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Examiners' report

PHYSICS B (ADVANCING PHYSICS)

H157
For first teaching in 2015

H157/01 Summer 2018 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. 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.

Paper H157/01 series overview

This was the third 'Foundation of Physics' examination for this new 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 two papers from the previous series, although the specification content and many of the assessment techniques were similar to those employed in the legacy Physics B AS papers, particularly G491 'Physics in Action'.

Section A consisted of twenty multiple choice questions, each worth one mark. The candidates were required to write their response in a box; in contrast to previous series, there were no candidates who did not understand this rubric. However, it was noted that several candidates attempted to write over a previous answer and this makes the response either unreadable or uncertain and cannot be credited. When 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. When candidates changed their mind, many made this clear by fully crossing out the incorrect response and writing the new response next to it, often in a newly drawn box.

Section B consisted of 6 questions, totalling 20 marks. They typically each examine a single context, with single state calculation, structured answers, problem solving and estimation. There is little room for extended writing in section B although question 26 had two sections which would allow for some development of writing.

Section C consisted of three questions, totalling 30 marks. These allow the candidates to explore a context in more depth with several multistage calculations and two opportunities for extended writing, each worth 4 marks. One of these concerned uncertainties in the previously described situation, which allowed for both writing and calculations to support the candidates arguments.

There was little evidence of lack of time for the vast majority of 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.

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.

Question 1

1 Which of the following correctly describes ceramic materials?

A ductile

B plastic

C stiff

D tough

Your answer ☐

[1]

Approximately 80% of the candidates answered this question correctly. The materials terms have strict definitions and it was encouraging to see that candidates were able to apply them to a given material. The main incorrect response was, perhaps unsurprisingly, D.

Question 2

2 The sum of the currents entering a junction is equal to the sum of the currents leaving the junction.

This is the principle of conservation of which quantity?

A charge

B energy

C mass

D momentum

Your answer ☐

[1]

Approximately 78% of candidates answered this question correctly. Candidates are mostly familiar with conservations laws of B and D, and response B was a common incorrect response.

Question 3

3 Which of these statements about metals is **not** correct?

A They have a high number density of charge carriers.

B They have directional bonds between the metal ions.

C They have mobile dislocations.

D Pure metals are usually ductile.

Your answer [ ]

[1]

Approximately 64% of candidates answered this question correctly. Candidates find "which is **not** correct" questions challenging and should aim to work through each response. Many candidates cross out incorrect responses or put a tick at the side of responses which they consider correct to assist, which is good practice.

Exemplar 1

A They have a high number density of charge carriers.

B They have directional bonds between the metal ions.

C They have mobile dislocations.

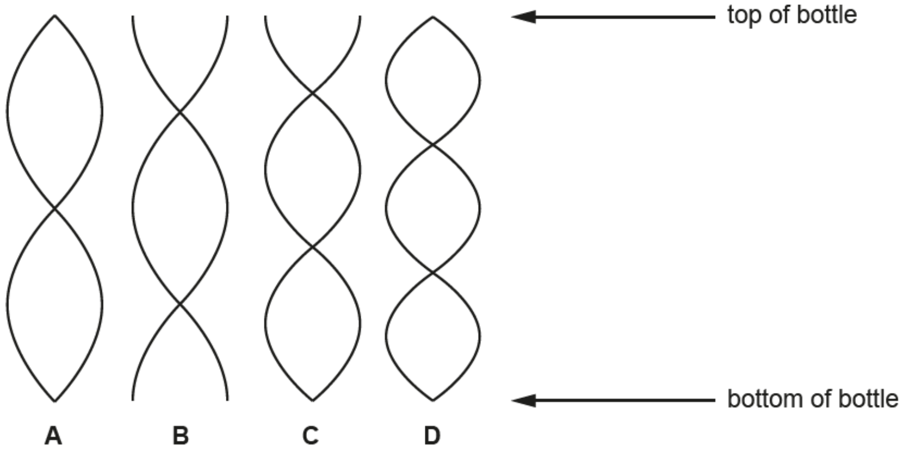
D Pure metals are usually ductile.

Your answer [B]

Question 4

4 A student blows across the open top of an empty bottle.

Which diagram represents a standing wave that can be produced in the air in the bottle?



