tube which would be required to produce the same standing wave pattern at the same frequency of 1.7 kHz in helium gas.

length of tube = ... m **[2]**

8 This question is about photon energies.

(a) An excimer laser is a powerful type of laser which emits ultraviolet radiation in a series of regularly-spaced pulses.

The frequency of the radiation emitted by the laser is 1.7×10^{15} Hz.

(i) The energy in each pulse is 25 mJ.

Calculate the number of photons in each pulse.

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

number = ... **[2]**

(ii) The laser has a mean output power of 4.5 W.

Calculate the number of pulses emitted each second by the laser.

number per second = ...s^{-1} **[1]**

(iii) Each pulse of radiation lasts for 1.2×10^{7} periods of the ultraviolet radiation.
Show that the power during the pulse is about 8×10^{5} times greater than the mean output power of the laser.

[2]

(b) A photon emitted from the excimer laser strikes a nickel metal surface, causing it to emit an electron.

The minimum energy required to release an electron from a nickel surface is 8.3×10^{-19} J.

(i) Show that the maximum kinetic energy of the emitted electron is about 3×10^{19} J.

[1]

(ii) A green laser emits light of wavelength three times that of the excimer laser. Explain why the green laser would not be able to make the nickel surface emit electrons.

....

....

.... **[2]**

(c) Excimer lasers are used to cut through materials. Unlike many ultraviolet lasers, which also emit visible light, this laser emits only ultraviolet radiation.

Suggest and explain one hazard of working with this laser in a laboratory.

....

....

.... **[2]**

9 This question is about a projectile.
Fig. 9.1 shows a multi-flash picture of the motion of a dried pea fired horizontally from a pea-shooter in a classroom. The effect of air resistance is negligible.

Fig. 9.1

(a) The time interval between successive flashes is constant. At each flash, the new position of the pea is shown on the picture as a bright image on the dark background.

The horizontal displacement of the pea increases by equal amounts between flashes but the vertical displacement increases by increasing amounts.

Explain these observations.

[2]

(b) Describe how the multi-flash picture would have differed from Fig. 9.1 if the pea were replaced with a sphere made of low-density material such as polystyrene foam.

In your answer, you should consider the effect on both the horizontal and the vertical motion observed at regular time intervals.

[4]

(c) The pea is fired horizontally at a speed v from a vertical distance y above the floor. It strikes the ground a time t later after travelling a horizontal distance x, as shown in Fig. 9.2.

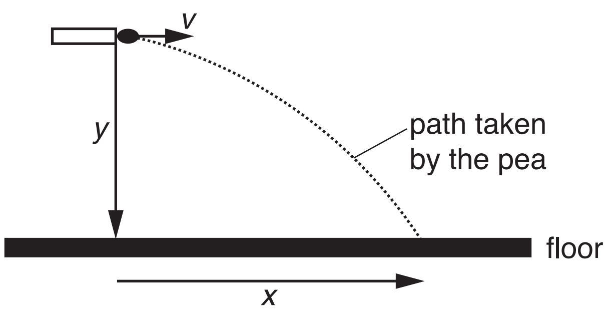


Fig. 9.2

The horizontal range x and the vertical distance fallen y are given by the equations

$$x = vt \qquad \text{and} \qquad y = \frac{1}{2}gt^2$$

where g is the acceleration due to gravity.

Show that these two equations can be combined to give the range x of the pea:

$$x = v\sqrt{\frac{2y}{g}}$$

[2]

(d) The pea-shooter is fired horizontally from a height of 1.5 m above the ground.

Calculate the speed v at which the dried pea must leave if it is to hit the bottom of a waste bin 2.6 m away.

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

v = ... $\mathrm{m\,s^{-1}}$ **[2]**

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Question 10 begins on page 14

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10 This question is about a gannet, a large sea bird that dives to catch fish.
Gannets dive from a great height h above the sea to a remarkable depth d (Fig. 10.1).

