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AS LEVEL

Examiners' report

PHYSICS A

H156

For first teaching in 2015

H156/02 Summer 2022 series

Version 1

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Contents

Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates.

The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. A selection of candidate answers are also provided. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report.

A full copy of the question paper and the mark scheme can be downloaded from OCR.

Advance Information for Summer 2022 assessments

To support student revision, advance information was published about the focus of exams for Summer 2022 assessments. Advance information was available for most GCSE, AS and A Level subjects, Core Maths, FSMQ, and Cambridge Nationals Information Technologies. You can find more information on our website.

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Paper 2 series overview

This is the second paper of the AS Physics course.

To do well on this paper candidates need to have an in-depth knowledge and understanding of the subject content in modules 3 and 4 as well as the foundation physics and practical skills in modules 1 and 2.

A good range of marks were achieved by candidates, and it did not appear that candidates were short of time. There are several questions on the paper which test the practical skills that candidates should have experienced in their AS course.

The quality of written work was variable. A significant number of candidates could have gained more marks by stating definitions correctly and carefully answering the questions set showing all their working. It is important for all candidates to understand key command terms such as state, describe, define, etc.

For numerical questions, candidates should state the equation that is to be used and substitute the data before evaluating an answer.

It is worth reminding candidates that their scripts are scanned and then electronically marked by examiners. It is therefore important that answers are not written outside the space provided for the answers. The legibility of some candidates' work remains a concern.

There were two levels of response (LoR) questions which gave candidates the opportunity of demonstrating their knowledge and understanding of physics. It is important that candidates answer the question set in a logical way with clear explanations. Candidates should also make sure that they answer the question set.

A number of the questions are designed to assess the practical skills that candidates have developed throughout their physics course. When planning experiments, candidates should identify the independent and dependent variables as well as the quantities which need to be kept constant. A description of how each quantity should be measured should be included.

There were also several "show" questions on the paper. These types of questions prevent candidates who struggle with one part of a question being penalised on the next part. These "show" questions do require candidates to clearly indicate their method. The unknown should be the subject of any equation – marks are not given for using the "show" value.

Candidates who did well on this paper generally did the following:	Candidates who did less well on this paper generally did the following:
• demonstrated good knowledge of definitions • wrote logical reasoned answers when answering explanation type questions • clearly demonstrated the working to numerical questions substituting in the appropriate numbers into stated equations • used technical terms correctly • demonstrated an understanding of practical skills	• omitted detail when answering explanation type questions • omitted to show clear substitution of data into equations in calculation questions • were unsure of some technical terms and did not know definitions.

Question 1 (a)

1 A student investigates the motion of a steel ball in oil in a laboratory.

The radius r of the ball is 8.1 mm.

(a) Describe how the student can determine r accurately in the laboratory.

....

....

....

.... **[3]**

Most candidates correctly stated the use of a micrometer (or calliper) to measure the diameter of the ball. Candidates who did not score highly either did not state that the radius was determined by dividing the diameter by two or stated that readings were just repeated and averaged rather than repeating the measurements of the diameter in difference directions.

Question 1 (b)

(b) The student uses a measuring cylinder and a digital balance to determine the density of the oil.
The student records the following measurements:

- mass of empty measuring cylinder = 96 g
- volume of oil added to measuring cylinder = 87 cm^3
- total mass of measuring cylinder and oil = 169 g

Show that the density of the oil is about 840 $kg\,m^{-3}$.

[2]

Most candidates were able to determine the mass of the oil correctly and divide the mass by the volume. A significant number of candidates did not demonstrate that 73 g was 0.073 kg and that 87 cm^3 was 87×10^{-6} m^3. More able candidates clearly showed how the cm^3 was converted to m^3.

Question 1 (c)

(c) The steel ball is submerged in the oil.

Show that the upthrust acting on the steel ball is 1.8×10^{-2} N.

[2]

