Qualification Accredited

Oxford Cambridge and RSA

AS LEVEL

Examiners' report

PHYSICS A

H156

For first teaching in 2015

H156/01 Summer 2023 series

Version 1

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 is 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.

Previous examination series have been impacted by the pandemic with Advance Information given to Centres in 2022 to support candidates sitting an examination in this Component H156. June 2023 will be comparable to candidates taking this component in June 2019 but it is unknown whether there is an impact on performance due to the legacy of disruption to learning caused by the pandemic.

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

Paper 1 series overview

H156/01 is one of the two assessed components of AS Physics A. The component is worth 70 marks and is split into two sections. Section A contains 20 multiple choice questions (MCQs) and allows the breadth coverage of the specification. Section B includes short-answer style questions, problem solving, calculations and practical. The assessment of practical skills, as outlined in Module 1 (Development of practical skills in physics) and Module 2 (Foundations of physics), forms an integral part of the assessment. The Data, Formulae and Relationships booklet forms a valuable resource in examination and allows candidates to demonstrate their application of physics without the need to rote learn physical data, equations and mathematical relationships. The weighting of this component is 50% and duration of the exam paper is 1 hour 30 minutes.

H156/02 Component is characterised by its in-depth questions and includes two Level of Response (LoR) questions.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
The positive attributes of the candidates in this component were: • answering most of the multiple choice questions and making good use of the spaces provided to do any rough analysis or calculations • good use of calculators, especially handling values given in standard form • correct selection of equations from the Data, Formulae and Relationship booklet • well-structured solutions with clear manipulation of equations, good substitution and expressing the final answers to appropriate significant figures and units even though units were given on the answer line • good comprehension of command terms such as describe, explain, show, compare, etc. • generally, good use of information and data given whether numerical or displayed in a table.	There were some missed opportunities in this component. Candidates are reminded that they can maximise marks in future examinations by following some of the procedures below: • underline or circle key data within a question to help with the calculations. If a question specifically asks to refer to information/data in a figure it must be used/manipulated in candidate responses • do not round up, or down, numbers in the middle of long calculations. Try to retain all the digits on your calculator for subsequent stages of a calculation. Truncating numbers in the middle of calculations may result in the loss of marks • make good use of technical and scientific vocabulary in descriptions and explanations. Using words like oscillation, superposition, interference, work function, resolution, (directly) proportional, etc. can help you to succinctly get your physics across • understanding of vector notation when calculating the change of momentum when an object travels in opposing directions • convert values into SI units, e.g. mm to m, to avoid power of ten errors • finally, be aware of the information available on the Data, Formulae and Relationship Booklet.

Section A overview

Section A contains 20 multiple choice questions (MCQs) from topics across the four modules of the specification. This section is worth 20 marks and you are expected to spend about 25 minutes.

Questions can assess understanding from all aspects of the specification including knowledge and application of practical skills.

Space is provided on the exam paper for any working. It is important for candidates to insert their correct response in the square box provided.

All questions showed a positive discrimination, and the less able candidates could access the easier questions. MCQs require careful inspection. Candidates are allowed to annotate text and diagrams if it helps to get to the correct answer. No detailed calculations are expected on the pages, so any shortcuts, or intuitiveness, can be employed to get to the correct answers.

Questions 2, 4, 6, 10 and 19 proved to be particularly straightforward, allowing most of the candidates to demonstrate their knowledge and understanding of physics. At the opposite end, Questions 1, 3, 5 and 16 proved to be more challenging, and as such, were only accessible to the top-end candidates.

Question 1

1 What is a typical value, in cm, for the wavelength of microwave radiation?

A 0.0003

B 0.03

C 3

D 300

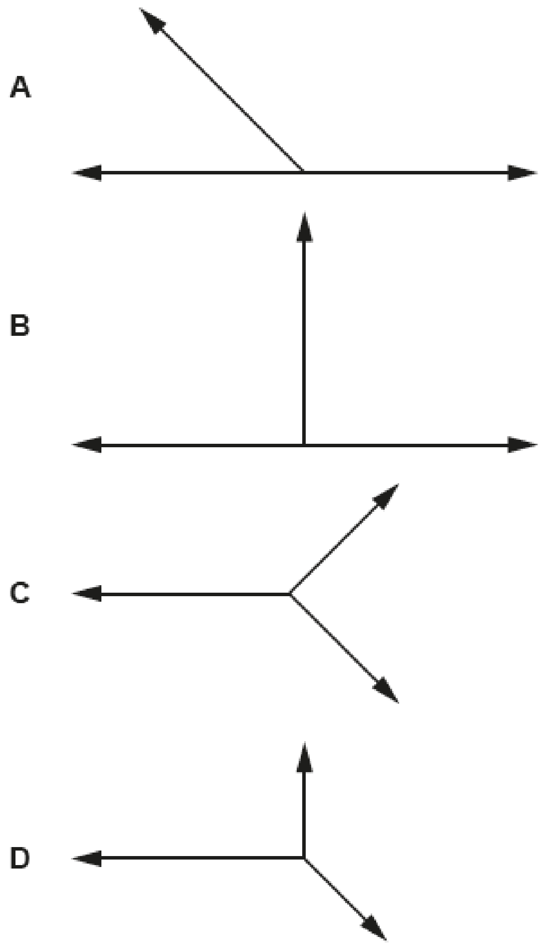
Your answer ☐ **[1]**

This should have been a straightforward starting question for all the candidates in determining the wavelength of microwaves in cm wavelength but less than half of the candidates got the correct answer C. The most common distractor was D.

Question 2

2 The diagrams show four systems of forces with three forces acting at a single point. The forces are in the same plane. The diagrams are drawn to scale.

Which system could be in equilibrium?



Your answer ☐ **[1]**

This question assessed candidates understanding of forces acting in a system in equilibrium with most candidates applying their knowledge of forces as vectors. This meant that most candidates answered C correctly.