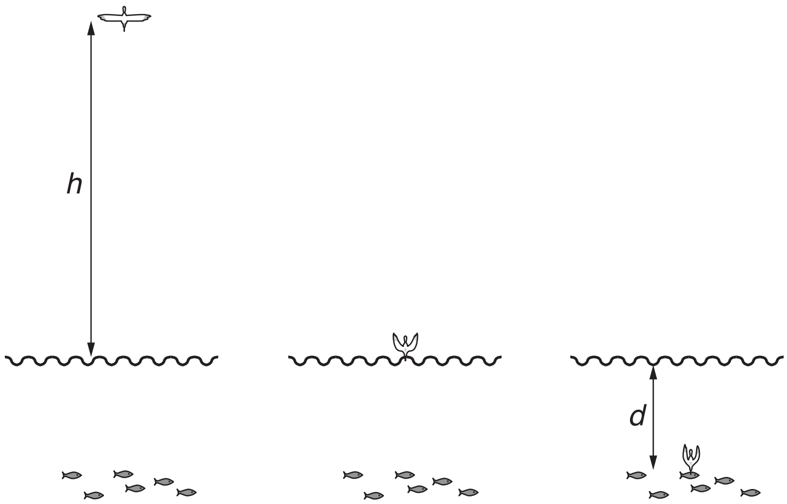


Fig. 10.1

(a) Starting at a height h above the surface of the sea, the gannet folds its wings so that it falls vertically under gravity with negligible air resistance.

Calculate its velocity at the surface after plunging from a height h of 25 m.

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

v = ... $\text{m}\,\text{s}^{-1}$ **[3]**

(b) **(i)** Calculate the kinetic energy E_k of the gannet as it enters the water.

mass of gannet = 2.8 kg

E_k = ...J **[1]**

(ii) State where this kinetic energy comes from.

[1]

(c) After entering the water, there is a resultant upward force F on the gannet which brings it to rest in a distance d of 8.0 m
This force varies with the distance x below the water surface as shown in the graph of Fig. 10.2.

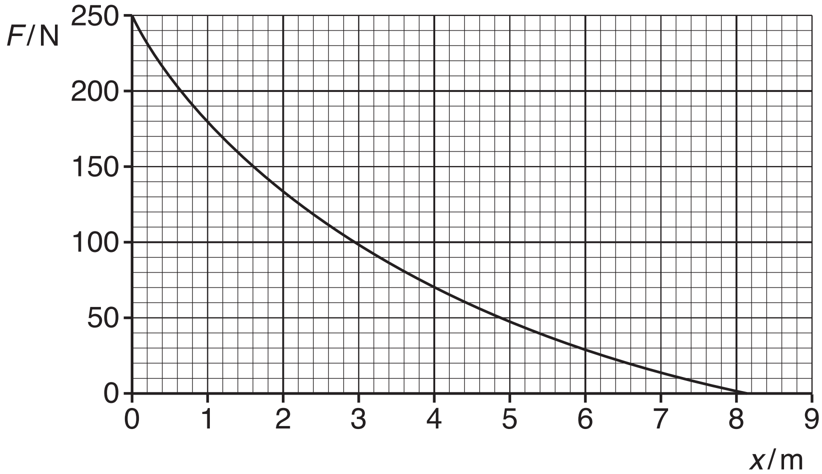


Fig. 10.2

(i) Describe the way in which the force varies, and suggest an explanation for this variation.

....

....

....

.... **[2]**

(ii) Use the graph of Fig. 10.2 to calculate the work done as the gannet travels the distance of 8.0 m

Make your method clear.

