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Examiners' report

PHYSICS B (ADVANCING PHYSICS)

H157
For first teaching in 2015

H157/01 Summer 2019 series

Version 1

Contents

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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. 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 can be downloaded from OCR.

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Paper 1 series overview

This was the fourth 'Foundation of Physics' examination for this specification, and the nature and style of the paper would have been familiar to candidates. For preparation, the candidates will have the two specimen papers and the three papers from the previous series. The specification content and many of the assessment techniques are similar to those employed in the legacy Physics B AS papers, particularly G491 'Physics in Action', so also are useful preparation.

Section A consisted of twenty multiple choice questions, each worth one mark. The candidates were required to write their response in a box; as with the last series. There were very few candidates who did not understand this rubric and it is good to see that candidates are encouraged to do this. Alternatives such as circling or underlining the correct response will gain credit if it is fully clear, but a correct mathematical solution with no attempt to link it to a response will not be credited. Candidates should also make very clear the difference between their writing of response B and response D. It was noted again that several candidates attempted to write over a previous answer making the response either unreadable or uncertain and cannot be credited. If candidates change their mind, they should make this clear by fully crossing out the incorrect response and writing the new response next to it, preferably in a newly drawn box. Many candidates did appropriate working in the spaces, showing how they reached their answer although this is not required. There are still a number of candidates who did not attempt one or more of the multiple choice questions, although there is no penalty for incorrect responses.

Section B consisted of 3 questions, totalling 21 marks. With a little contrast to previous years, the questions in section B allowed a little more depth, although all within a single context. It is expected that most candidates will be familiar with the style of section B responses and they should in many cases find the questions relatively straightforward with only a little room for extended writing. There were several calculations in section B which required a couple of steps and it is hoped that the space available allows candidates to structure these calculations carefully.

Section C consisted of three questions, totalling 29 marks. These allow the candidates to explore a context in more depth with several unfamiliar calculations and some opportunities for more extended writing, allowing candidates to give explanations to physical phenomena. These questions are generally based in a practical context and it is expected that all candidates will be familiar with the apparatus and terminology used.

There was no evidence of lack of time for any of the candidates and questions not attempted were often those which provided a challenge to weaker candidates. The additional answer space was used by some candidates, mostly replacing work which had been crossed out, although a few used it to write in more depth where they had used all of the given space.

Note

From this series students have been provided with a fixed number of answer lines and an additional answer space. The additional answer space will be clearly labelled as additional and is only to be used when required. Teachers are encouraged to keep reminding students about the importance of conciseness in their answers. Please follow this link to our SIU:
https://www.ocr.org.uk/administration/support-and-tools/siu/alevel-science-538595/

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Section A overview

Section A consists of 20 multiple choice questions with four possible responses. The questions cover a variety of skills and knowledge and allow for breadth of the specification to be assessed. The questions were of differing challenge and discriminated well between the candidates although in general it was noted that candidates performed better on this section than in previous series.

Question 1

1 The unit of electrical charge, the coulomb, C, can be expressed in base units as

A ampere per second, $A\,s^{-1}$

B ampere-second, A s

C ampere second-squared, $A\,s^2$

D second per ampere, $s\,A^{-1}$

Your answer ☐

[1]

The majority of candidates were able to obtain the correct response. Many wrote an equation – either in units, words or symbols, to the side of the answer to help them. This is considered good practice.

Question 2

2 Three identical resistors each of conductance G are connected in parallel.

The conductance of the combination is

A $3G$

B $\frac{3}{G}$

C G^3

D $\frac{G}{3}$

Your answer ☐

[1]

The majority of candidates were able to obtain the correct response. It is hoped that candidates will work using conductance, however the working indicated that a few still work in resistance and convert back correctly afterwards. Although this requires an additional step, it did not seem to cause candidates any difficulties.

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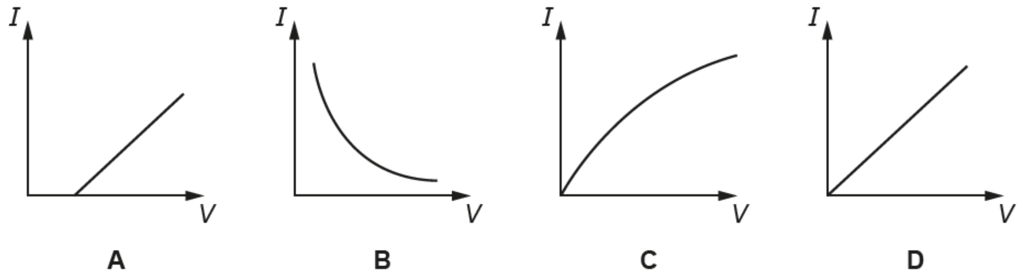
Question 3

3 Which sketch graph shows how the current I in an ohmic resistor varies with the p.d. V across it?



Your answer ☐

[1]

The majority of candidates were able to give the correct response. Response C was a common incorrect response with candidates presumably thinking of the filament lamp.

Question 4

4 A paintball is fired from a gun 1.8 m above the ground at a velocity of 75 m s^{-1} horizontally.

Ignore the effect of air resistance.

How long will the paintball take to hit the ground?

A 0.012 s

B 0.61 s

C 15 s

D 31 s

Your answer ☐

[1]

The majority of candidates were able to obtain the correct response. Several candidates drew a sketch to help, which is good practice if uncertain, and structured the calculations clearly.

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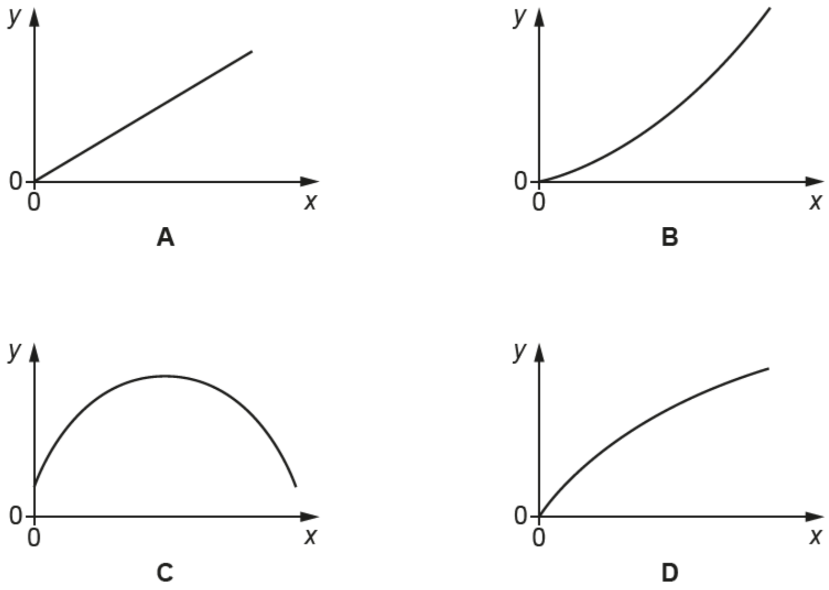
Question 5

5 A large object falls vertically through the atmosphere. Write down the letter of the graph that would be obtained by plotting:

- velocity v of the object on the y-axis;
- distance d fallen on the x-axis.