Your answer ☐

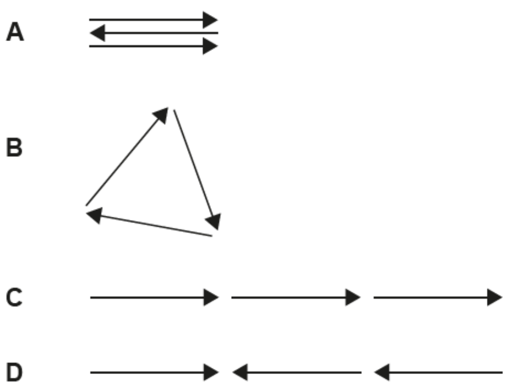
[1]

Approximately 78% of candidates answered this question correctly. It was encouraging to see that many candidates were able to extract the correct information from a diagram that they may be unfamiliar with.

Question 5

5 Monochromatic light passes through 3 closely spaced parallel slits at a point. A maximum is produced at a point on a distant screen where the phase difference between light from successive slits is π radians.

Which phasor diagram represents the constructive interference at this point?



Your answer ☐

[1]

Approximately 22% of candidates answered this question correctly. Phasor diagrams are traditionally challenging for candidates and there was a lot of information contained in the question for the candidates to process. The term "constructive interference" led a large number of candidates to response C.

Question 6

6 Light can be modelled as a wave or as particles (photons).

Which one of these phenomena can **only** be explained if light is made of photons?

A diffraction

B photoelectric effect

C polarisation

D reflection

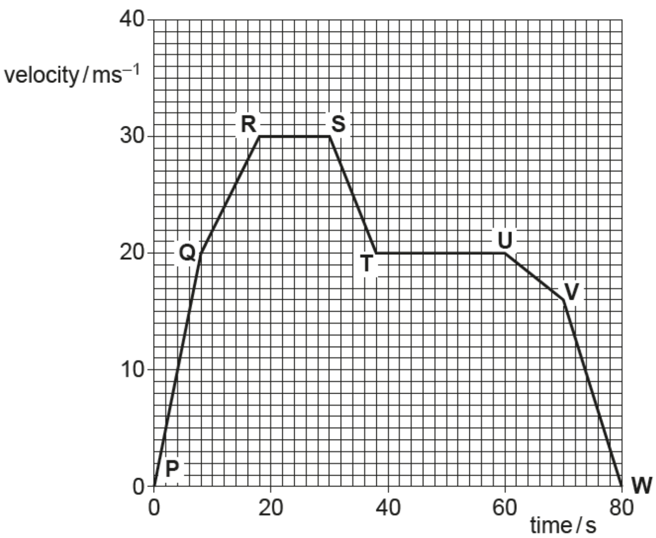
Your answer [ ]

[1]

Approximately 96% of candidates answered this question correctly. This question was correctly answered by the vast majority of candidates who had a clear understanding of the most common application of photon model of light.

Question 7

7 Here is a velocity-time graph for a car.



Between which points does the car have the largest acceleration?

A **P** and **Q**

B **Q** and **R**

C **S** and **T**

D **V** and **W**

Your answer [ ]

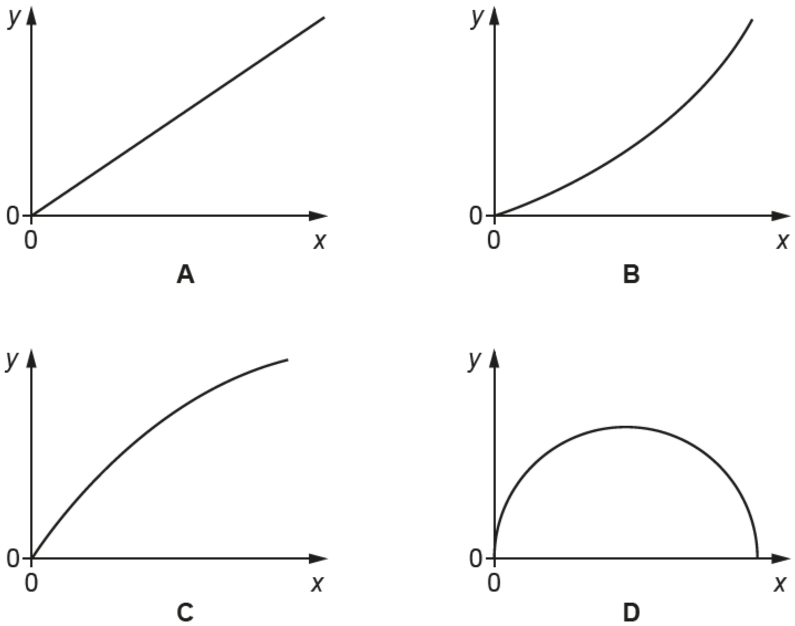
[1]