Question 3

3 An electron beam is passed through a thin slice of graphite and a diffraction pattern is produced.

The approximate spacing between the carbon atoms in the graphite is d.
The approximate de Brogie wavelength of an electron in the beam is λ.

Which statement is correct?

A $\lambda \approx d$

B $\lambda \approx \frac{1}{d}$

C $\lambda \gg d$

D $\lambda \ll d$

Your answer ☐ **[1]**

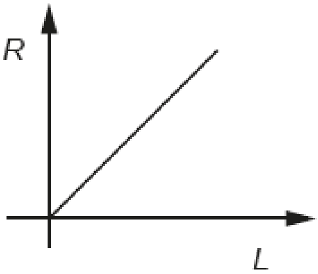
Just over half of candidates answered this correctly and determined that the correct conditions for a diffraction pattern to be produced was when the spacing between atoms was roughly equal to the de Broglie wavelength of an electron. The most common distractor was D.

Question 4

4 A student investigates a conducting wire of constant cross-sectional area, at constant temperature.

The resistance R is measured for a range of lengths L.

The following graph is plotted:



Which expression is equal to the gradient of the graph?

A resistivity

B resistivity × cross-sectional area

C $\frac{\text{resistivity}}{\text{cross-sectional area}}$

D $\frac{\text{cross-sectional area}}{\text{resistivity}}$

Your answer ☐ **[1]**

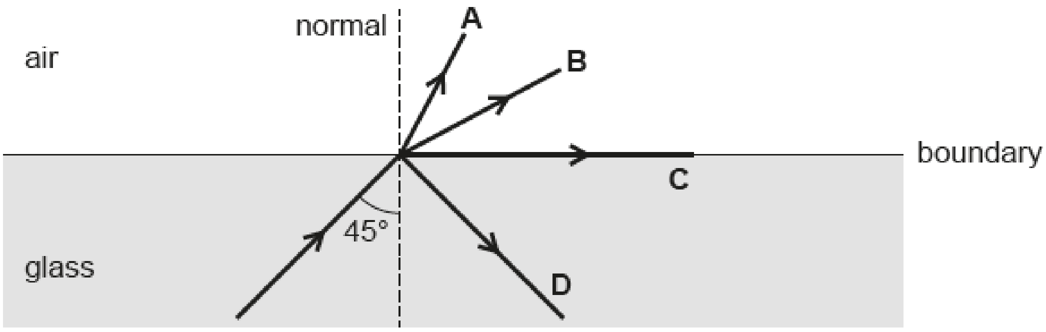
This question was answered well as candidates were able to determine the correct expression for the gradient by applying the equation $R = \rho L/A$.

Question 5

5 A ray of monochromatic light is travelling through glass.

The refractive index of the glass is 1.5.

The ray is incident on a glass-air boundary with angle of incidence of 45°.



Which is the correct path of the ray after it reaches the boundary?

Your answer ☐ **[1]**

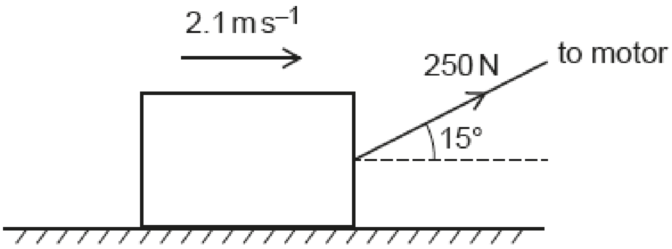
Less than half of candidates answered this question correctly by applying understanding of Total Internal Reflection and the use of sin $C = 1/n$. The most common distractor was C.

Question 6

6 The diagram shows a motor pulling a load along a flat, horizontal surface.

The load is connected to the motor by a string at an angle of 15° to the surface. The tension in the string is 250 N. The load reaches a constant speed of 2.1 m s^{-1}.

The diagram does not show the other forces acting on the load.



What is the output power of the motor?

A 120 W

B 140 W

C 460 W

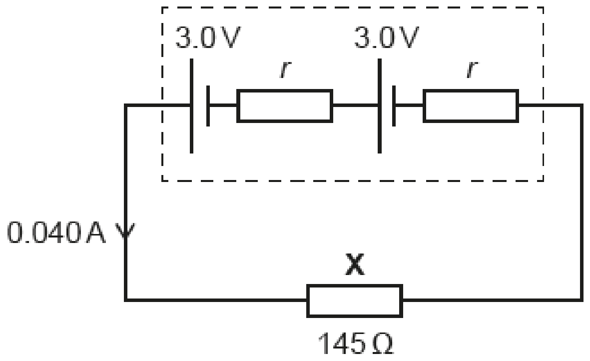
D 510 W

Your answer ☐ **[1]**

This question was answered well as candidates were able to calculate the correct output power by applying the equation $P = Fv$ and resolving the 250 N to give its horizontal component.

Question 7

7 Two identical cells are connected in series in a circuit with a resistor **X** of resistance 145 Ω. The e.m.f. of each cell is 3.0 V. The current in **X** is 0.040 A.



What is the internal resistance *r* of one of the cells?

A 0.10 Ω

B 0.20 Ω

C 2.5 Ω

D 5.0 Ω

Your answer ☐ **[1]**

Most of the candidates gave the answer C by correctly applying the equation $\mathcal{E} = I(R + r)$.

Question 8

8 Electromagnetic radiation is incident on a clean metal plate. Electrons are released from the surface of the plate.

Which statement is correct?

A The energy of a photon is directly proportional to its frequency.

B The kinetic energy of the released electrons depends on the rate of incidence of photons.

C The photoelectric effect demonstrates the wave-like nature of electromagnetic radiation.

D The rate at which electrons are released depends on the frequency of the radiation.

Your answer ☐ **[1]**

This question was answered well with the most candidates applying the equation $E = hf$ to give the correct answer A.