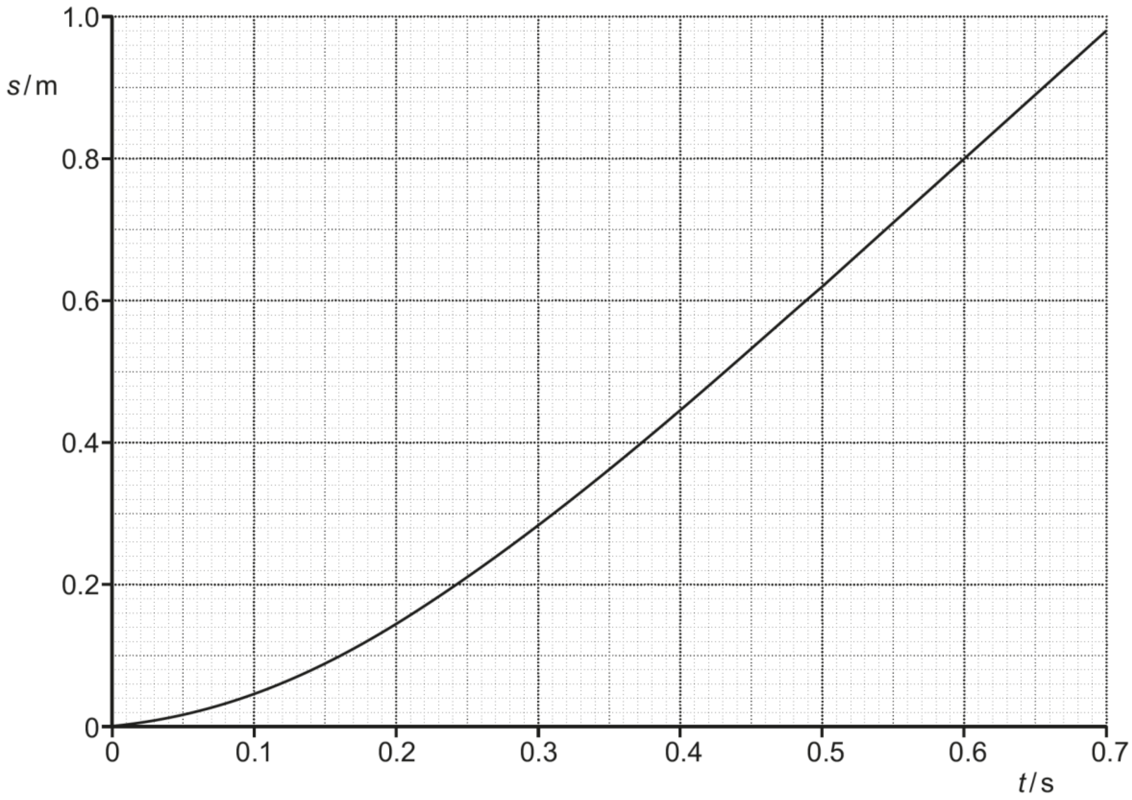
Candidates who understood that the upthrust was equal to the weight of the oil displaced scored well on this question. To score the marks it was necessary to show how the volume of the ball was calculated. Some candidates had difficulties with the powers of ten.

Some candidates then went on to use one equation of density $\times$ volume $\times$ g while other candidates calculated the volume, then the density and then the weight. Both these methods were acceptable.

Question 1 (d) (i)

(d) The student fills a long tube with the oil.
The student drops the steel ball from rest at the surface of the oil at time $t = 0$.
The displacement s of the ball is measured from the surface of the oil.

The graph shows the displacement s against time t for the steel ball from the instant it enters the oil.



(i) The terminal velocity v of the steel ball is $1.8\,\text{m}\,\text{s}^{-1}$.

Describe and explain how this can be determined from the graph.

....

....

....

.... **[3]**

Candidates needed to describe and explain how the terminal velocity was determined from the graph. A good way of answering the question was to state what was meant by terminal velocity, explain how velocity could be determined from the displacement time graph and then state where the velocity was constant. Candidates who were successful demonstrated the gradient calculation of the straight section by substituting numbers into the gradient formula and calculating 1.8 m s^{-1}.

Question 1 (d) (ii)

(ii) Use the graph to calculate the velocity u of the steel ball at time t = 0.20 s.

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

High scoring candidates drew a tangent to the line at 0.2 s.

Misconception

The instantaneous velocity from a displacement time graph is equal to the displacement divided by time.

Assessment for learning

Candidates should practice drawing tangents to curves.

The tangent should cover as much of the graph paper as possible.

Assessment for learning

Candidates should practice determining the gradient from a graph.

Two data points should be selected from the line (not from a data table). The two data points should be easy to read from the graph and as far apart as possible (at least half the length of the straight line).

The data points should clearly be substituted in the equation to determine the gradient *m*.

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$

The advantage of this method is that it also allows correctly for both positive and negative gradient graphs.

Although the *y*-intercept did not have to be determined in this question, this method also help candidates to easily determine the *y*-intercept by substituting a data point from the graph used in the determination of the gradient, i.e.

y-intercept = $y_2 - mx_2$ or $y_1 - mx_1$

Question 1 (e)

(e) The mass of the steel ball is 17 g.

The drag F acting on the steel ball falling through the oil is given by the equation

$F = 6\pi\eta rv$

where η is a constant for the oil, r is the radius of the steel ball and v is the speed of the steel ball through the oil.

At $v = 1.8\,\text{m}\,\text{s}^{-1}$, the force F is equal to the **difference** between the weight of the steel ball and the upthrust acting on the steel ball.

Calculate η.

Include an appropriate unit.