Your answer

[1]

The majority of candidates were able to determine the correct response. This is an unfamiliar graph without time on the x axis and so candidates were expected to use the equations of motion to determine the relationship, which many were able to do.

Question 6

6 A student measures the potential difference across a wire = 1.05 V (±0.01 V) and the current through the wire = 0.34 A (±0.01 A).

The percentage uncertainty in the resistance of the wire is

A 0.1%

B 2%

C 4%

D 8%

Your answer

[1]

The majority of the candidates were able to calculate the correct response. This question can only be answered by a carefully structured calculation and it was encouraging to see most candidates using the space available to provide working, such as in Exemplar 1.

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Exemplar 1

A student measures the potential difference across a wire = 1.05 V (±0.01 V) and the current through the wire = 0.34 A (±0.01 A).

The percentage uncertainty in the resistance of the wire is

A 0.1%

B 2%

C 4%

D 8%

$V = IR$ $\quad \frac{V}{I} \quad + \%$

$= \frac{0.01}{1.05} \times 100 + \frac{0.01}{0.34} \times 100$

$= 3.89$

Your answer $\boxed{C}$

[1]

Question 7

7 A ball of momentum *X* collides with an identical stationary ball.

All of the kinetic energy of the first ball is transferred to the second ball.

The change in momentum of the second ball is

A $-2X$

B $-X$

C X

D $2X$

Your answer

[1]

The majority of candidates were able to determine the correct response. Several drew a diagram to help although for most the answer was instinctive. A few put the response "X" in the answer box and it was not felt that this could be credited as it does not obey the rubric.

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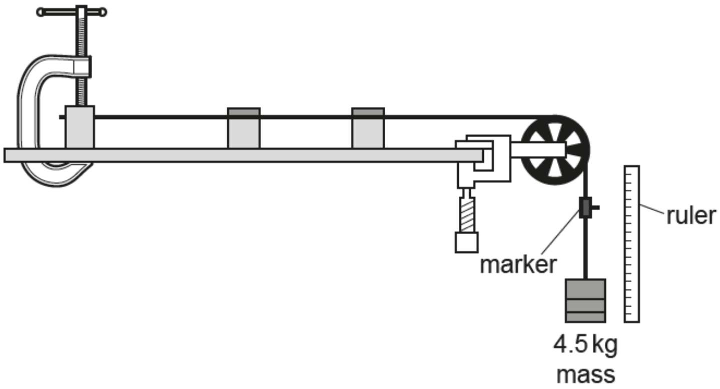
Question 8

8 A wire of length 2.1 m is stretched using the apparatus shown.



A mass of 4.5 kg is attached to the end of the wire. The wire extends by 2.0 mm. The cross-sectional area of the wire is $7.5 \times 10^{-7}\,m^2$.

The Young modulus of the wire material is

A 56 kPa

B 5.6 GPa

C 6.2 GPa

D 62 GPa

Your answer

[1]

The majority of the candidates were able to determine the correct response. Most of the errors came from a failure to convert the extension to metres.

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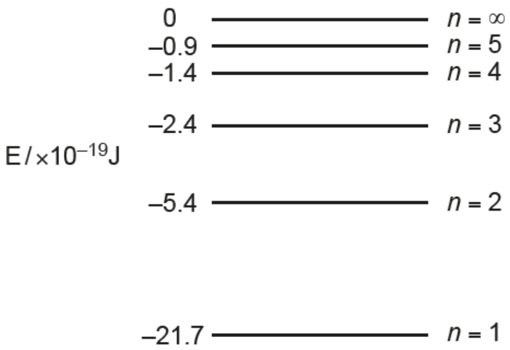
Question 9

9 The diagram shows the energy levels in an atom.



An electron moves from n = 3 to n = 2. The frequency of the emitted light is

A 1.5×10^{14} Hz

B 4.1×10^{14} Hz

C 4.5×10^{14} Hz

D 2.5×10^{15} Hz

Your answer ☐

[1]

The majority of candidates were able to obtain the correct response. Several initially missed out the power factor on the energy scale but were able to correctly appreciate that it needed to be included.

Question 10

10 A sensor is made up of 32 × 32 pixels.

In one experiment:

– a source emits 4096 photons, all of which are detected by the sensor;

– the probability of arrival of a photon is the same for each pixel.

The expected number of photons detected in each pixel is

A 1

B 4

C 128

D 4096

Your answer ☐

[1]

Most candidates were able to calculate the correct response. Although this calculation may not have been covered directly, it was clear that they had a good understanding of how to proceed.

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Question 11

11 Ceramic materials are generally

A Hard and brittle

B Stiff and tough

C Strong and flexible

D Tough and hard

Your answer ☐

[1]

Most candidates were able to correctly determine the correct response. Many crossed out answers which were clearly incorrect to allow them to identify the correct features, as shown in Exemplar 2**.**

Exemplar 2

Ceramic materials are generally

A Hard and brittle

~~B Stiff and tough~~

~~C Strong and flexible~~

~~D Tough and hard~~

Your answer $\boxed{A}$

Question 12

12 A source emits ultraviolet light of wavelength 200 nm.

The power emitted by the source is 100 mW.

The number of photons emitted by the source in 1 s is of order

A 10^{9}

B 10^{12}

C 10^{14}

D 10^{17}

Your answer ☐

[1]

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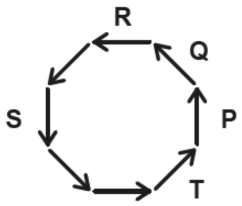
Less than half of candidates were able to correctly determine the correct response. Most candidates were able to identify how to solve this problem, although the conversion of units caused most errors. It was noted in some calculations that candidates thought the nano prefix was a millionth, confusing it with micro.