Question 9

9 Two copper wires, **X** and **Y**, are connected in series to a source of e.m.f.

The length of **X** is equal to the length of **Y**.
The cross-sectional area of **X** is greater than the cross-sectional area of **Y**.

Which **two** quantities are equal in value for both **X** and **Y**?

A charge carrier density, current

B charge carrier density, electron drift velocity

C current, resistance

D electron drift velocity, resistance

Your answer ☐ **[1]**

Only half of candidates gave the correct answer A by understanding and applying the equation $I = Anev$.

Question 10

10 Resistance and resistivity are two quantities used to describe the behaviour of a conductor.

How do these quantities change, if at all, when the length of a conductor is increased?

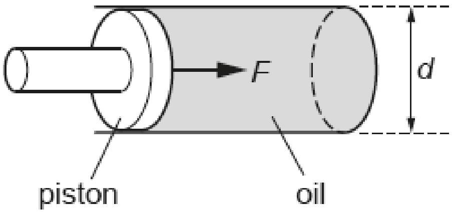
	resistance	**resistivity**
A	constant	constant
B	constant	increase
C	increase	constant
D	increase	increase

Your answer ☐ **[1]**

This question was answered well with most candidates giving the correct answer C by applying the equation $R = \rho L/A$ for a conductor.

Question 11

11 The diagram shows a closed cylinder with internal diameter d.



The cylinder is filled with oil. A piston applies a force F to the oil.

Which is the correct expression for the pressure in the oil?

A $\frac{2F}{\pi d^2}$

B $\frac{\pi d^2}{2F}$

C $\frac{4F}{\pi d^2}$

D $\frac{\pi d^2}{4F}$

Your answer ☐ **[1]**

This question was answered well with most candidates giving the correct answer C by applying the equations $P = F/A$ and $\pi d^2/4$.

Question 12

12 An LED is designed to emit red light. In an experiment, the potential difference across the LED is gradually increased. It begins to emit light when the potential difference reaches a value V_0.

The experiment is repeated for an LED designed to emit green light. A different value of V_0 is observed.

Which row of the table describes the values in the second experiment?

	change to V_0	**change to wavelength of emitted light**
A	decrease	increase
B	decrease	decrease
C	increase	increase
D	increase	decrease

Your answer ☐ **[1]**

About half of candidates performed well on this question by determining the correct answer of D by understanding that green light has a shorter wavelength and increased energy (due to having a greater frequency) compared to red light. The most common distractors were B and C.

Question 13

13 Unpolarised light is observed through a single polarising filter.

The intensity of the light transmitted by the filter is half the intensity of the incident light.

What happens to the intensity of the transmitted light when the filter is rotated through 90°?

A decreases

B decreases and then increases

C increases

D does not change

Your answer ☐ **[1]**

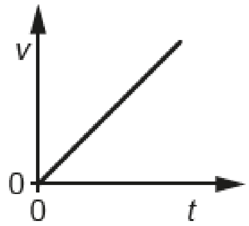
About half of candidates performed well on this question by determining the correct answer of D by understanding the behaviour and intensity of unpolarised light when transmitted through a polarising filter.

Question 14

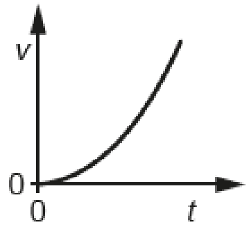
14 An object is released from rest and then falls freely under gravity. Air resistance is negligible.

Which graph shows how the velocity *v* of the object varies with time *t*?

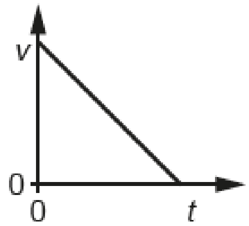
A



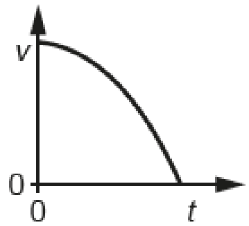
B



C



D

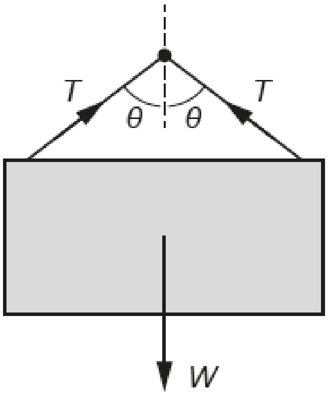


Your answer ☐ **[1]**

Just over half of the candidates correctly interpreted the graph to understand that the object was falling with constant acceleration due to gravity to give the answer A. The most common distractor was B.

Question 15

15 A cable is used to hang a picture from a nail. The diagram shows all the forces acting on the picture. T is the tension in the cable and W is the weight of the picture.



Which is the correct expression for W?

A $W = T\cos\theta$

B $W = 2T\cos\theta$

C $W = T\sin\theta$

D $W = 2T\sin\theta$

Your answer ☐ **[1]**

This question was generally answered well as most candidates correctly resolved T, tension to determine an expression for W.

Question 16

16 An object is in equilibrium.

Only two forces, **X** and **Y**, act on the object.

Which of the following statements must be correct?

1 **X** and **Y** are equal and opposite.
2 **X** and **Y** are a Newton's 3rd law force pair.
3 The object is at rest.

A Only 1

B 1 and 2

C 1 and 3

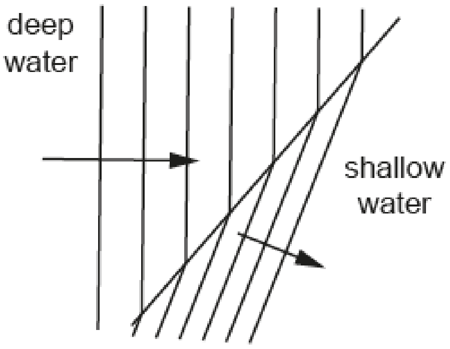
D 1, 2 and 3

Your answer ☐ **[1]**

Candidates performed less well on this question as they either interpreted that since the forces acting on the object in equilibrium were equal and opposite the object was at rest, or that the pair of forces were an interaction pair of forces, so B and C were the most common distractors.