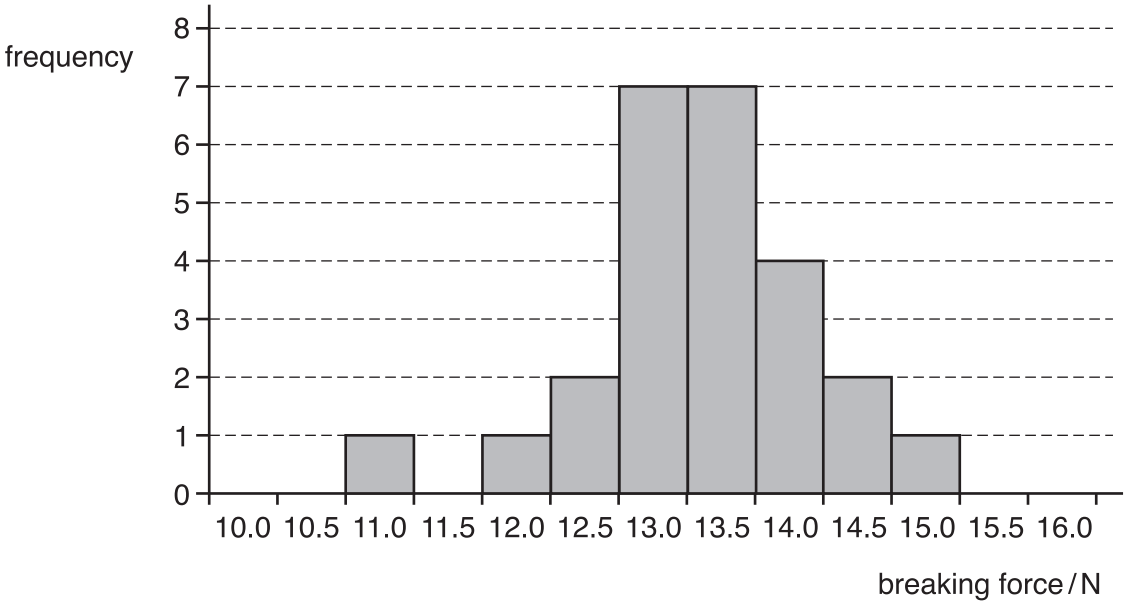
[3]

SECTION C

11 This question is about the article *Uncertainty in a calculated result*.

(a) Students in a class measured the force needed to break 25 samples of copper wire from the same reel.

Their results are shown in the chart.



(i) Explain why the single value at 11.0 N should **not** be considered to be an outlier. You can assume that the mean of the results excluding that value is between 13.0 and 13.5 N

[2]

(ii) Use data from the chart to calculate the mean breaking force of the copper wire and the uncertainty in that mean force. Express your answers to an appropriate number of significant figures.

breaking force = ... ± .... N **[3]**

(b) The diameter of the wire used was measured several times along its length, using a micrometer of resolution 0.005 mm.

The reading was 0.46 mm each time.

Use these values, together with your results to **(a)(ii)**, to explain why the uncertainty in measurement of the diameter can be ignored in calculation of the breaking stress of copper. Support your statement with appropriate calculations.

[3]

(c) Use your results to calculate the breaking stress of copper, including its uncertainty, expressed in MPa.

breaking stress = ... ± .... MPa **[3]**

12 This question is about the article *Spectacles for the Third World.*

Melanie, the engineer designing the simple method of measuring the focal length of diverging lenses, set up the experiment as detailed in the article.

She sets up the arrangement shown in Fig. 12.

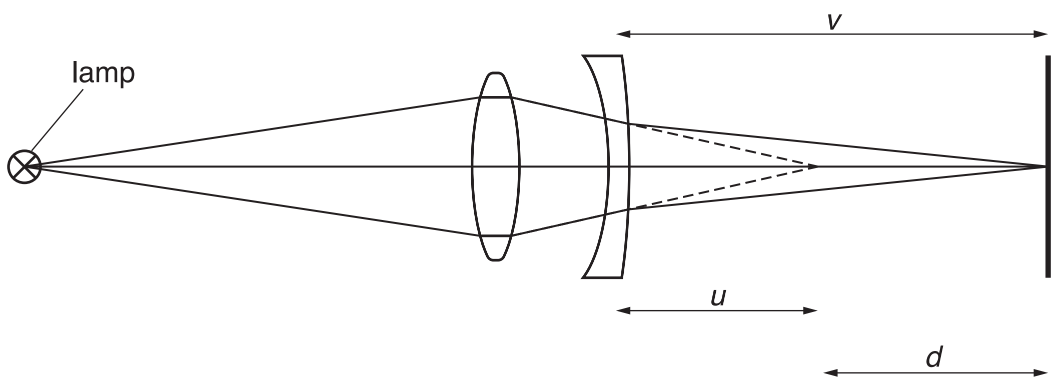


Fig. 12

(a) In a preliminary experiment, the engineer measured *v* with a typical diverging spectacle lens and different converging lenses to investigate the best converging lens to use.