Question 13

13 The diagram shows a number of phasors.



The two phasors with a phase difference of π radians are

A **P** and **R**

B **P** and **S**

C **Q** and **T**

D **S** and **R**

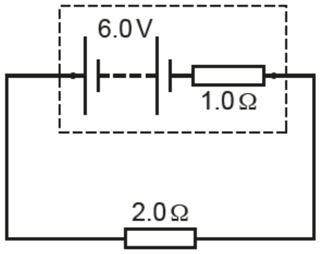
Your answer

[1]

The majority of candidates were able to identify the correct response. Many converted radians to get 180 degrees to help them identify the difference between the phasors.

Question 14

14 In the circuit shown, the p.d. across the 2.0 Ω resistor is



A 2.0 V

B 3.0 V

C 4.0 V

D 6.0 V

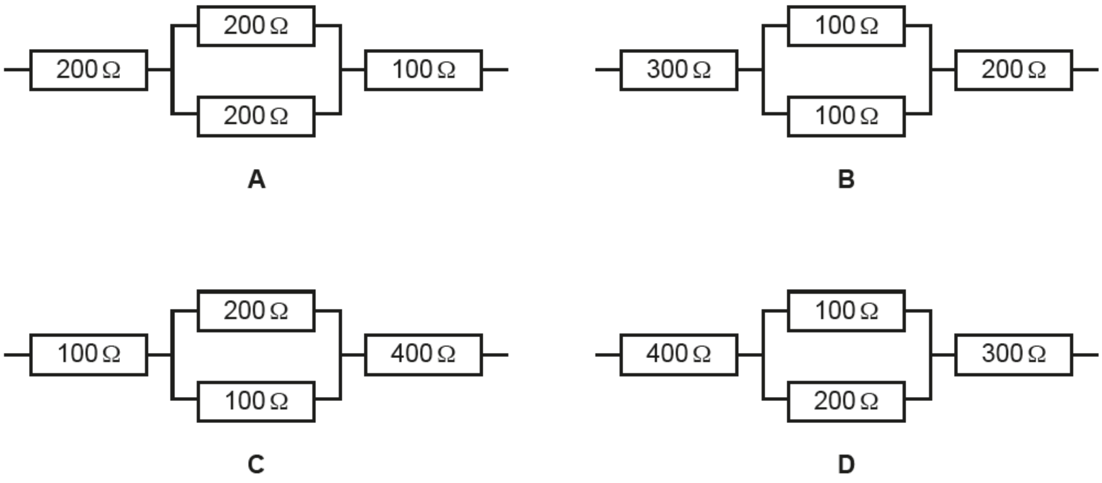
Your answer

[1]

The majority candidates were able to correctly calculate the correct response. Although most used the Ohm's law formula, it was clear that there was uncertainty in which resistance to use. Some calculated a current and evaluated the answer through a typical internal resistance calculation although the most confident candidates did a simple potential divider/ratio calculation.

Question 15

15 Which combination of resistors gives the **lowest** overall resistance?



Your answer

[1]

The majority of the candidates were able to calculate the correct response. Most evaluated each resistance in turn to identify the lowest resistance.

Question 16

16 An unstretched spring is 20 cm long and has a spring constant of 25 N cm^{-1}.

It is stretched to 3 times its length and is still following Hooke's law.

The energy stored in the spring is

A 50 J

B 200 J

C 450 J

D 900 J

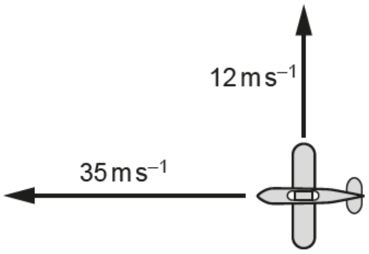
Your answer

[1]

About half of candidates were able to determine the correct response. Many candidates seemed to take the extension as three times the original length.

Question 17

17 An aircraft is flying with a velocity of 35 m s^{-1} westwards, relative to the air. A wind from the south pushes the aircraft northwards at a velocity of 12 m s^{-1}.



What is the magnitude of the resultant velocity of the aircraft, relative to the ground?

A 23 m s^{-1}

B 37 m s^{-1}

C 47 m s^{-1}

D 169 m s^{-1}

Your answer

[1]

The majority of candidates answered this correctly and showed appropriate working. A common error was to forget to take the square root of their calculation.

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Question 18

18 Two moving bodies, **X** and **Y**, collide and then move off together.

Mass of **X** = 3.0 kg
Speed of **X** = 3.0 m s^{-1}

Mass of **Y** = 4.0 kg
Speed of **Y** = 2.0 m s^{-1}

What is the speed of the combined body after the collision?

A 0.14 m s^{-1}

B 1.5 m s^{-1}

C 2.4 m s^{-1}

D 5.0 m s^{-1}

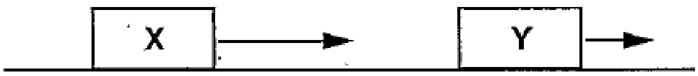
Your answer

[1]

This was answered correctly by the majority of the candidates. Those who obtained the correct response structured their calculation carefully in the space provided, as shown by Exemplar 3.

Exemplar 3

Two moving bodies, **X** and **Y**, collide and then move off together.



Mass of **X** = 3.0 kg
Speed of **X** = 3.0 m s^{-1}

Mass of **Y** = 4.0 kg
Speed of **Y** = 2.0 m s^{-1}

What is the speed of the combined body after the collision?

A 0.14 m s^{-1}

B 1.5 m s^{-1}

C 2.4 m s^{-1}

D 5.0 m s^{-1}

$3 \times 3 + 4 \times 2 = 7 \times V$

$\frac{9+8}{7} = V$

$V = 2.42858$

Your answer C

[1]

Question 19

19 What is the de Broglie wavelength of an electron accelerated from rest through a p.d. of 0.90 kV?

A 4.1×10^{-11} m

B 5.8×10^{-11} m

C 1.4×10^{-9} m

D 1.8×10^{-9} m

Your answer

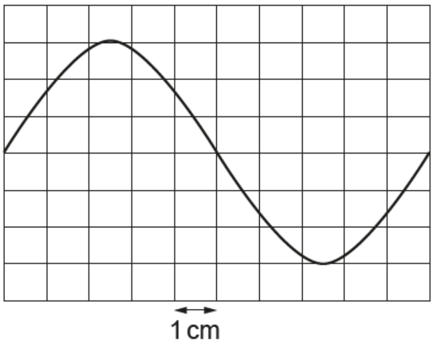
[1]

A relatively few candidates were able to calculate this correctly. Several started the solution appropriately but found it difficult to determine how the momentum could be calculated.