Question 17

17 A ripple tank can be used to demonstrate wave effects. When water waves in a ripple tank travel from deep to shallow water the wavelength decreases.



What happens to the speed and frequency of the waves as they move from deep to shallow water?

	speed	frequency
A	decrease	increase
B	decrease	constant
C	increase	increase
D	increase	constant

Your answer ☐ **[1]**

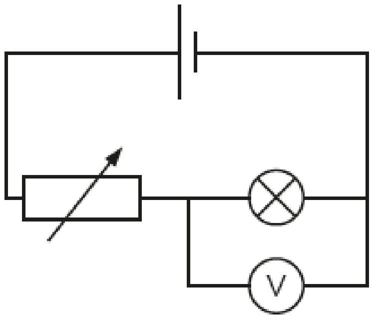
Only half of candidates correctly applied the behaviour of waves and understood that frequency of the waves remains constant when they travel through different media (different depths of water) and the wave speed equation to determine the correct answer B. Hence, the most common distractor was A.

Misconception

This is a common misconception that the frequency changes when waves travel through different media, whether it is water waves travelling through different depths of water or light when it travels through media with different refractive indices. When applying the wave speed equation $v = f\lambda$ the frequency remains constant, so v is directly proportional to λ.

Question 18

18 A tungsten filament lamp is connected in a circuit as shown.



The variable resistor is adjusted so that the temperature of the filament lamp increases.

What happens to the resistance of the lamp and the reading on the voltmeter?

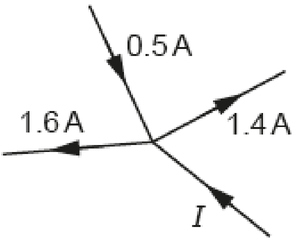
	resistance of the lamp	voltmeter reading
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

Your answer ☐ **[1]**

This question was generally answered well with most candidates correctly determining that as the temperature of the filament lamp increased so did the resistance of the filament lamp. By applying $V = IR$ they then determined that the potential difference would also increase due to increased resistance. The most common distractor was C.

Question 19

19 The diagram shows the currents passing in and out of a point in a circuit.



What is the value of the current I?

A 0.3A

B 0.5A

C 2.5A

D 3.0A

Your answer ☐ **[1]**

This question was answered well as most candidates applied Kirchhoff's Law and that the sum of the currents entering a junction is equal to the sum of the currents out of the junction to give the correct answer of C.

Question 20

20 An uncharged oil drop gains a charge of $+4.0 \times 10^{-18}$ C.

What is the change in the number of electrons on the oil drop?

A Gained 25 electrons

B Gained 64 electrons

C Lost 25 electrons

D Lost 64 electrons

Your answer ☐ **[1]**

Most candidates correctly answered this question as they determined that the oil drop had lost electrons (since the oil drop had gained a positive charge) and used the charge of an electron to give the correct answer C. The most common distractor was D.

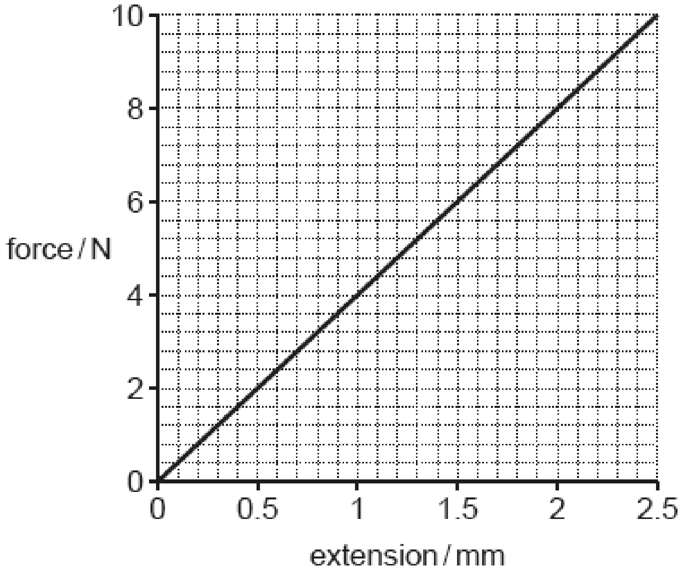
Section B overview

Section B includes short-answer style questions, problem solving, calculations and practical. This section is worth 50 marks and candidates are expected to spend about 1 hour 5 minutes completing questions.

Questions can assess understanding from all aspects of the specification including knowledge and application of practical skills.

Question 21 (a)

21 A student investigates the properties of a spring. They hang masses from the spring and measure the extension of the spring for every 100 g mass added. They plot their results on a graph of force against extension.



(a) Calculate the force constant of the spring.

force constant = ... $N\,m^{-1}$ **[2]**

Candidates performed well on this question as they correctly applied *F* = *kx* to determine the gradient of the graph to give the force constant. Most candidates converted mm to m but about a quarter of candidates did not recognise that a unit conversion was required so gave an answer of 4 ($N\,m^{-1}$) which was given 1 mark.

Question 21 (b)

(b) The student extends their investigation to determine the Young modulus of copper. They make measurements to determine the length and the cross-sectional area of a copper wire.

Describe how they should determine the cross-sectional area of the wire.

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.... **[3]**

Candidates scored well on this question with about half of candidates being given 3 marks for correctly describing how the cross-sectional area could be determined. About a third of candidates only achieved 2 marks as they didn't describe that the diameter needed to be measured in different places on the wire rather than just repeat readings. Nearly all candidates were able to identify the correct equipment required to measure the diameter of the wire.