η = ... unit .... **[3]**

This was a challenging question and as a consequence some candidates only attempted to determine the unit. Common errors included either not allowing for the powers of ten correctly or not determining F as detailed in the question.

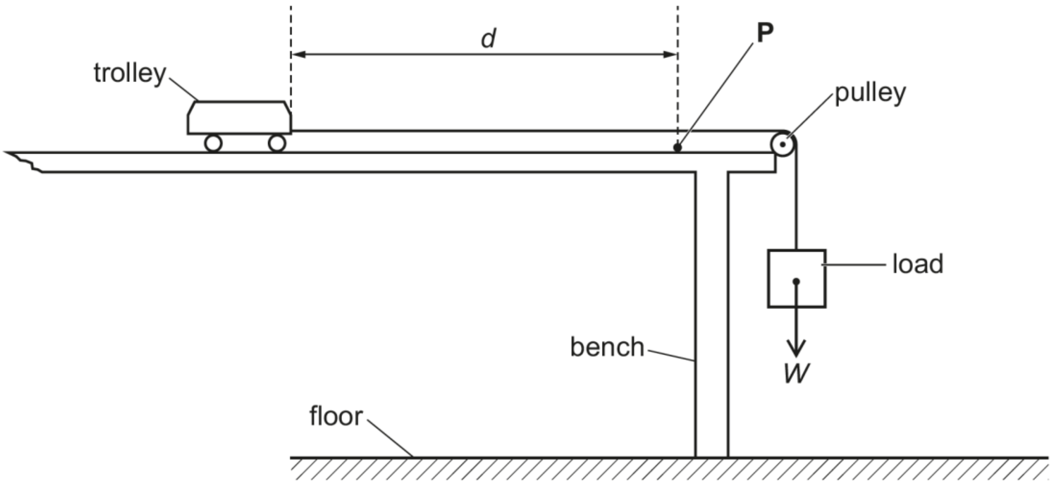
Candidates also needed to determine the unit of η. A common incorrect unit seen was $\text{N s}^{-1}\,\text{m}^{-2}$.

Assessment for learning

Candidates should practice determining units in base units and checking the homogeneity of equations.

Question 2*

2* A student is investigating the motion of a trolley as it accelerates from rest along a horizontal surface.
The diagram shows the trolley on a horizontal surface. A load of weight *W* accelerates the trolley.



Point **P** is a distance *d* from the initial position of the trolley.
A light gate connected to a timer is used to determine the velocity *v* of the trolley at point **P**.

It is suggested that the relationship between *v* and the mass *M* of the trolley is

$$\frac{1}{v^2} = \frac{M}{2dW - Q} + R$$

where *Q* and *R* are constants.

Describe, with the aid of a suitable diagram,
- how an experiment can be safely conducted to test this relationship between *v* and *M*, and,
- how the data can be analysed to determine *Q* and *R*. **[6]**

The question was designed to assess candidates' practical skills.

Candidates were advised to draw a 'suitable diagram', it was anticipated that they would draw a diagram with one light gate positioned at point P and a rectangular card added to the trolley to interrupt the light beam.

To gain a Level 3 mark on this question candidates needed to explain both the procedure and measurements that needed to be taken. In particular candidates needed to explain how the velocity *v* was determined at P. Many candidates incorrectly used two light gates and determine the average speed to travel distance *d*.

Appropriate measuring instruments should be specified to determine the other constants.

The analysis of the data should include an appropriate graph to plot and an explanation of how *Q* and *R* could be determined from the gradient and intercept. *Q* and *R* should be the subject of the equation.

Exemplar 1

$\cancel{\frac{1}{v^2} = \frac{M}{2dW-Q} + R}$

$\cancel{2dW - Q = Mv^2 + Rv^2}$

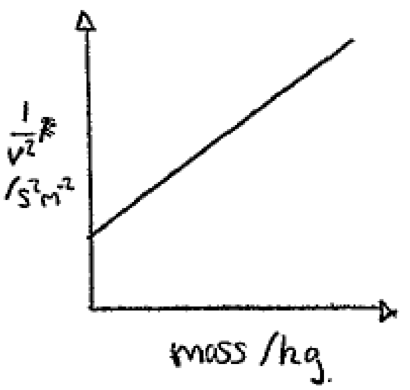
$\cancel{2dW - Q = v^2(M+R)}$

$\cancel{\frac{2dW-Q}{M+R} = v^2}$

$$\frac{1}{v^2} = \frac{1}{2dW-Q}(M) + R$$

$$Y = m \quad x \quad + c$$

therefore y intercept is R and $\frac{1}{2dW-Q}$ = gradient



$$\frac{1}{\text{gradient}} = 2dW - Q$$

$$Q = 2dW - \frac{1}{\text{gradient}}$$

Place a cushion underneath the load for safety. Keeping W and d constant, measure the velocity at P when M is a value. Repeat two more times. Increase M and record v using the light gates, and repeating two more times for every value of M. Repeat for 10 values of M. Find the mean of v for each value, and plot a graph of M against $\frac{1}{v^2}$*. It should be a straight line. Find the Y intercept of the line, this is R. Find the gradient of the line, then, using the gradient and the distance d and weight W, do $2dW - \frac{1}{\text{gradient}}$ to find out Q

See additional answer

Additional answer space if required

*Plot a line of best fit

Exemplar 1 - The candidate was awarded 4 marks as the scientific content of the response meets the Level 2 descriptors and the communication statement is also satisfied.