Question 20

20 The diagram shows an oscilloscope trace of the p.d. from a signal generator.

The time base of the oscilloscope is set to $0.50\,\text{ms}\,\text{cm}^{-1}$.



What is the frequency of the signal shown?

A 0.2 Hz

B 5 Hz

C 200 Hz

D 2000 Hz

Your answer

[1]

Over half of the candidates were able to determine the correct response. Some attempted to use the wave equation, generally not being able to solve it this way.

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Section B overview

Section B consists of 3 structured questions of a variety of styles. Assessment techniques are mostly calculation based, with a derivation of an equation and a suggestion of an experimental method. The questions are expected to be accessible to all candidates but do include some more challenging ideas which will require detail to differentiate between candidates.

Question 21 (a)

21 **Fig. 21** shows a model of current in a wire.

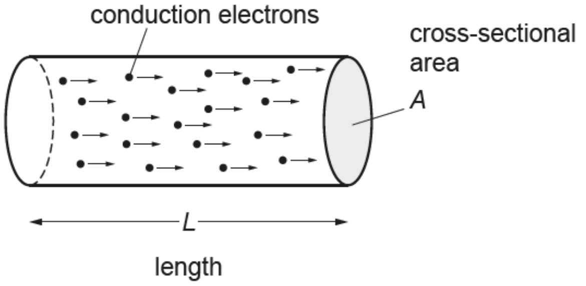

Fig. 21

n is the number density of charge carriers in the wire.

(a) What is the SI unit of charge?

.... **[1]**

Many candidates were able to correctly identify the coulomb as the correct unit. A common error was to give the response 'As'.

Question 21 (b)

(b) Show that the total charge, ΔQ, in the cylinder above is $nALe$, where e is the charge of an electron.

[2]

With a "show that" question of this style, it is very important for the candidates to provide some written commentary to support the solution. Candidates were expected to provide two clear quantities in their response; generally, it was anticipated that the volume of the cylinder could be calculated and then the charge per unit volume. By determining the product of these, the correct value could be determined. Candidates who simply multiplied the letters together with little or no valuable explanation could not be credited. Multiplying a correctly explained volume term by e and n with no further explanation would only score the first mark. Other alternative routes, such as using the current = nAve formula could score full credit if the explanations during the derivation were clear, and also as that shown in Exemplar 4.

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Exemplar 4

(b) Show that the total charge, ΔQ, in the cylinder above is *nALe*, where *e* is the charge of an electron.

The volumn of the wire

$V = LA.$

∴ The number of conduction electrons

is nLA.

∴ The total charge is

$nLAe$

[2]

Question 21 (c)

(c) The current in a cylindrical wire is related to the number density of charge carriers (electrons) by the equation

$I = nAve$

where I is the current and v is the drift velocity of the electrons.

The drift velocity is the average speed of the electrons in the wire in the direction of the current.

The wire carries a current of 3.2A.

Calculate the diameter of the wire.

Drift velocity of electrons in the wire is $0.50\,\text{mm}\,\text{s}^{-1}$.
Number density of electrons is $8.0 \times 10^{28}\,\text{m}^{-3}$.

diameter = ... m **[3]**

An encouraging number of candidates were able to score full marks on this question. With a calculation such as this, it is recommended that the cross sectional area first be evaluated separately before going on to determine the diameter. Any error in this – which can be carried forward – could then be awarded. It was good to see that most candidates correctly converting the drift velocity units correctly. Many candidates determined the radius of the wire, and this could be given two of the three marks assuming all else was correct. Candidates should always aim to set out their working clearly, as if arithmetic errors are to be given, then it must be evident where they have occurred.

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Question 22 (a)

22 **Fig. 22.1** shows the bottom end of some organ pipes.

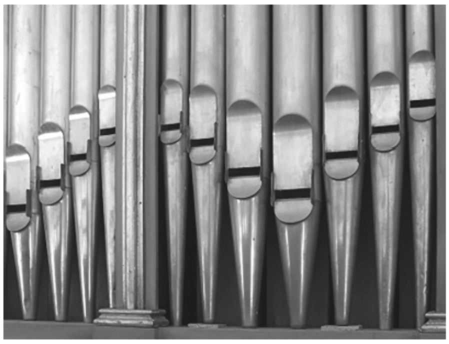

Fig. 22.1

Air is blown into the pipes from the bottom. The small opening causes the air inside to vibrate. The vibrations are reflected from the top of the pipe and form a standing wave.

Fig. 22.2 shows the pipe and the positions of the nodes (**N**) and antinodes (**A**).

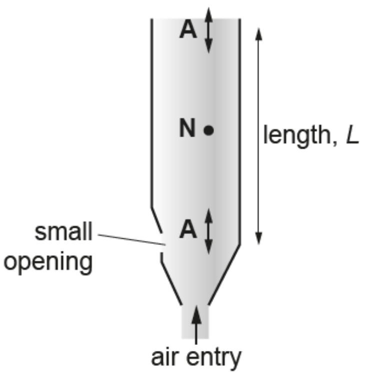

Fig. 22.2

L is the length of the vibrating air column in the pipe.

(a) What, in terms of *L*, is the wavelength of the standing wave shown in **Fig. 22.2**?

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

Most candidates were able to correctly identify that diagram corresponded to 2L. Many drew a transverse wave on the diagram to help and appreciated that it is was half a complete cycle. Some candidates incorrectly mixed up the node and antinode which led them to making the wavelength equal to L.

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Question 22 (b)

(b) An organ pipe like the one shown in **Fig. 22.2** has length L = 61 cm.

The speed of sound in air is 340 m s^{-1}.

Calculate the frequency of the vibration shown in **Fig. 22.2**.