Question 21 (c) (i)

(c) (i) Show that an expression for the Young modulus *E* is

$$E = \frac{kL}{A}$$

L = length of wire
A = cross-sectional area of wire
k = force constant of wire

[2]

Over half of candidates correctly selected the equations $E = \sigma/\varepsilon$, $\varepsilon = x/L$, $\sigma = F/A$ *and* $F = kx$ and showed clear substitution to give the expression for the Young modulus *E.* Some candidates did confuse the quantity of *E* and selected the incorrect equation $E = ½ Fx$; $E = ½kx^2$ from the Data, Formulae and Relationships booklet.

Question 21 (c) (ii)

(ii) The student records the following results for a copper wire.

$L = 2.0\,\text{m} \pm 0.05\,\%$
$A = 2.9 \times 10^{-8}\,\text{m}^2 \pm 2\,\%$
$k = 1670\,\text{N m}^{-1} \pm 1.25\,\%$

Calculate the value of the Young modulus of the wire and its percentage uncertainty.

Young modulus = ... N m^{-2} ± .... % **[3]**

Candidates performed well on this question with about 90% of candidates correctly calculating a value for the Young modulus. About two thirds of candidates correctly determined the percentage uncertainty by calculating the sum of the individual percentage uncertainty values for each of the results.

Question 21 (c) (iii)

(iii) The student researches the Young modulus of copper.

They find a value of $1.17 \times 10^{11}\,N\,m^{-2}$.

Determine whether this value is consistent with your answer to **(c)(ii)**.

[2]

Candidates performed less well on this question, over half the candidates did not achieve marks. Candidates were required to make a quantitative comparison to determine that the researched value was consistent with their calculated value from 21(c)(ii). A significant number of candidates gave a qualitative comparison or simply calculated the difference between the two values to state that the researched value was consistent with their answer to (c)(ii).

Misconception

When attempting to calculate a percentage difference to compare the calculated and researched 'true' value candidates would often find the difference in the calculated and researched value i.e. 0.02×10^{11} and divide by the calculated value of 1.15×10^{11}. Candidates would obtain a decimal value, but it would not be a correct percentage difference.

The method to calculate a percentage difference is

$$\frac{(\text{measured value} - \text{accepted value})}{\text{accepted value}} \times 100\%$$

Refer to page 47 in the Practical Skills Handbook on correct methodology on calculating percentage difference for uncertainty in measured and accepted values.

Question 22 (a)

22 Sound waves in air are longitudinal waves consisting of compressions and rarefactions.

(a) Explain how the movement of air molecules creates compressions and rarefactions.

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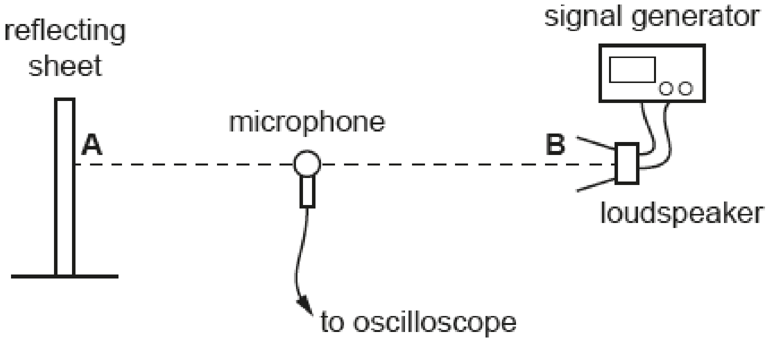
.... **[3]**

Candidates' performance on this question was variable with about of half of candidates scoring 1 or 2 marks but few candidates achieving all 3 marks for correctly explaining the movement of air molecules in compression and rarefaction of longitudinal waves. Descriptions of the movement of particles to transfer energy as a longitudinal wave was often weak with limited use of scientific language such as oscillation and parallel. The most common mark that was given was for an explanation of how compressions and rarefactions are formed in reference to the proximity of air molecules.

Question 22 (b) (i)

(b) A student investigates sound waves. They set up the following apparatus.



The sound wave emitted from the loudspeaker at **B** travels to the reflecting sheet at **A** and is reflected. A stationary wave is formed between the loudspeaker and the sheet.

The student moves a microphone along the line **AB**. The microphone is connected to an oscilloscope. The oscilloscope shows the relative amplitude of the stationary wave at each point along the line. The student observes a series of nodes and antinodes.

(i) Explain how a stationary wave with nodes and antinodes is formed.

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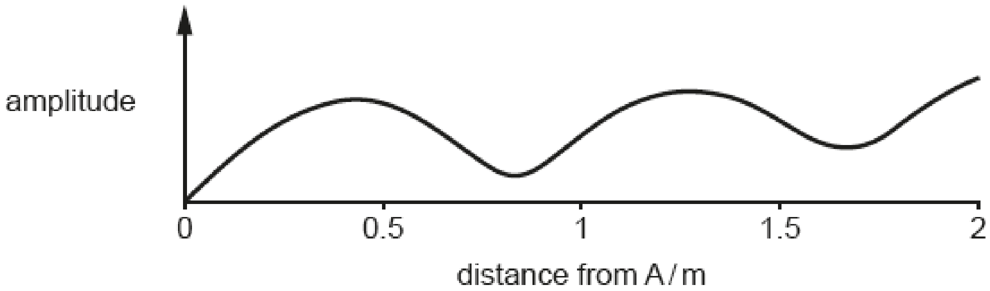
.... **[3]**

About a third of candidates achieved no marks on this question but most candidates were able to correctly explain that a stationary wave is formed from the superposition of the incident and reflected wave. Often descriptions of nodes and antinodes was confused and lacked effective and correct use of scientific language by referring to constructive and destructive interference and explaining how these formed antinodes and nodes respectively.