For each arrangement, she recorded the largest and smallest values of *v* which gave a sharp image.

Her preliminary results are shown in this table.

converging lens power / D	smallest value of v / cm	largest value of v / cm
3	19.5	21.0
6	10.3	11.3
9	6.3	6.5

Decide which of the three converging lenses would be the best to use in this method.
Make your method clear.

[3]

(b) Using her chosen converging lens, Melanie makes measurements on a typical diverging lens.

She determines the distance v as shown above by adjusting the position of the screen until a sharp image was seen. She judges that this was within a range of values $39.2\,\text{cm} \leqslant v \leqslant 40.8\,\text{cm}$.

Melanie then removes the diverging lens and measures the distance that she needs to move the screen until a sharp image is produced by the converging lens alone.

She judges that d is within a range of values $12.1\,\text{cm} \leqslant d \leqslant 12.9\,\text{cm}$.

(i) Write down the range of values of u given by these measurements. Show your working clearly.

.... cm $\leqslant u \leqslant$ .... cm **[3]**

(ii) State why it is necessary to convert these values from cm to m before calculating the power of the lens.

[1]

(c) Use the values of u and v to calculate the power $P = \dfrac{1}{v} - \dfrac{1}{u}$ of the diverging lens and its uncertainty. Remember that, for the diverging lens set up as in Fig. 12, both u and v are positive.

P = ... ± .... D **[4]**

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13 This question is about the article *Measuring the Planck constant using LEDs*.

(a) Simon sets up the experiment described in the article in a dark room.
Explain why he does this.

[1]

(b) Simon repeats the reading of V_s for the deep red LED five times and uses the values to obtain the mean value of V_s and its uncertainty as $1.94 \pm 0.3\,V$.

He decides to use this same uncertainty of $\pm\ 0.3\,V$ for each value of V_s throughout the experiment and to measure V_s just once for each LED.

Evaluate this assumption.

In your answer, you should consider both advantages and disadvantages.

[4]

(c) (i) Show that the striking voltage for an LED of wavelength λ is given by

$$V_s = \frac{hc}{e\lambda}.$$

[3]