The candidate structures the response by initially determining the graph that would need to be plotted to determine the constant *Q* and *R*. The candidate then explains how the gradient and *y*-intercept is used to determine *Q* and *R*.

The candidate describes a brief procedure and includes the use of a cushion, repeating results and keeping *d* and *W* constant.

To gain Level 3, the candidate needed to have included a diagram showing the position of the light gate and explained the measurements that would need to be taken to determine *v* from a light gate connected to a timer.

Assessment for learning

Candidates should understand how light gates attached to a timer can be used to determine velocity and acceleration. In particular, candidates should understand the distance measurements and shape of the interrupt card.

Other data logging methods such as a motion sensor should also be understood.

Misconception

Many candidates incorrectly calculated the velocity *v* at P since they measured the time for the trolley to travel distance *d* and then calculated the average speed to travel distance *d*.

Assessment for learning

Candidates should be able to determine appropriate axes to plot graphs and then explain how constants can be determined from the gradient and *y*-intercept.

Question 3 (a)

3 **(a)** State the **two** conditions for an object to be in equilibrium.

1. ....

....

2. ....

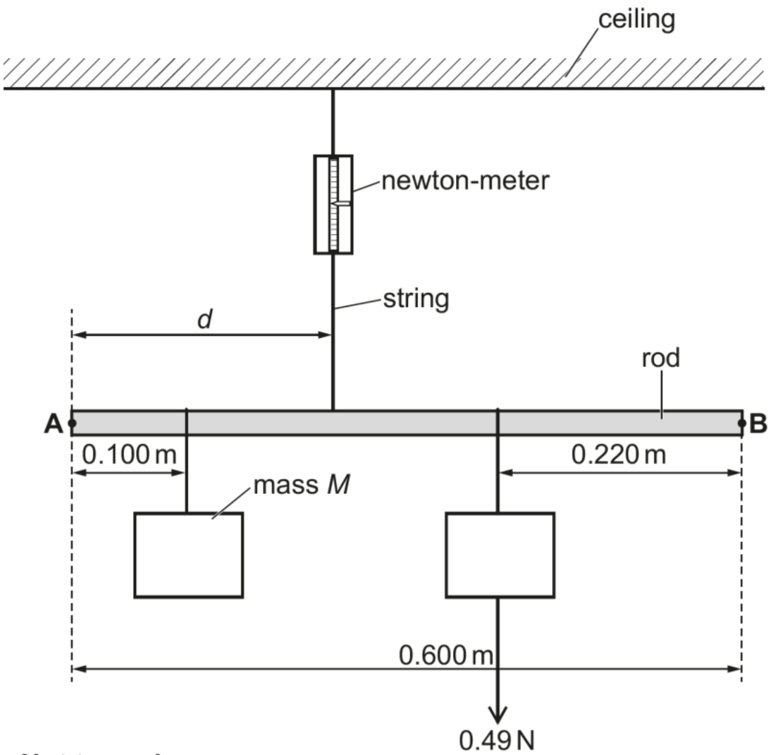
.... **[3]**

Candidates were often able to score marks for stating that the resultant force was zero (often referring to one direction, e.g., upwards) and that the resultant moment was zero. Very few candidates added the extra detail that the resultant force was zero **in any direction** and that the resultant moment **about any point** was zero.

Candidates who were less successful were often vague in their use of terminology. For example, all the forces are the same without any reference to direction.

Question 3 (b) (i)

(b) The diagram shows a uniform rod which is in equilibrium. The rod has a circular cross-section and has length 0.600 m and weight 2.1 N.



Not to scale

Mass M is suspended at a distance of 0.100 m from point **A**.
A weight of 0.49 N is suspended at a distance of 0.220 m from point **B**.
A string is attached to the rod at a distance d from point **A**.
The tension in the string, measured by the newton-meter (force meter), is 3.9 N.

(i) Show that M is about 0.13 kg.

[2]

Most successful candidates stated the equilibrium of forces in the vertical direction. Some candidates incorrectly used a value of 10 N kg^{-1} rather than the value of 9.81 N kg^{-1} given on the data sheet.