Use an appropriate number of significant figures in your answer.

frequency = ... Hz **[3]**

Many candidates were able to correctly apply the wave equation here and use their response from 22(a) to evaluate the frequency. The third mark in this question was for following the request to give to a suitable number of significant figures. Many candidates wrote their answer to 3 or more sf, but then converted it correctly to 2 significant figures (sf) for full credit (Exemplar 5). However, many candidates ignored this, or perhaps did not see it, and it is good practice for a candidate to underline or star this request before answering this question to allow them to remember to do this. Several candidates did correctly write their answer to 3 sf – and made it clear – but this would not be credited and they should remember that the appropriate number is the minimum given in the question, in this case to 2sf; see Exemplar 6. Error carried forward from the 22(a) is applied here for potentially full credit.

Exemplar 5

An organ pipe like the one shown in **Fig. 22.2** has length L = 61 cm.

The speed of sound in air is 340 m s^{-1}.

Calculate the frequency of the vibration shown in **Fig. 22.2**.

Use an appropriate number of significant figures in your answer.

frequency = $\frac{\text{wavespeed}}{\text{wavelength}}$

$\frac{340}{1.22}$

2 x 0.61 = 1.22

= 278.68

frequency = ...280.......... Hz **[3]**

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Exemplar 6

An organ pipe like the one shown in **Fig. 22.2** has length $L = 61\,\text{cm}$.

The speed of sound in air is $340\,\text{m s}^{-1}$.

Calculate the frequency of the vibration shown in **Fig. 22.2**.

Use an appropriate number of significant figures in your answer.

$v = f\lambda$ $f = \frac{v}{\lambda}$ $\frac{340}{0.61 \times 2} = 278.6885$ Hz

frequency = ...279...... Hz **[3]**

Question 22 (c)

(c) Some organ pipes are closed at the top. This causes the top end to be a node instead of an antinode.

Calculate the lowest frequency produced by a closed pipe with the same 61 cm length as in part **(b)**.

frequency = ... Hz **[2]**

Candidates who re-drew their wave in the pipe were most likely to come to the correct conclusion. Although many simply appreciated that the frequency would simply halve and gave half of their answer to 22(b). Bare answers will be credited full marks here, although it is good practice to always show working and give as much explanation as possible. Error carried forward applies as usual.

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Question 23 (a)

23 **Fig. 23** shows the motion of a dropped ball of mass 50 g bouncing on a hard surface.

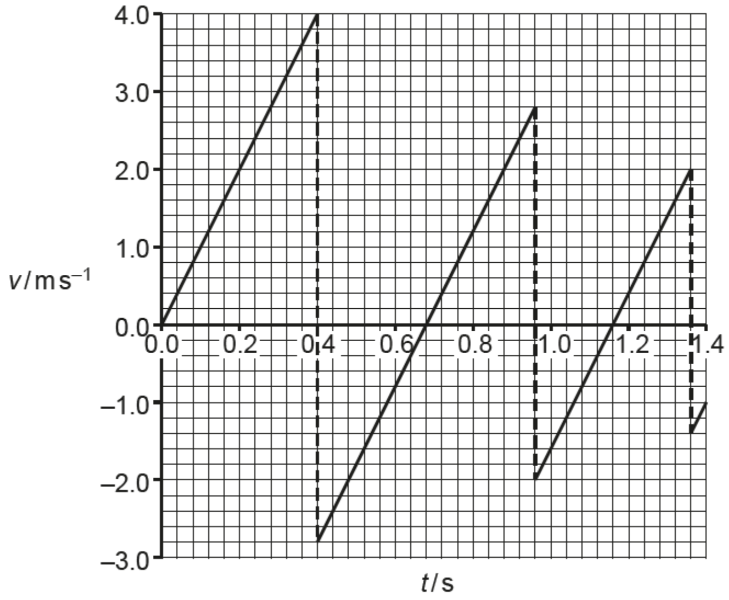

Fig. 23

The data for the graph were obtained by video capture.

(a) Explain one advantage of using video capture to collect these data.

....

.... **[1]**

As the expected response is an explanation, and simply statement alone will not be sufficient. Anticipated answers involved a statement usually followed by a "so that….". Credit was given to any valid response, although it did need to relate clearly to the idea of video capture. Exemplar 7 shows an acceptable response, whereas that in Exemplar 8 is too vague for credit.

Exemplar 7

Explain one advantage of using video capture to collect these data.

The video can be slowed down so the motion of the ball can be viewed more accurately **[1]**

Exemplar 8

Explain one advantage of using video capture to collect these data.

More precise measurements for distance travelled in each time interval ∴ precise measurements of V **[1]**

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Question 23 (b)

(b) Use the graph to show that the acceleration due to gravity is approximately 10 $m s^{-2}$.

.... **[2]**

As this is a "show that" it is important to give explanation where the values used come from. A simple 4/0.4 = 10 will yield the correct answer but it is not fully clear why these values have been used. An additional statement showing that it is a gradient calculation is required for full credit. It is highly recommended that in this style of question that a candidate gives some written reason for their answer. Nearly all candidates were able to score the calculation mark. Some used an equation of motion calculation which was sufficient for both marks. A few candidates did an incorrect calculation to give a wrong value.

Question 23 (c)

(c) Calculate the kinetic energy of the ball just before it hits the surface for the first time.

kinetic energy = ... J **[3]**

This question was answered well by the vast majority of candidates, with the only common error being a failure to convert g to kg. As always, working is recommended should an arithmetic error occur. A very small number of candidates gave an incorrect value for the velocity at this point and it was felt that this could not achieve any credit here but may give an error carried forward in the next part.

Question 23 (d)

(d) Calculate the percentage change in kinetic energy of the ball on the bounce occurring at $t = 0.4$ s.

percentage change = ... % **[3]**

This was a reasonably challenging question but was answered to a good degree by many candidates. Most were able to correctly calculate the rebound kinetic energy and calculate differences, but the percentage difference calculation provided a challenge. Rounding earlier answers provides different possible final answers, but this was not penalised in this question.

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Section C overview

Section C consists of 3 longer structured questions, expected to assess candidates understanding of principles and in particular the application of these to practical situations. Less guidance is generally given to these questions than those in section B and candidates are expected to use their familiarity of physics to appreciate how to progress. Section C will expect candidates to use a variety of techniques and information from various parts of the question, including previously calculated answers, to complete each question. It is expected that candidates will have had experience of the practical situations presented and the apparatus used.

Question 24 (a)

24 A student uses the equipment shown in **Fig. 24.1** to determine the refractive index of the glass used to make the glass block.