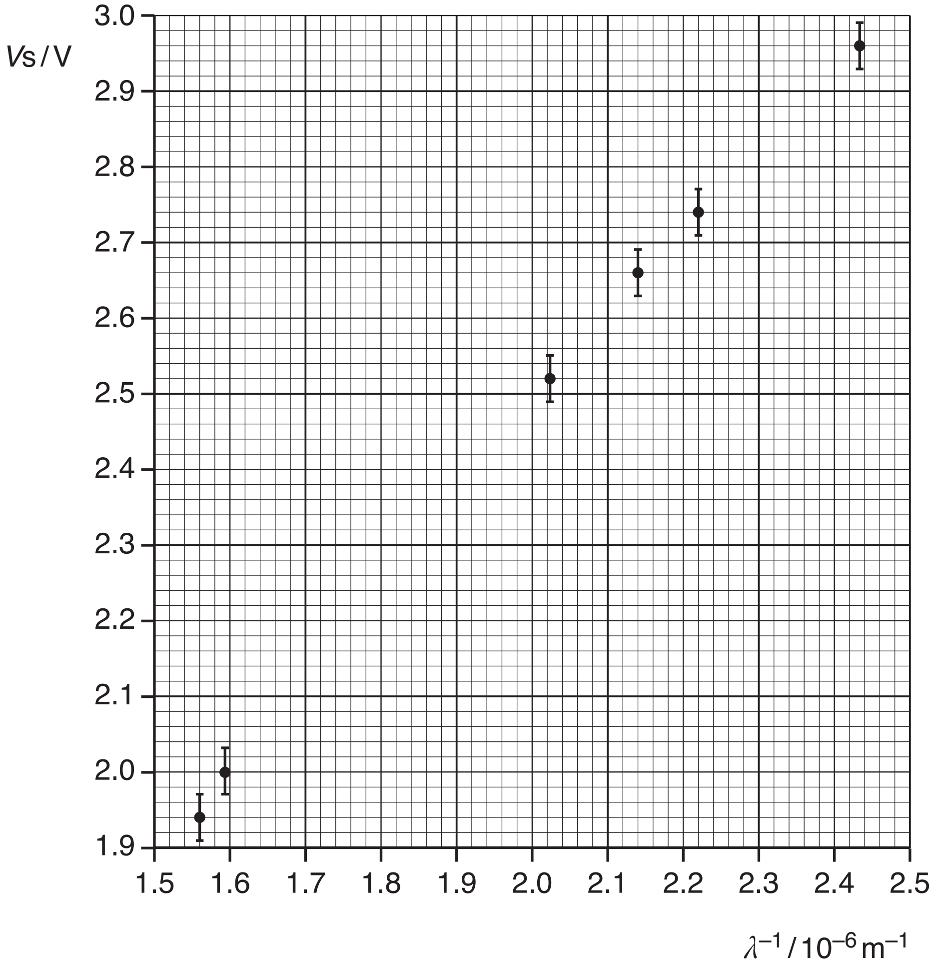
(ii) Explain why you would expect a graph of V_s (y-axis) against $\frac{1}{\lambda}$ (x-axis) to be a straight-line with gradient $\frac{hc}{e}$.

[1]

(d) Data from Simon's experiment are shown in the table below.

LED colour	λ/nm	$\lambda^{-1}/10^6\,m^{-1}$	V_s/V	ΔV_s/V
deep red	641	1.56	1.94	± 0.03
red	627	1.59	2.00	± 0.03
yellow	600		2.08	± 0.03
green	574		2.17	± 0.03
turquoise	494	2.02	2.52	± 0.03
blue	468	2.14	2.66	± 0.03
deep blue	451	2.22	2.74	± 0.03
violet	411	2.43	2.96	± 0.03

(i) Complete the table, plot the two missing points on the graph opposite and draw a best-fit straight line. **[3]**



(ii) Determine the gradient of the line.

gradient = ... V m **[3]**

(iii) Use your value of the gradient to determine the Planck constant, *h*.

$c = 3.0 \times 10^{8}\,\mathrm{m\,s^{-1}}$
$e = 1.6 \times 10^{-19}\,\mathrm{C}$

h = ... J s **[3]**

ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

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G492/01 Understanding Processes / Experimentation and Data Handling

Duration: 2 hours

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INSTRUCTIONS TO CANDIDATES

- This Insert contains the material required to answer the questions in Section C.

INFORMATION FOR CANDIDATES

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1 Uncertainty in a calculated result

When thinking about the uncertainty in an experiment, you need to consider the uncertainty in every measurement. It is important to identify the most uncertain measurement, because this is the measurement which will be most worthwhile improving. Also, this uncertainty is the one which contributes most to the uncertainty of the final result. Fig. 1 shows a chart of repeated measurements of the breaking force of samples of the same cotton thread.