Question 3 (b) (ii)

(ii) By taking moments about point **A**, determine *d*.

d = ... m **[3]**

Candidates who scored highly on this question clearly determined the individual moments. Common errors were ignoring moment due to the weight of the beam and incorrectly determining the distance for 0.49 N weight.

Question 4 (a) (i)

4 **(a)** A ball of mass 0.16 kg is dropped from rest from a height of 2.5 m above the ground.

Assume air resistance is negligible.

Calculate

(i) the change in gravitational energy E_p

E_p = ... J **[1]**

This question was generally answered well.

Question 4 (a) (ii)

(ii) the velocity v of the ball as it reaches the ground.

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

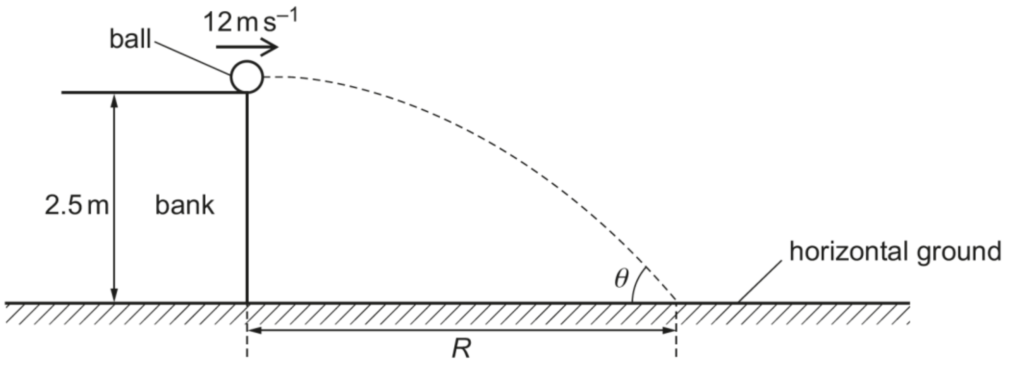
Most candidates correctly equated the change in gravitational potential energy to kinetic energy and gained the correct answer. Other candidates correctly used $v^2 = 2\,gh$.

A number of candidates gave the answer as 7 (m s^{-1}) – since the data in the question was given to two significant figures the answers should also be given to two significant figures.

Ideally the substitution of data into appropriate equations should be shown.

Question 4 (b) (i)

(b) The ball from **(a)** is now fired horizontally with a speed of $12\,m\,s^{-1}$ from a bank.
The height of the bank is 2.5 m.
The time for the ball to travel from the edge of the bank to the horizontal ground is 0.71 s.
The path of the ball is shown in the diagram.
The ball hits the horizontal ground a distance R from the bottom of the bank.
Assume air resistance is negligible.



Calculate

(i) R

R = ... m **[1]**

It was expected that candidates would multiply the horizontal velocity by the time. This was generally answered well.

Assessment for learning

When considering projectile motion, candidates should treat the vertical and horizontal velocities independently.

Question 4 (b) (ii)

(ii) the kinetic energy E_k of the ball as it reaches the ground

E_k = ... J **[2]**

Many candidates calculated the kinetic energy of the ball using the velocity of the ball in the horizontal direction but then did not add the change in potential energy of the ball as it fell.

Other candidates determined the resultant velocity of the ball and then calculated the kinetic energy.

Question 4 (b) (iii)

(iii) the angle θ between the ground and the direction of the ball as it reaches the ground.

θ = ... ° **[1]**

Candidates achieving on this question correctly determined the angle using the horizontal and vertical velocities.

Where the response was incorrect, candidates had used either energies or distances.

Question 5 (a)

5 The table shows the refractive index of air, glass and oil for red light. It also shows the speed v of red light in air.

	air	**glass**	**oil**
refractive index n	1.00	1.52	1.46
speed of light v / m s^{-1}	3.00×10^8		

(a) Complete the table by determining the missing values for v for glass and oil.
Write your answers to 3 significant figures.

[1]

This question was well answered with most candidates giving answers correct to three significant figures by using standard form.

Question 5 (b)

(b) Show that the critical angle for a ray of red light at the boundary between glass and air is less than 45°.

[2]

Most candidates clearly demonstrated the method to determine the critical angle. Some candidates incorrectly used 45° rather than 90°.

Assessment for learning

To determine the critical angle, the angle of refraction is 90° so sin 90° = 1.

Question 5 (c)

(c) **Fig. 5.1** shows a glass block inside a beaker.