Approximately 97% of candidates answered this question correctly. This question is a simple application of a velocity time graph; several candidates did working at the side to confirm their response which would be good practice and advised for a graph which may not be as simple as this.

Question 8

8 An object falls freely from rest.

Which graph represents distance fallen (*y*-axis) against time (*x*-axis)?



Your answer ☐

[1]

Approximately 57% of candidates answered this question correctly. A number of candidates wrote out a suitable equation of motion and examined the relationship and for this style of question this is good practice. Wrong answers were generally spilt equally amongst the other responses, suggesting a level of guesswork.

Question 9

9 There is a current of 5.0 mA in a 250 Ω resistor for 40 minutes.

How much energy is dissipated in the resistor?

A 2.5×10^{-6} J

B 1.5×10^{-4} J

C 0.25 J

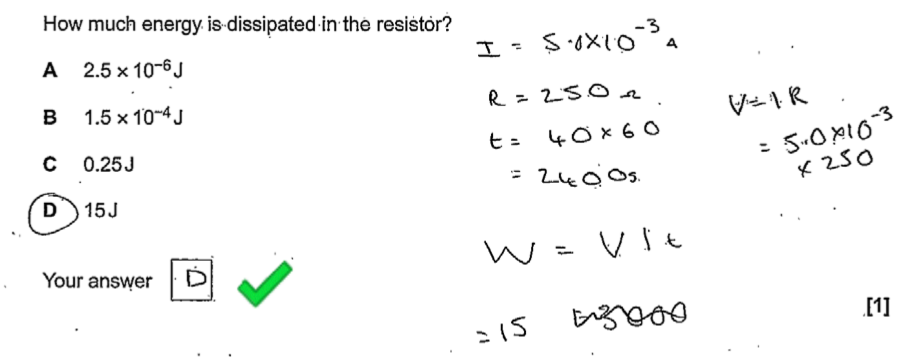
D 15 J

Your answer ☐

[1]

Approximately 62% of candidates answered this question correctly. This question can involve a couple of stages depending who it is done and does have some unit conversions. It is recommended that candidates write down the working in the space – as many do – to make sure that each stage is clearly identified.

Exemplar 2


How much energy is dissipated in the resistor?

A 2.5×10^{-6} J

B 1.5×10^{-4} J

C 0.25 J

D 15 J

Your answer D

[1]

Question 10

10 Light of wavelength 650 nm is incident at right angles on a diffraction grating with 300 lines per mm.

What is the angle of the third-order maximum?

A 4°

B 11°

C 34°

D 36°

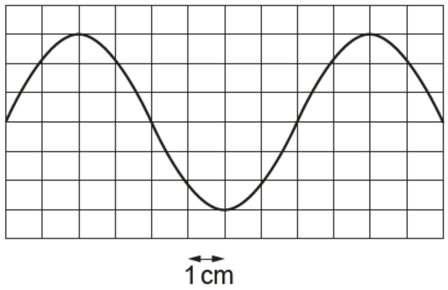
Your answer

[1]

Approximately 51% of candidates answered this question correctly. Candidates are recommended to write the working in the space as there are a couple of stages in this calculation involving unit conversions. It was noted that several candidates used a wrong equation relating to double slits.

Question 11

11 The oscilloscope trace shows the variation in p.d of a signal. The time base of the oscilloscope is set at 0.25 ms cm^{-1}.



What is the frequency of the signal?