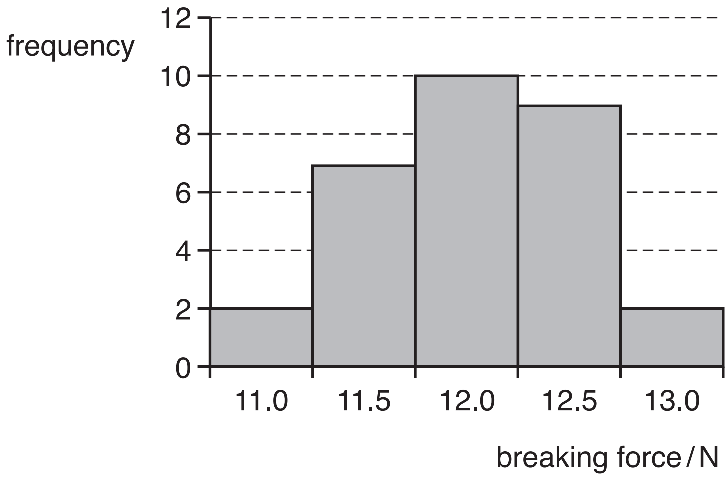

Fig. 1

There are no outliers in this data, and you can easily find the mean of the 30 measurements, which is 12.0 N. The spread (half the range) is 1 N, so the value is (12 ± 1) N, giving a percentage uncertainty of 8%.

Measuring the diameter of the same cotton thread with a micrometer shows that the diameter measurement is less variable than that of the breaking force, so you can get a minimum estimate of the variation in breaking stress from the variation in breaking force.

In this case, the diameter of the thread is 0.24 mm (2.4×10^{-4} m), giving a cross-sectional area of $4.5 \times 10^{-8}\,m^2$, so the breaking stress can be easily calculated for the maximum and minimum values of breaking force. This allows calculation of the mean breaking stress and also an estimate of its uncertainty.

2 Spectacles for the Third World

Many charities collect unwanted spectacle lenses for reuse in the Third World. The power of these lenses varies from +5D (converging) to –5D (diverging), with the majority being in the latter category. There is a need for a quick and easy-to-use method of measuring the power of these lenses when they arrive at their destination, using appropriate technology and expertise.

Measurement of the power of a converging lens is fairly straightforward. All you need is a beam of parallel light, a piece of stiff white card and a ruler, as shown in Fig. 2.

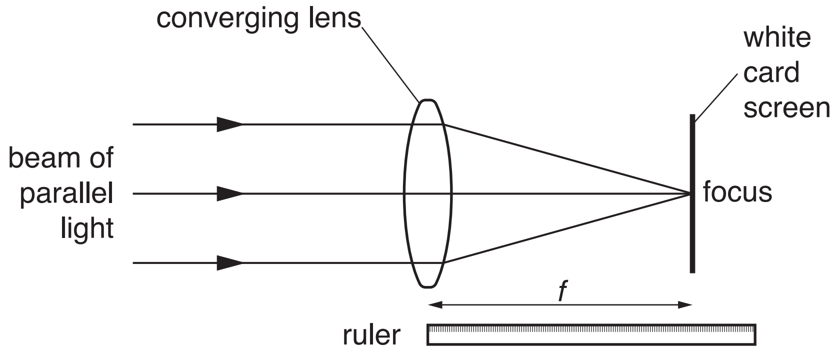

Fig. 2

This method does not work for a diverging lens. This is because the light which leaves the lens appears to come from a point behind it, where you cannot put a screen to find the focus, as shown in Fig. 3.

The way that a diverging lens *can* be made to focus light to a point on a screen is to use a converging lens to arrange for the incoming light beam to be already aiming to a focus, as shown in Fig. 4.