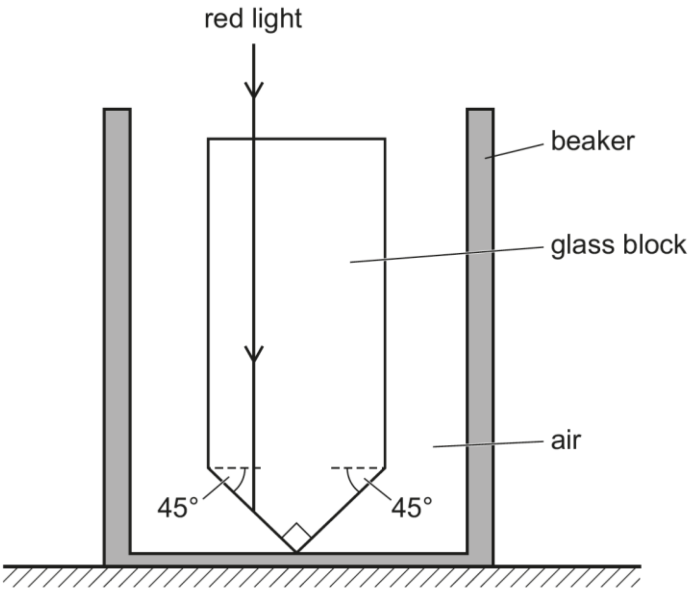


Fig. 5.1

The path of a ray of red light is shown entering the glass block.
Complete **Fig. 5.1** to show the path of the ray through the block until it leaves the block. **[2]**

Candidates needed to realise that the angle of incidence was 45° which was greater than the critical angle. So, the total internal reflection occurs at the first surface. No marks were given for candidates who drew any rays that showed refraction.

Candidates who scored the first mark invariably realised that the angle of incidence at the second boundary was also 45° so again drew a totally internally reflect ray parallel to the incident ray.

Rays should be straight and therefore drawn with a ruler.

A significant number of candidates omitted this question.

Question 5 (d) (i)

(d) Oil is now added to the beaker as shown in **Fig. 5.2**.

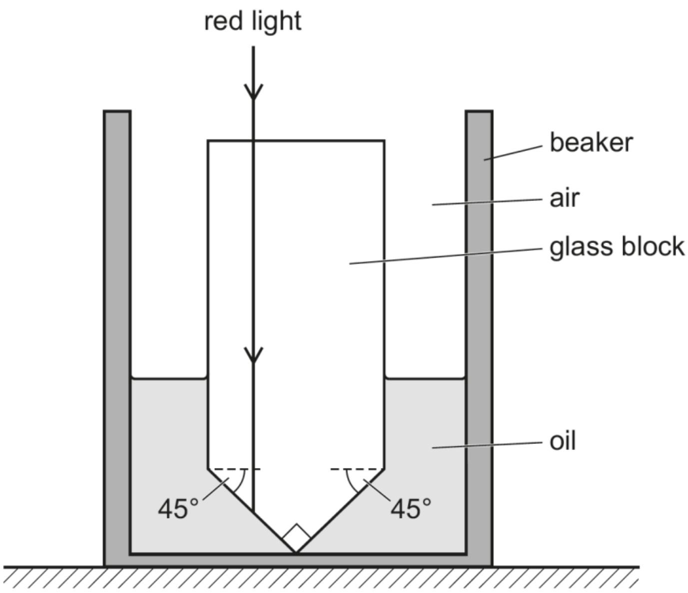


Fig. 5.2

The path of a ray of red light is shown entering the glass block.

(i) Calculate the critical angle *C* for a ray of red light at the boundary between glass and oil.

C = ... ° **[2]**

Candidates found this question challenging. Good candidates used the two refractive indexes 1.42 and 1.52 correctly.

Many candidates incorrectly used an angle of 45° or 41° rather than 90°. A significant number of candidates omitted this question.

Question 5 (d) (ii)

(ii) Complete **Fig. 5.2** to show the path of the ray through the block until it leaves the block. **[1]**

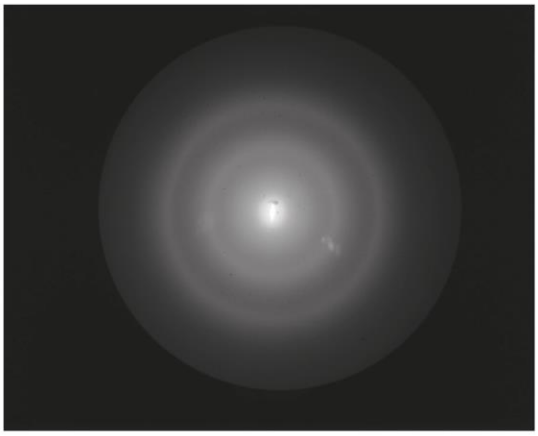
Candidates often did not draw a refracted ray. Of those candidates who gained the answer to the previous part correctly, many did not realise that the ray would bend (slightly) away from the normal.

A significant number of candidates omitted this question.

Question 6 (a)

6 A student is investigating electron diffraction. A beam of electrons is directed towards a thin slice of graphite in an evacuated tube.