A 333 Hz

B 500 Hz

C 1000 Hz

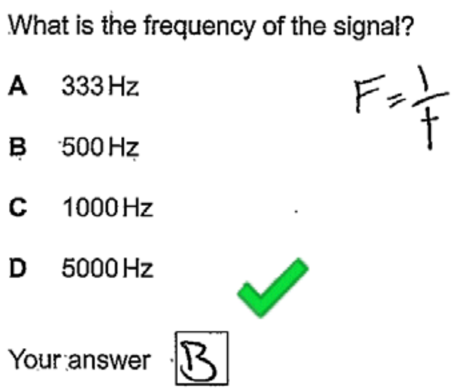
D 5000 Hz

Your answer ☐

[1]

Approximately 73% of candidates answered this question correctly. Most common errors came from using the whole trace as a single period and candidates are advised to draw on the diagram a single time period to help them.

Exemplar 3


What is the frequency of the signal?

A 333 Hz

B 500 Hz

C 1000 Hz

D 5000 Hz

Your answer B

$F = \frac{1}{t}$

Question 12

12 A converging lens produces a focused image at a distance of 0.40 m from the lens. The magnification of the image is 2.0.

What is the power of the lens?

A 0.13 D

B 0.20 D

C 5.0 D

D 7.5 D

Your answer ☐

[1]

Approximately 39% of candidates answered this question correctly. Candidates can find the use of the lens formula challenging at this stage, but it is noted that most correct responses came from candidates who showed clear working. Although there is no requirement for this, candidates are always advised to set out their working as if it was.

Question 13

13 The power of a beam of light is 3.5 mW. The wavelength is 445 nm.

How many photons are emitted each second?

A 8×10^{15}

B 8×10^{18}

C 8×10^{21}

D 8×10^{24}

Your answer ☐

[1]

Approximately 32% of candidates answered this question correctly. It was noted in working that many candidates were able to correctly calculate the photon energy in joules, but not then able to relate this to the power. Candidates should be advised to consider the watt in terms of a joule per second when relating to energy.

Question 14

14 A ball of mass 0.12 kg falls vertically from rest and bounces. The collision with the ground is **elastic**, so kinetic energy is conserved. The duration of the collision is 0.040 s, and the ball leaves the ground with a speed of 10 m s^{-1}.

What is the average resultant force on the ball while it is in contact with the ground?

A 0 N

B 1.2 N

C 30 N

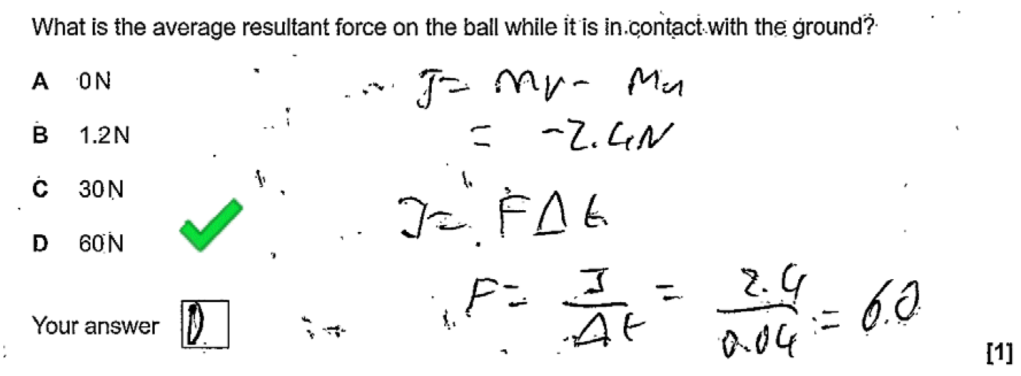
D 60 N

Your answer [ ]

[1]

Approximately 13% of candidates answered this question correctly. This was a challenging question as it involved calculations and an understanding of the vector nature of velocity. It was encouraging to see many candidates using the correct equation (or an alternative and correct variation of it) and showing their working but unfortunately one slip would generally lead to an incorrect response.

Exemplar 4


What is the average resultant force on the ball while it is in contact with the ground?

A 0 N

B 1.2 N

C 30 N

D 60 N

$J = mv - mu$

$= -2.4N$

$J = F\Delta t$

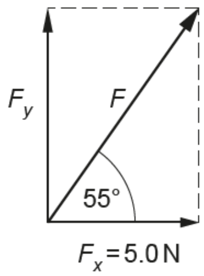
$F = \frac{J}{\Delta t} = \frac{2.4}{0.04} = 60$

Your answer D

[1]

Question 15

15 A force vector, F, is resolved into a vertical component F_y and a horizontal component F_x. The diagram is not to scale.