Question 22 (b) (ii)

(ii) The student measures the amplitude of the stationary wave at a range of distances from the reflecting sheet **A**. Their results are shown below.



The amplitudes at the nodes are observed to be:

- not exactly equal to zero
- closer to zero at distances closer to the reflecting sheet.

Explain these observations.

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....

....

.... **[3]**

Candidates performed less well on this question with only about a third of candidates achieving 1 or more marks. Candidates had to explain both observations regarding the amplitudes of the nodes to fully access the question by interpreting that the change in amplitude was related to the decrease in intensity/amplitude of the reflected wave as it travelled a greater distance from the reflecting sheet **A**.

Exemplar 1

* more out of phase, phase difference increases

The amplitudes at nodes may not be perfectly 0 due to waves being slightly out of phase, thus incoherent. At larger distances, this has a bigger effect*, thus amplitude at nodes tends to increase further away. There may also be background noise, which causes further interference. **[3]**

This response is an example of a typical response where candidates have confused the change in amplitude of the nodes to either a change in frequency or phase difference due to the reflected wave being 'out of phase' with the incident wave. There was also a common misconception that the reflected wave from the reflecting sheet **A** had experienced interference from either background noise or from further reflections of the wave in the room. The candidates had assumed that the two waves were no longer coherent, and this resulted in a difference in the amplitude of the nodes further from the reflecting sheet **A**.

Question 22 (b) (iii)

(iii) The student measures the distance between two adjacent nodes as 0.84 m.

The frequency of the sound wave is 200 Hz.

Use these measurements to calculate a value for the speed of sound waves in air.

speed of sound waves = ... $m\,s^{-1}$ **[2]**

Candidates performed well in this question as two thirds correctly determined that the wavelength of the sound wave was twice the distance between the adjacent nodes and then applied the wave speed equation $v = f\lambda$ to calculate the speed of sound waves as 336 $m\,s^{-1}$.

Question 22 (b) (iv)

(iv) The student wants to reduce the uncertainty in their calculated value for the speed of sound waves in air.

Suggest a suitable improvement to the student's method.

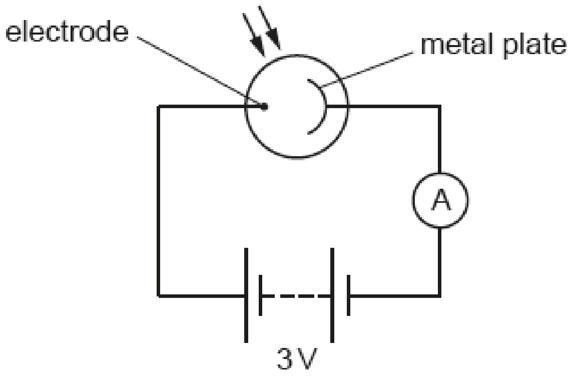
....

.... **[1]**

Less than half of candidates were able to suggest a suitable improvement to the student's method to reduce uncertainty in their calculated value of the speed of sound waves in air as suggestions were often referenced to carrying out repeats but omitted that an average needed to be calculated from repeat readings to improve accuracy. Most candidates did not understand that simply increasing measurements across more nodes would have reduced the uncertainty or that by decreasing the frequency the wavelength increased and hence the uncertainty was reduced.

Question 23 (a)

23 A light meter is used to measure the intensity of electromagnetic radiation. The meter consists of a metal plate and an electrode within an evacuated glass tube. It is connected to a circuit with an ammeter, a battery of e.m.f. 3.0 V and negligible internal resistance.



Electromagnetic radiation is incident on the metal plate. Electrons are released due to the photoelectric effect and are attracted to the electrode.

(a) Calculate the work done on an electron as it moves from the metal plate to the electrode.

work done = ... J **[2]**

Candidates performed well on this question as most candidates correctly applied the equation $W = VQ$ to calculate the work done on an electron and its corresponding charge as it moved from the metal plate to the electrode with a potential difference of 3 V from the battery connected in the circuit.

Question 23 (b)

(b) Explain why the frequency of the electromagnetic radiation must be above a minimum value for electrons to be released.

....

....

....

....

....

.... **[3]**

Just under two thirds of the candidates achieved 1 or more marks for correctly explaining the minimum energy required to emit electrons from incident photons related to the photoelectric effect. The most common response where candidates were given 1 mark was for relating the energy of radiation to the frequency by applying $hf = \Delta E$ but without referencing photons in their explanation and hence were not given any further marks. About 40% of candidates did reference photons in their response with 20% of candidates directly relating it to the work function as the minimum amount of energy required to release an electron to gain all 3 mark points.

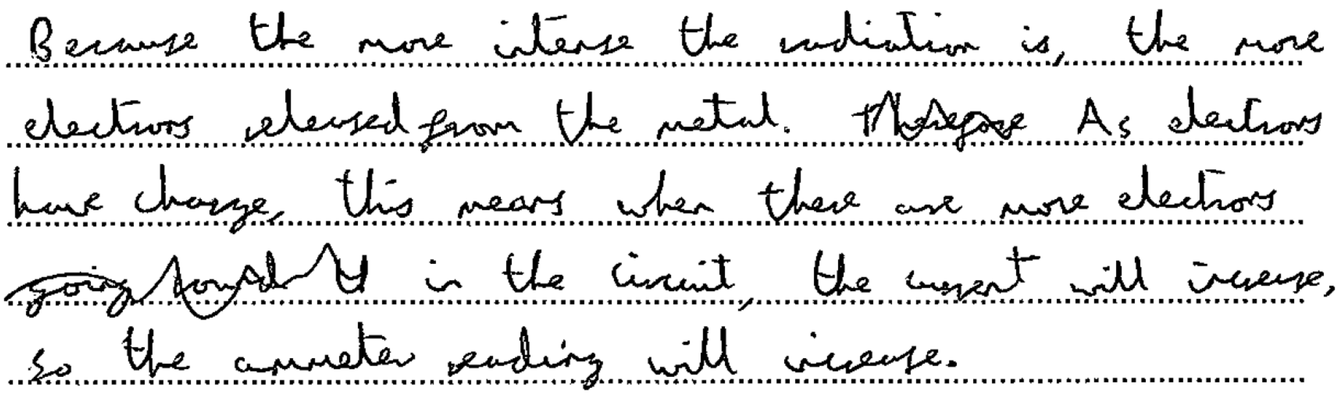
Question 23 (c) (i)

(c) (i) The reading on the ammeter is proportional to the intensity of the radiation. Use your knowledge of the photoelectric effect to explain why.