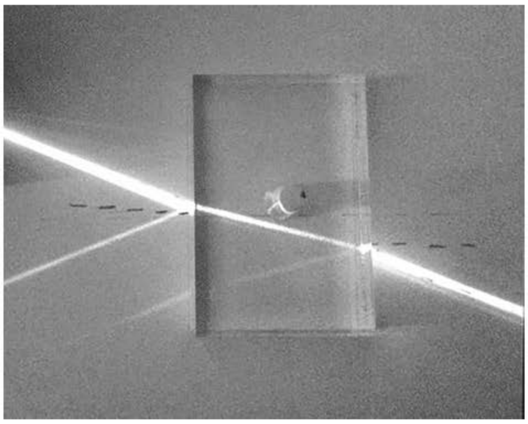

Fig. 24.1 equipment

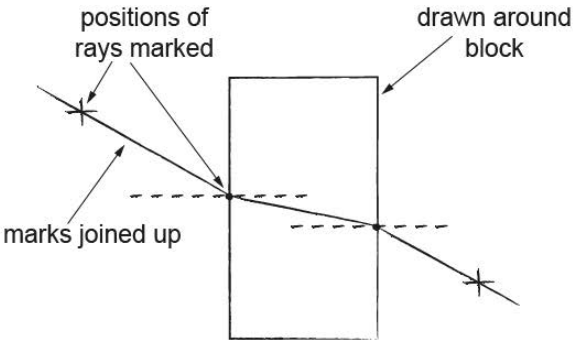

Fig. 24.2 student's marks on paper

The student measures two angles to determine the refractive index.

(a) Mark on **Fig. 24.2** two angles she can measure to determine the refractive index. **[2]**

Most candidates were able to mark correctly two appropriate angles. Many used the commonly used arc notation, although any other acceptable clear identification, such as arrows or letters, was accepted. Any pair that would work was allowed but if more than two angles were marked then no credit was given.

Question 24 (b)

(b) Suggest and explain one way to improve the accuracy of the angle data.

....

....

.... **[2]**

This question asks about how the angles could be measured more accurately (i.e. close to the true value) and so it is essentially looking for a potential fault in the way it has been done. The key solution – identified by many candidates – was that the beam was too thick and so a method to reduce this was to be suggested and explained. Alternative correct responses were allowed, but those which would improve the percentage uncertainty were not.

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Question 24 (c)

In a repeat of the experiment, the two angles are found to be 28° and 17°.

(c) Calculate the refractive index of the glass.

refractive index = ... **[2]**

This was a relatively simple calculation, well completed by the vast majority of candidates. There was no penalty for significant figures here (although clearly 1sf would not be appropriate). Several candidates simply did incident angle/refracted angle which produced an approximately correct answer but gained no credit. As always, working is best shown to make it clear what method is being used.

Question 24 (d)

(d) How does the refractive index of a material affect the properties of light passing through it?

....

.... **[2]**

Many candidates were able to correctly state that the speed slowed in a higher refractive index, but it was important to state the sense of change. As the question asks for properties (plural) the second mark was for a correct statement regarding frequency or wavelength which few candidates supplied. Exemplar 9 shows a candidate who was able to supply a very clear response, whereas Exemplar 10 can only be given a single mark. Candidates are advised to give as much detail as appropriate in this type of response.

Exemplar 9

How does the refractive index of a material affect the properties of light passing through it?

doesn't affect frequency but does

higher refractive index means slower wave speed and decreased wavelength ~~but constant~~ **[2]**

Exemplar 10

How does the refractive index of a material affect the properties of light passing through it?

higher refractive index slows and refracts the light more. **[2]**

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Question 25 (a)

25 A source of coherent light waves (a laser) is used to illuminate a single slit.

A diffraction pattern is formed on a screen a distance D = 2 m from the slit.

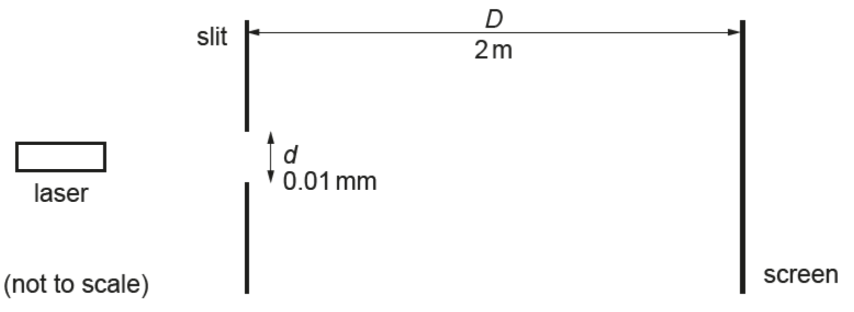

Fig. 25.1

(a) Explain the term **coherent**.

....

.... **[1]**

Many candidates were able to give a good and clearly learnt response to this question. Coherence is a specific term and vague responses relating to "same wavelength sources" will not be worthy of credit and it is essential to use the term "phase".

Question 25 (b)

The pattern observed on the screen is shown in **Fig. 25.2**.

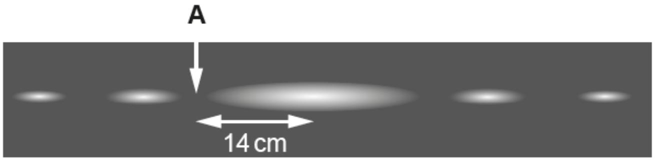

Fig. 25.2

The point labelled **A** is completely dark. **A** is at a distance of 14 cm from the centre of the pattern.

(b) Show using the small angle approximation that this is 0.07 radian from the centre line.

[2]

This question required the use of the small angle approximation and without a clear use of this, it was felt that there could be no credit despite a correct calculation. The approximation requires a clear statement of the sin or tan of angle being approximately equal to the angle for small angles. Only a small number of candidates made this clear and as with all "show that" questions, it is very important to include as much explanation as possible.

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Question 25 (c)

A is completely dark.

(c) Explain why the path difference between two wavelets arriving at **A** from the top and bottom of the slit must be ½ λ.

....

....

....

....