What is the magnitude of F_y?

A 2.9 N

B 3.5 N

C 7.1 N

D 8.7 N

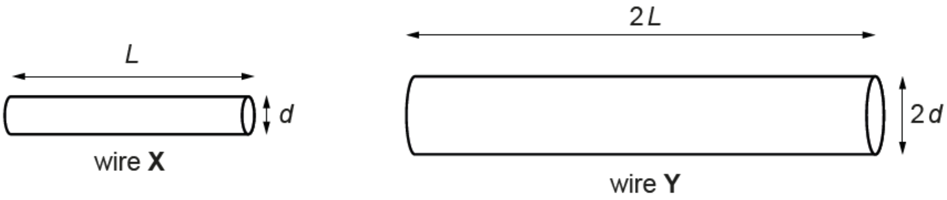
Your answer

[1]

Approximately 79% of candidates answered this question correctly. It was encouraging to see than many candidates were able to correctly set up the equation to find the force and calculate it correctly. A common incorrect response was A, where candidates had (presumably) resolved the 5.0N into a component. From the diagram, candidates should have been aware that the value of the force would have been larger than the component.

Question 16

16 Two wires of the same material have the dimensions shown in the diagram.



What is the ratio $\frac{\text{conductance of wire } \mathbf{X}}{\text{conductance of wire } \mathbf{Y}}$?

A $\frac{1}{2}$

B 1

C $\sqrt{2}$

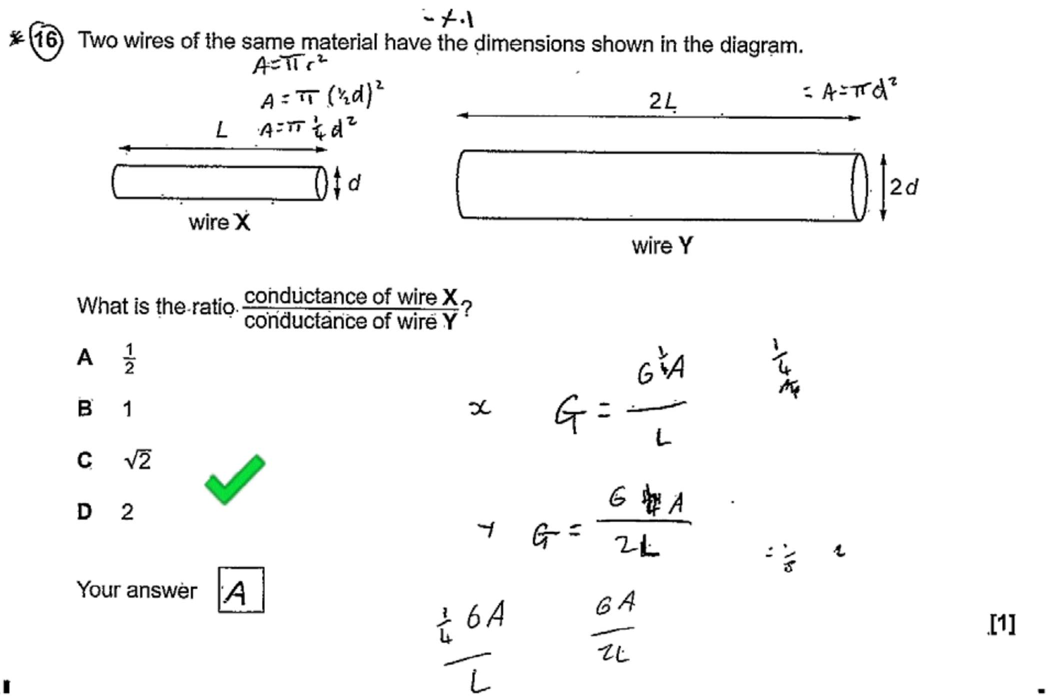
D 2

Your answer

[1]

Approximately 39% of candidates answered this question correctly. Candidates can often find these questions involving ratios challenging however using a carefully structured solution should allow them to work towards the correct response. Those candidates who set out their complete working generally were successful. Several candidates treated the diameter as being proportional to the area which caused an error and a few candidates attempted to use resistivity and follow through this way, although this did not often prove successful. This type of question can be practised by candidates quite easily and with this practice they can become more confident.