.... **[3]**

Candidates did not perform well on this question as 60% of candidates achieved no marks. A common response was to describe that greater intensity leads to more photoelectrons which was not given, and few made the important connection between intensity and 'rate of photons hitting the plate'. Also, many candidates did not apply the 1:1 correlation between photons and electrons in the photoelectric effect as they simple stated that more electrons were released without applying knowledge of the individual interaction between incident photons to the release of electrons. Many took the reverse view that greater current led to greater intensity or simply referred to the ammeter reading rather than referencing current.

Exemplar 2


Because the more intense the radiation is, the more electrons released from the metal. As electrons have charge, this means when there are more electrons in the circuit, the current will increase, so the ammeter reading will increase.

This exemplar demonstrates a typical response from candidates where a simple statement is made in relation to the intensity of electrons emitted and corresponding current reading on the ammeter. As in many similar responses the intensity of radiation is not linked to the 'rate of incident photons' resulting in a similar 'rate of electron emission' due to the 1:1 interaction between photons and electrons. Candidates were then required to link the rate of electron emission to the equation $\Delta Q = I\Delta t$ to conclude that current is equal to the rate of flow of charge and hence the ammeter reading is proportional to the intensity of the radiation.

Question 23 (c) (ii)

(ii) When the light meter is irradiated with monochromatic radiation of frequency 8.2×10^{15} Hz, the number of electrons emitted every second is $3.1 \times 10^{18}\,s^{-1}$.

The surface area of the metal plate normal to the incident radiation is $4.9 \times 10^{-3}\,m^2$.

Determine the intensity of the radiation.

intensity = ... $W\,m^{-2}$ **[4]**

Candidates did not perform well on this question as just over half of candidates scored 0 marks. Candidates had to select the equations $hf = \Delta E$ and $I = P/A$ from the Data, Formulae and Relationship booklet and then apply that the power was equal to the energy as the rate of emission of electrons was in a time of 1 second. Many candidates would select the correct equation $I = P/A$ but would then try and calculate power by using the equation $P = VI$ and $\Delta Q = I\Delta t$ by using the charge of an electron to calculate the current and using the battery e.m.f. of 3 V given in the circuit diagram. This demonstrated for a majority of candidates a lack of a confident understanding of the photoelectric effect that the energy of incident photons results in the release of electrons.

Exemplar 3

image). ~~[SEE END]~~ [SEE END]

(ii) When the light meter is irradiated with monochromatic radiation of frequency 8.2×10^{15} Hz, the number of electrons emitted every second is $3.1 \times 10^{18}\,s^{-1}$.

The surface area of the metal plate normal to the incident radiation is $4.9 \times 10^{-3}\,m^2$.

Determine the intensity of the radiation.

Energy per photon : $E = hf = 6.63 \times 10^{-34} \times 8.2 \times 10^{15}$

$= 5.4366 \times 10^{-18}$ J 85...

Total photons energy : $5.4366 \times 10^{-19} \times 3.1 \times 10^{18} = 16.9$ J (3sf)

intensity $= \frac{P}{A} = \frac{E}{At} = \frac{16.85..}{4.9 \times 10^{-3}} = 3400\,Wm^{-2}$ (2sf)

intensity = 3400 Wm^{-2} **[4]**

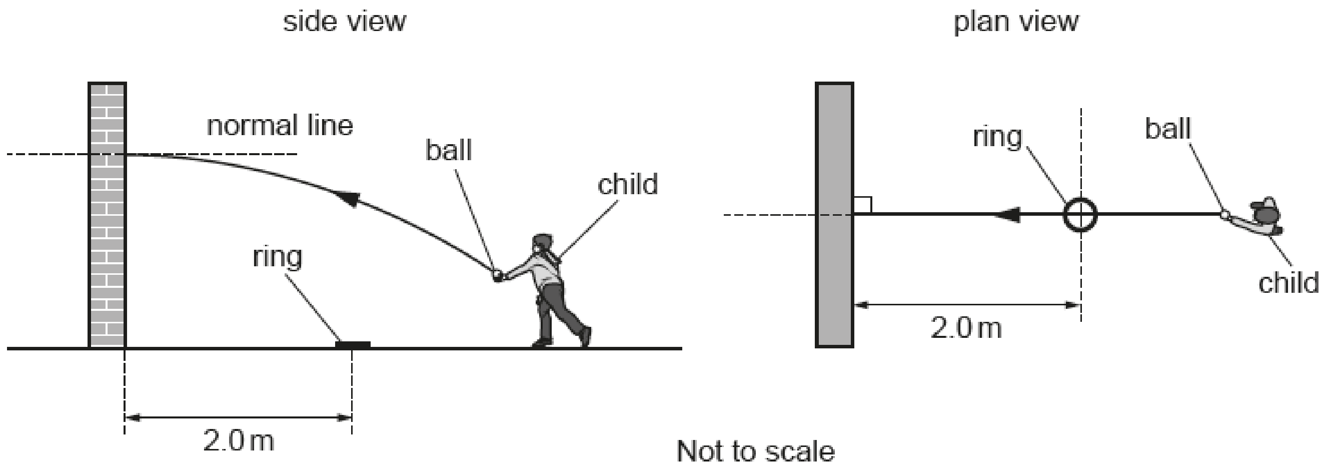
end

$Q = It$

This response demonstrates the correct and clear selection and application of formulae to calculate the intensity of the incident radiation.