The electrons are accelerated by a potential difference of 1800 V. The diagram below shows the pattern formed on the fluorescent screen of the evacuated tube.



(a) Explain why this pattern is formed.

....

....

....

....

....

.... **[3]**

This question gave opportunities for candidates to demonstrate their knowledge and understanding of a standard experiment. To improve answers to this question candidates needed to use the terms accurately.

Many candidates stated that electrons can behave as a wave, however some candidates tended to state this is the wave particle duality rather than applying it to the question. Also, a popular answer was that the diffraction of electrons occurs because the de Broglie wavelength is comparable to the spacing in graphite.

Some candidates also describe why circular rings were produced in terms of the irregular arrangement of graphite and there were also bright and dark rings.

Few candidates stated that the kinetic energy transferred to light when the electrons collided with the screen.

Question 6 (b)

(b) The relationship between the de Broglie wavelength λ and the accelerating potential difference V is

$$\lambda = \frac{h}{\sqrt{2meV}}$$

where m is the mass of the electron and e is the elementary charge.

Calculate the momentum p of an electron.

p = ... kg m s^{-1} **[2]**

This question was generally well answered.

Many candidates realised that the denominator was momentum. Other candidates calculated the wavelength and then calculated the momentum. Some candidates omitted the 1800 V.

A significant number of candidates omitted the question, presumably based on the perceived difficulty of the question. To assist candidates in the examination it may help if they write the numerical values beside each quantity.

Assessment for learning

When dealing with questions with powers of ten, write the equation down, then substitute the numbers including the powers of ten. It is worth calculating intermediate values and writing these down before calculating the final answer.

Question 7 (a) (i)

7 An electric cooker has two independent heating rings **A** and **B** as shown in **Fig. 7.1**.

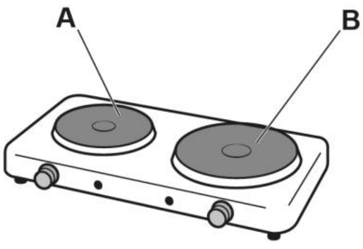


Fig. 7.1

The cooker rings **A** and **B** are connected in parallel to a 230 V power supply. At maximum power, ring **A** has a power of 1100 W and ring **B** has a power of 1700 W.

(a) **(i)** Show that the maximum current in the cooker is less than 13 A.

[2]

This question was generally well answered with candidates often demonstrating that current was power divided by potential difference.

Some candidates simply worked out the current in each ring but did not state the total current. Some candidates attempted to work out the maximum power using 13 A – this did not answer the question since the question required candidates to show that the maximum current in the cooker was less than 13 A

Assessment for learning

When answering "show" questions, it is essential to demonstrate that the answer matches the question. In this question high scoring candidates often stated that 12.2 A is less than 13 A.

Question 7 (a) (ii)

(ii) The cost of 1 kW h of energy is 18p.
Calculate the cost of using the cooker at maximum power for 30 minutes.

cost = ... p **[1]**

This question was generally answered well. Where errors were made it was usually in the conversion of minutes to hours or not converting the power in watt to kilowatt.

Question 7 (b)

(b) The filament in ring **A** is a metallic wire of length 11.8 m.
At maximum power the wire has resistance 31 Ω and the metal has resistivity 4.8×10^{-7} Ω m.

Calculate the diameter *d* of the wire.

d = ... m **[3]**

Many candidates scored all three marks on this question. High scoring candidates often determined the cross-sectional area of the wire before determining the diameter.

Some candidates omitted to take a square root or determined the radius of the wire.

Question 7 (c) (i)

(c) **Fig. 7.2** shows the circuit symbol for ring **A**.

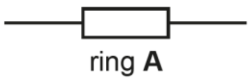


Fig. 7.2

A student uses a battery of four cells, an ammeter and a voltmeter to determine the resistance of the wire in ring **A** experimentally.

(i) Complete **Fig. 7.2** to show how the student should connect the circuit to determine the resistance. **[2]**

It was expected that the correct circuit symbols would be used. A small number of candidates were unable to position the ammeter and voltmeter correctly.

Question 7 (c) (ii)

(ii) The current in the wire is 0.34 ± 0.02 A and the potential difference across the wire is 6.2 ± 0.2 V.
Calculate the resistance *R* of the wire.

R = ... Ω **[1]**

The majority of the candidates answered this question correctly. Although it is a simple question, candidates should be advised to show their working.

Question 7 (c) (iii)

(iii) Calculate the percentage uncertainty in *R*.

percentage uncertainty = ... % **[2]**

This question was answered well by the large majority of candidates. Many correctly worked out the percentage uncertainty in the current and added it to the percentage uncertainty in the potential difference. This was the simplest method.

A few candidates used maximum/minimum methods. In this case it needed to be maximum potential difference divided by minimum current or minimum potential difference divided by maximum current.