.... **[2]**

The situation of a single slit and the reasons for the interference pattern from various parts of the slit is unlikely to have been covered by any candidates. However, this question is simply asking why dark region of any interference pattern must have a half wavelength path difference. Candidates were expected to describe what half a wavelength refers to in terms of phase – or with a sketch to show this – and then lead this to the conclusion of the appropriate interference. Many were able to do this very well and there was no confusion for any candidates about the phase difference between the top and bottom of a single slit. Better candidates were able to use the concept of phasors, with or without diagrams, in their responses. Exemplar 11 shows a candidate with a clear appreciation of the concepts and is able to obtain both marks.

Exemplar 11

Explain why the path difference between two wavelets arriving at **A** from the top and bottom of the slit must be ½ λ.

A is an area of destructive interference where the waves are 180° out of phase (ie ½ λ) so that the troughs of one wave and the peak of another coincide to result in a 0 resultant amplitude. The phasors of both wavele~~ngths~~ts have the same magnitude but point in opposite directions so cancel out **[2]**

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Question 25 (d)

(d) Calculate the wavelength, in nm, of the light used.

wavelength = ... nm **[2]**

Although not using a standard formula, there was sufficient information within the question for candidates to be able to calculate the wavelength. It requires use of the given information along with the value given (or calculated) in 25(b). Several candidates converted radians to degrees correctly and were able to evaluate the correct wavelength. The wavelength was to be given in nm, and several candidates did not do the conversion at all, or incorrectly. It was felt that a missing of the factor of ½ leading to 350nm could be awarded a single mark. A few candidates attempted to use the double slit formula which could not be awarded any marks here.

Question 25 (e)

The screen is moved further away from the slit and the distance from the centre of the pattern to **A** is measured again.

(e) Suggest one advantage and one disadvantage of this change when measuring the distance to **A**.

advantage ....

.... **[1]**

disadvantage ....

.... **[1]**

Candidates who have carried out a double slit experiment may well have discussed or experienced the various advantages and disadvantages of changing some variables and this can be applied to this situation. Increasing the screen-slit distance will increase the distance to A, and hence decrease the percentage uncertainty. It is important that candidates appreciate the difference between uncertainty (which remains constant and is based upon the measuring apparatus) and the percentage uncertainty. A few candidates gave vague responses such as “makes the measurements better” or “improves the accuracy” which cannot be credited here. The disadvantage of dimmer bright leads to lack of contrast and it was felt important that candidates gave a full reason. The term “clarity” was not felt to clearly explain the reason, nor certain practical suggestions such as longer measuring apparatus. Exemplar 12 shows two acceptable responses for credit of both marks, whereas Exemplar 13 can only be credited with the first mark.

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Exemplar 12

Suggest one advantage and one disadvantage of this change when measuring the distance to **A**.

advantage Percentage uncertainty is decreased in measurements of distance as total distance is longer **[1]**

disadvantage the light becomes less bright on the screen so it's harder to find the exact point at which it's completly dark. **[1]**

Exemplar 13

Suggest one advantage and one disadvantage of this change when measuring the distance to **A**.

advantage The distance is larger so % error in measuring will decrease **[1]**

disadvantage A larger tape measure or ruler will be needed **[1]**

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Question 26 (a)

26 A student is investigating the resistivity of a metal.

The student has a 1.0 m length of wire made from the metal.

Fig. 26.1 shows the circuit used by the student.

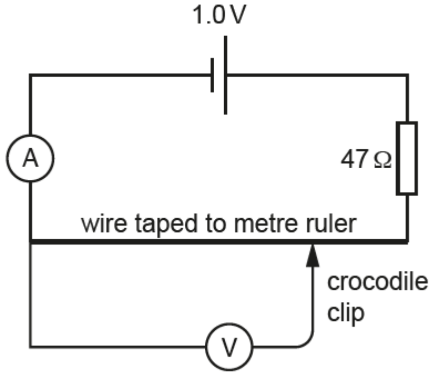

Fig. 26.1

(a) Explain why the voltmeter should have a very high resistance.

....

....

....

.... **[2]**

Candidates familiar with "ideal voltmeters" should be able to explain the purpose of a very high resistance voltmeter. Candidates were able to gain marks in various ways, including the effect on the ammeter or voltmeter, and a reason for this usually in terms of current flow. Candidates should be encouraged to avoid using vague terminology such as "makes the readings accurate" as this does not fully answer the question and in some cases (such as this) is not strictly correct.

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Question 26 (b)

The cell has an e.m.f. of 1.0 V and negligible internal resistance.

The wire has a resistance of 3.0 Ω.

The crocodile clip is connected at the centre of the wire as shown in **Fig. 26.2**.

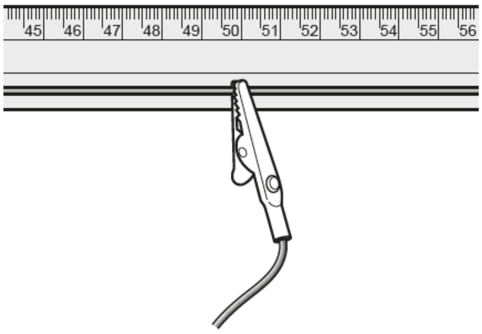

Fig. 26.2

(b) Calculate the voltmeter reading you expect the student to see.

Expected reading = ... V **[2]**

It was anticipated that candidates would calculate the current through the wire and then apply this to the wire. Several candidates drew a circuit diagram which led them to a solution through a potential divider, which was seen to be more likely to produce the correct answer. Candidates who calculated the voltage across the whole wire were credit with a mark.

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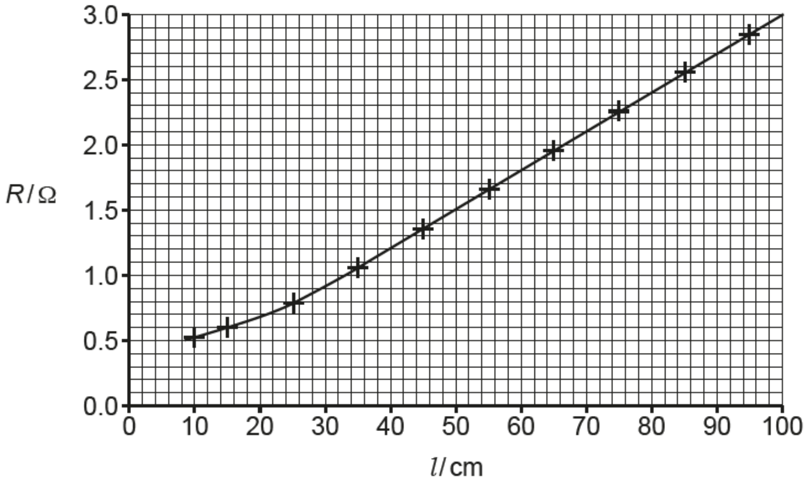
Question 26 (c) (i)

The student records the readings on the voltmeter and ammeter for a range of positions of the crocodile clip.