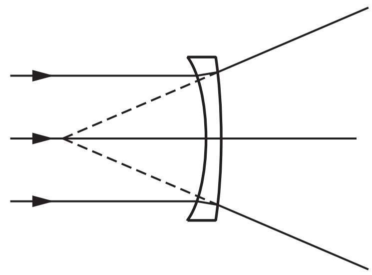

Fig. 3

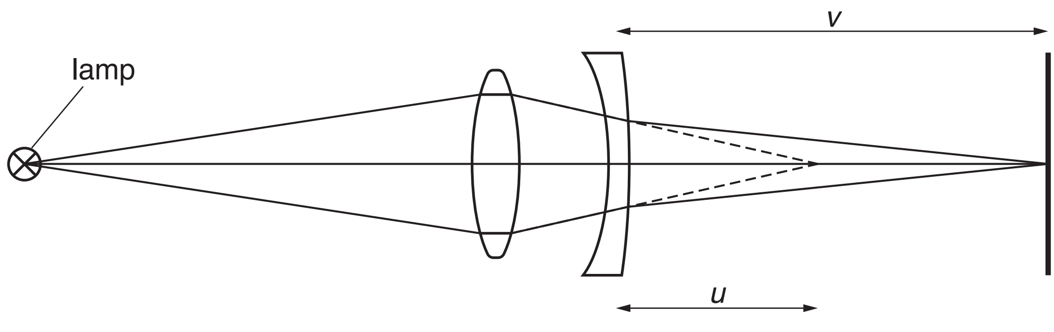

Fig. 4

A charity appoints an engineer, Melanie Brown, to design a simple method for use in the Third World to measure the power of diverging spectacle lenses. She uses the arrangement shown in Fig. 4 and follows this procedure:

- With both lenses in place, measure the distance from the diverging lens to the position of the screen where the light is focused. This is the image distance, v.
- Remove the diverging lens, and move the screen until the light is focused by the converging lens alone. The distance from where the diverging lens was placed to the new screen position is the object distance, u.

3 Measuring the Planck constant using LEDs

You may wish to try out this experiment in the laboratory so that you will know in advance how the experiment works, what the difficulties are and how the data can be processed. The quantisation of light as discrete packets of energy called photons can be explored experimentally using LEDs in a circuit such as that shown in Fig. 5.

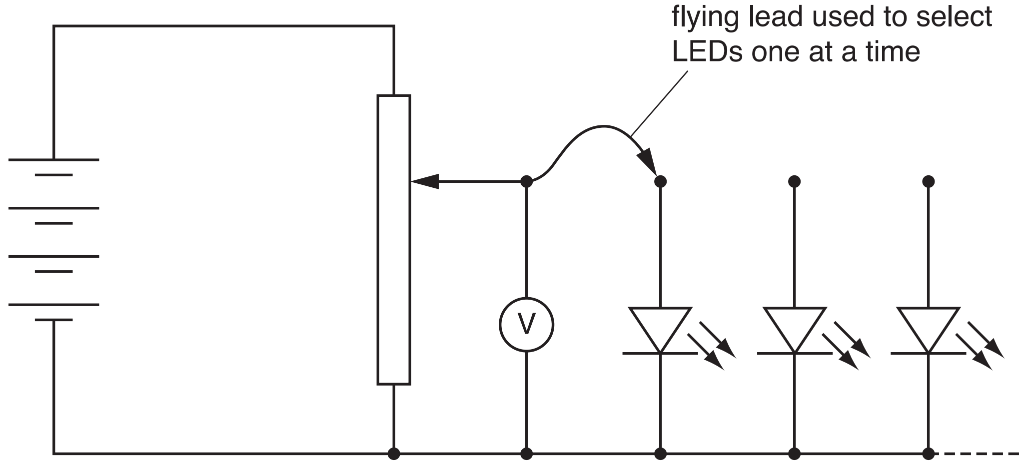

Fig. 5

The potential difference (p.d.) across the LED is gradually increased until it emits photons (strikes). The p.d. at which the LED just emits photons is known as the striking voltage V_s.

Each electron of charge e 'falling through' a p.d. V_s releases energy $E = V_s\, e$ as a single photon of light. The most significant uncertainties in this experiment are associated with consistently and accurately judging the voltage at which the LED strikes. To allow the strike to be detected with greater sensitivity, it is usual to shield the LED with a small opaque paper tube down which the observer can peer at the LED.

Data from one such experiment are shown in the table below.

LED colour	λ/nm	average V_s/V
deep red	641	1.94
red	627	1.98
orange	609	2.04
green	574	2.17
turquoise	494	2.52
blue	468	2.66
violet	411	3.02

Plotting an appropriate graph of the data obtained from the experiment allows a value for the Planck constant to be determined.

END OF ARTICLE