Question 24 (a)

24 In a game, a child throws a ball at a flat, vertical wall. The ball rebounds from the wall. The child wins the game if the ball lands within a circular ring placed on the ground.



Not to scale

The ring has a radius of 15 cm. The centre of the ring is 2.0 m from the wall. The child throws a ball with a mass of 0.058 kg towards the wall.

(a) The ball is incident normally on the wall with a horizontal velocity of 7.2 m s^{-1}. The ball is in contact with the wall for 52 ms before rebounding normally with a horizontal velocity of 3.6 m s^{-1}.

Calculate the average magnitude of the force that the wall exerts on the ball.

force = ... N **[3]**

Over half of candidates correctly selected the equations $F = \Delta p/\Delta t$ and $p = mv$ to calculate the average magnitude of the force but about a third of candidates did not understand vector notation and that the rebounding horizontal velocity 3.6 m s^{-1} was in the opposite direction to the incident horizontal velocity 7.2 m s^{-1}. As a result they calculated the change in momentum as 0.058 × (7.2 – 3.6) leading to an incorrect value for the average magnitude of the force of 4.0 N.

Misconception

This question demonstrated a common misconception to apply vector notation for the quantity of momentum. To correctly answer this question candidates needed to apply understanding that momentum is a vector and hence the change in momentum was 0.058 × (7.2 – (-3.6).

Question 24 (b)

(b) The ball lands on the ground a time of 0.58 s after hitting the wall.

Show that the child wins the game. Air resistance can be assumed to be negligible.

[3]

Most candidates correctly calculated that the ball landed at a distance of 2.088 m from the wall and then compared this to the range of the target ring from the wall as 2.0 m ± 0.15 m to show that the child won the ring. Where candidates did not score full marks they had not clearly compared where the ball had landed with the full range of the target ring.

Question 25 (a)

25 A soil scientist investigates how different types of soil particles fall through water.

A soil scientist measures the terminal velocity of soil particles in water. He fills a tall glass cylinder with water and places a small sample of soil into the water. He uses a video camera, with a known frame rate, to measure the time taken for a particle in the soil to fall a measured distance.

The scientist records the total distance that the particle falls every 0.1 s.

Time / s	Total distance / cm
0.0	0.0
0.1	1.2
0.2	3.5
0.3	6.2
0.4	8.9
0.5	11.6

(a) Use the information in the table to explain why using a video camera to measure the time is more appropriate than a stopwatch in this investigation.

....

....

....

.... **[2]**

Just under half of candidates scored 1 mark for giving a reasonable explanation for the more appropriate use of a video camera to measure the time by reasoning that timing with the stopwatch was affected by human reaction time or that the uncertainty in the measurement was greater when using the stopwatch. Many responses from candidates lacked detail and did not use scientific language including random error (due to the reaction time), resolution and uncertainty as a reason to explain why the video camera was more appropriate. Some responses were often simplistic as candidates gave responses discussing accuracy and human error which was not given.

Question 25 (b)

(b) Suggest one other precaution that the scientist should take to ensure that the terminal velocity is determined as accurately as possible.

....

.... **[1]**

Candidates did not perform well on this question.The most common response was to suggest that repeat readings of the distance were taken to then calculate a mean value. While this was a reasonable and sensible suggestion it is not considered as a precaution as the correct response was to describe a method to avoid parallax error when measuring the distance the soil sample had fallen in the measuring cylinder.

Assessment for learning

Please refer to the Practical Skills Handbook for information on practical techniques including definitions of key scientific terminology and methodology.

Question 25 (c)

(c) Use the scientist's results to show that the terminal velocity is about $0.3\,\text{m}\,\text{s}^{-1}$.

[2]

A quarter of candidates correctly gave two calculations above a time of 0.3s to show that the soil sample had reached terminal velocity of 2.7 m s^{-1}. Many candidates calculated the distance that the soil sample had travelled for each 0.1 s interval which showed that the distance that the soil sample had travelled was 2.7 m but did not fully justify these values in relation to the soil sample reaching terminal velocity to secure 2 marks. Some candidates calculated the average velocity over the 0.5 s interval and then rounded it to show that it was about 0.3 m s^{-1} which did not receive credit.

Question 25 (d)

(d) Soil scientists classify soil samples according to the diameter of the particles, as shown in the table below.

Soil sample	Range of diameter / mm
clay	< 0.002
silt	0.002 – 0.05
sand	0.05 – 2.0
gravel	>2.0

The terminal velocity of a spherical particle of radius r, falling in water is given by

$$v = \frac{2r^2 g(\rho_s - \rho_w)}{9\eta}$$

ρ_w = density of water = 1000 kg m^{-3}
ρ_s = density of soil particle = 1500 kg m^{-3}
η = constant for water = 1.0×10^{-3} Pa s
g = acceleration of free fall = 9.81 m s^{-2}

Determine which soil sample was used by the scientist in this investigation.

soil sample = ... **[3]**

The performance on this question was variable as only just over half of candidates scored marks with only a quarter scoring full marks for determining the soil sample used by the scientist. Many candidates made errors when rearranging the equation of terminal velocity to give the radius, often by not taking the square root to give a value of the radius. In the subsequent step candidates were required to multiply the calculated value of radius by 2 to give the diameter and to convert from mm to m. These steps were often omitted and hence they used the radius value to determine the soil sample with most stating it was clay and as a result their answer was incorrect. Some candidates attempted to calculate the range of terminal velocities for each soil sample to then compare with the value 0.3 m s^{-1}. While this method was valid and given according to the mark scheme candidates did not always calculate the terminal velocity for each sample to then make a correct comparison and hence conclusion that the soil sample used was sand.

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