The student uses the results to calculate the resistance for each length l of wire under test.

The graph shows the results of the investigation.



The student expected the graph to show that R is directly proportional to l.

(c) **(i)** State the shape of graph expected if R were directly proportional to l.

.... **[1]**

The correct response for this was to be a straight line through the origin. There were a significant number of candidates who simply gave their response as linear, and it is important that candidates appreciate the difference between these two relationships. However, if it was seen from their graph that the extrapolation of the line passed through the origin, then it was felt that the candidate appreciated the relationship.

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Question 26 (c) (ii)

(ii) The graph is a curve for small lengths because the higher current heats the wire and its resistivity increases.

The resistivity of the metal increases by 0.4% for each °C temperature rise.

Calculate the temperature rise of the wire when $l = 20$ cm.

Temperature rise = ... °C **[4]**

This is a challenging calculation that only a small number of candidates were able to complete fully. However, a large number of candidates were given credit for part solutions and for showing that they had some understanding of how to approach the problem. When candidates are faced with an unfamiliar setting, it is good practice to give some explanation to their thinking, as they would if they were asked to discuss it. Markers were encouraged to be generous in tolerances and to credit clear methods, part correct answers and errors carried forward. Although this was the most challenging question on the paper, many candidates were able to score some marks. Exemplar 14 shows a candidate with an initially incorrect value for *R* who then goes on to carry out the remainder clearly and can be awarded 3 marks. Exemplar 15 is only worth a single mark for their answer of 0.035. The addition of extra explanations in Exemplar 14 makes it easier to determine where a candidate can be credited.

Exemplar 14

(ii) The graph is a curve for small lengths because the higher current heats the wire and its resistivity increases.

The resistivity of the metal increases by 0.4% for each °C temperature rise.

Calculate the temperature rise of the wire when $l = 20$ cm.

$\frac{0.3}{3} \times 100 = 10\%$ resistivity increase

$L = 20\text{cm}$ $R = 0.66$

call A as not given

$\text{Resistivity} = \frac{RA}{L} = \rho$

$\approx \frac{10}{0.4} = 25$

for when graph is straight so no temprise

at 20 cm $= \frac{0.66}{0.2} = 3.3$

$\frac{2.4 \times 1}{0.8} = 3$

Temperature rise = 25 °C **[4]**

Exemplar 15

(ii) The graph is a curve for small lengths because the higher current heats the wire and its resistivity increases.

The resistivity of the metal increases by 0.4% for each °C temperature rise.

Calculate the temperature rise of the wire when l = 20 cm.

$R = \frac{\sigma L}{A}$ $R \propto L$ ~~1.004~~ $\sigma \propto$ °C

$1.004 \times \sigma \propto$ °C

when $l = 20$cm
$R = 0.7\,\Omega$

20×1.004

$\frac{0.7}{20} = 0.035$

Question 26 (c) (iii)

(iii) State one other variable, apart from temperature, that should be controlled in this investigation.

.... **[1]**

Most candidates were able to select one of the suitable variables to control, although there were several responses such as "same voltmeter" that were not thought to be appropriate in this context. Candidates are always advised to consider what they would do in a practical situation in order to have a fair test.

Question 26 (d)

Another student repeats the experiment. The crocodile clip is replaced with a sliding contact which has a sharp edge and measurements are taken as shown in **Fig. 26.3**.

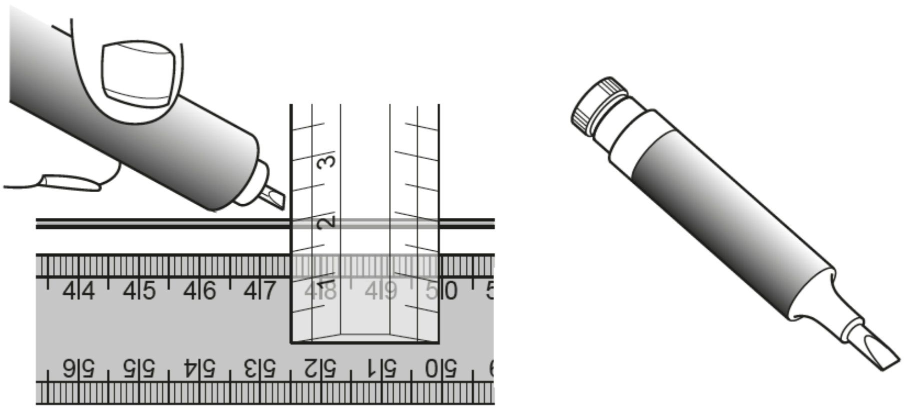

Fig. 26.3

(d) Explain how these changes will affect the quality of the measurements of length.

....

....

....

....

.... **[2]**

The term quality is used here as a term to cover the terms which may produce a "better outcome" to the measurement of the length. The candidates were required to state that "it reduces uncertainty/more accurate/more precise" before giving an answer, which most did. Many appreciated the thickness was the key factor and so were able to give a response scoring a single mark. The other change is the use of the ruler which many candidates did not explain, either at all or in sufficient detail. Candidates are expected to explain these changes, rather than just give statements of what has changed. Although Exemplar 16 is not explained in the clearest way, it is evident that this can gain both marks. Exemplar 17 only addresses the first marking point and so can only be awarded a single mark.

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Exemplar 16

(d) Explain how these changes will affect the quality of the measurements of length.

Using the shard edge connection means that the distance along the wire when clipped is more obvious as ~~there is~~ ~~one~~ ~~a~~ connection is fine so measurements will **[2]** be more accurate. The perpendicular ruler can be used to ensure the ruler is straight (parallel to the wire) and so the measurement taken is not shorter than its actual length

Exemplar 17

(d) Explain how these changes will affect the quality of the measurements of length.

This improves upon accuracy as readings can be made accurately to the centimeter where as previously with the crocodile ~~p~~ clip there would be connecs across a few centimeters at once making readings less accurate. It may also effect the readings if this sliding contact is made from **[2]** a different material. This sliding clip has a ~~lower~~ smaller surface area than the crocodile clip

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Question 22.1

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