Question 7 (c) (iv)

(iv) Suggest why *R* from **(c)(ii)** is less than 31 Ω.

....

....

....

.... **[2]**

Candidates found this question challenging. Few candidates realised that the current was smaller so the heating effect would be less.

Question 7 (c) (v)

(v) Suggest **two** improvements to the student's experiment to determine *R* experimentally.

1. ....

....

....

2. ....

....

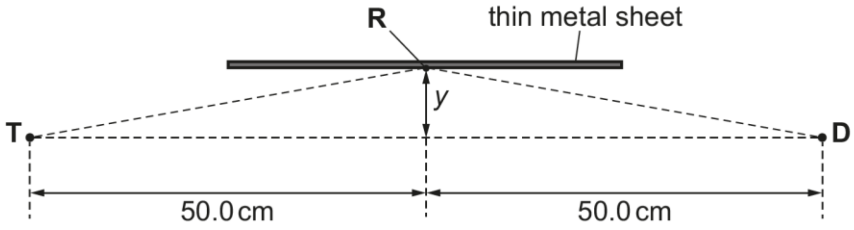
....

[2]

There were many vague answers to this question. Ideally there should be more measurements taken. Some candidates discussed using a variable resistor or potentiometer in the circuit and other suggested then plotting a graph. Some candidates discussed increasing the power supply. Some candidates also suggested using more sensitive meters or meters reading to a greater precision. Marks were not given for using more accurate meters or digital meters.

Question 8*

8* In an experiment to investigate microwaves, a microwave detector **D** is placed 100.0 cm from a microwave transmitter **T**.



A thin metal sheet is placed parallel to the line joining **T** and **D**. Point **R** is at the bottom of the metal sheet. The perpendicular distance between this line and point **R** is *y*.
The diagram shows the path of microwaves travelling directly from **T** to **D** and the path of microwaves from **T** reflected from **R** to **D**. There is a 180° phase change when microwaves are reflected at **R**.

The metal sheet is moved away from the line joining **T** and **D** so that *y* increases. The metal sheet remains parallel to the line from **T** and **D**. A series of maximum and minimum intensities are observed.

The table shows the values of *y* for successive maximum and minimum intensities.

Intensity	***y* / cm**
maximum	8.4
minimum	11.9
maximum	14.6
minimum	17.0

Explain the presence of the regions of maximum and minimum intensities **and** determine the wavelength of the microwaves. **[6]**

To answer this question well, candidates needed to explain why there were maxima and minima. Many correctly explained the different paths but some were confused between phase difference and path difference. A significant number of candidates incorrectly discussed standing waves or two source interference.

Most successful candidates clearly used the data correctly using Pythagoras to work out path differences and they realised that the difference between the two maxima or the two minima was the wavelength, however other candidates often just stated 14.6 – 8.4 was the wavelength or 11.9 – 8.4 x 2 was the wavelength.

Exemplar 2

Microwaves produced by transmitter T radiate in all directions, so some propagate directly towards D, whereas others to propagate towards R, where they are reflected and ~~interfe~~ meet waves travelling directly to D at D. This causes them to interfere (they superpose), and due to the principle of superposition ~~they~~ the displacement of the resultant wave is equal to the sum of the displacement of the 2 incident ~~wave~~ waves. When y = 8.4 cm, the 2 waves meet with a path difference λ, so interfere constructively to produce a ~~big~~ resultant wave with maximum displacement. Intensity ∝ amplitude², so this produces a signal with maximum intensity. When y = 11.9 cm, the 2 waves meet with a path difference $\frac{3}{2}\lambda$, so interfere destructively to produce a signal with minimum intensity. When y = 14.6, path difference = 2λ so the 2 incident waves again interfere constructively and when y = 17cm the 2 incident waves ~~inter~~ interfere destructively due to path difference $\frac{5}{2}\lambda$.

When y = 14.6 path difference = 2λ, when y = 8.4, path difference = λ.

$\sqrt{50^2+14.6^2} = 52.09$ cm $2(52.09) = 104.18$ cm total distance TD

$\sqrt{50^2+8.4^2} = 50.7$ cm $2(50.7) = 101.4$ total distance TD

~~tot~~ $104.18 - 101.4 = \lambda$ $\lambda = 2.78$ cm

This candidate scored full marks – the scientific content of the response meets the Level 3 descriptor, and the communication statement is also met so six marks.

The candidate structures the response by initially describing the experimental arrangement. There is appropriate scientific detail explaining how waves arrive at D. Importantly the candidate states that the resultant displacement is equal to the sum of the displacements of the individual waves. Although the phase change has not been discussed, there is a sensible discussion of path difference using the data given.

Towards the end of the response the candidate clearly demonstrates how the wavelength of the microwaves may be calculated using Pythagoras calculations of the path difference and relating the path difference to the wavelength.

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