Exemplar 5



16 Two wires of the same material have the dimensions shown in the diagram.

$A = \pi r^2$

$A = \pi (\frac{1}{2}d)^2$

$A = \pi \frac{1}{4} d^2$

$= A = \pi d^2$

What is the ratio $\frac{\text{conductance of wire } \mathbf{X}}{\text{conductance of wire } \mathbf{Y}}$?

A $\frac{1}{2}$

B 1

C $\sqrt{2}$

D 2

Your answer A

[1]

Question 17

17 The de Broglie wavelength of an electron with kinetic energy 900 eV is 4.1×10^{-11} m. What is the wavelength of an electron with kinetic energy 450 eV?

A 2.0×10^{-11} m

B 2.9×10^{-11} m

C 5.8×10^{-11} m

D 8.2×10^{-11} m

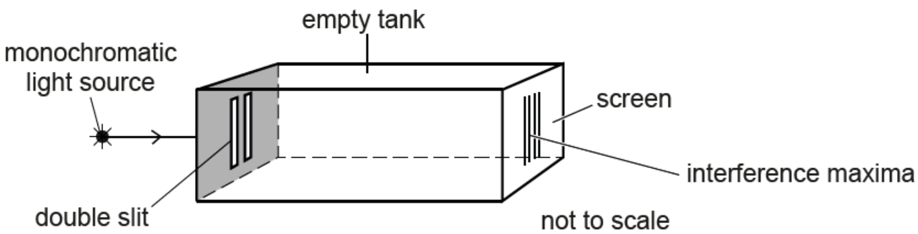
Your answer

[1]

Approximately 18% of candidates answered this question correctly. Some candidates were able to show working in this question by simply appreciating that the wavelength would increase by a factor of root 2. Most candidates appeared to do full calculations by changing to SI units and working through, but inevitably calculation errors come in during these, often leading to answers which were not part of the available responses. In this type of question, candidates should be encouraged to write down relevant formulae and look for relationships between those.

Question 18

18 This experiment produces an interference pattern on the screen.



The tank is filled with water, and the maxima become closer together. Which statement correctly explains this observation in terms of the behaviour of light inside the tank?

A The refractive index of the water is lower than that of air.

B The wavelength of the light has decreased.

C The time taken for the light to travel from the slits to the screen has decreased.

D The light waves from the slits are no longer coherent.

Your answer

[1]

Approximately 35% of candidates answered this question correctly. Many candidates put ticks or crosses next to the responses and wrote relevant formulae to show how the variables change. This practice is to be encouraged as it can support the candidates understanding.

The following information is for use in questions **19** and **20**.

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

X: mass = 2.0 kg
speed = 3.0 m s^{-1}

Y: mass = 1.0 kg
speed = 3.0 m s^{-1}

Question 19

19 What is the total initial kinetic energy (E_k) and momentum (p) of **X** and **Y**?

	total initial E_k	total initial p
A	4.5 J	3 N s
B	4.5 J	9 N s
C	13.5 J	3 N s
D	13.5 J	9 N s

Your answer ☐

[1]

Approximately 32% of candidates answered this question correctly. Many candidates did correct calculations of Ek and p, but ignored the vector property of the momentum leading to the incorrect response of D. Candidates could be encouraged to draw diagrams, or add on to given diagrams, and label on values with their signs.

Question 20

20 What is the total final kinetic energy (E_k) and momentum (p) of **X** and **Y**, as they move off together?

	total final E_k	total final p
A	1.5 J	3 N s
B	1.5 J	9 N s
C	4.5 J	3 N s
D	4.5 J	9 N s

Your answer ☐

[1]

Approximately 23% of candidates answered this question correctly. This response did rely – to some extent – on a partly successful solution to the previous question. However, several candidates did start from the beginning and were able to get the correct response on this, despite an incorrect answer to the previous question. In a structured question, candidates would set out solutions carefully to this problem and it is important that they follow the same procedure in a multiple choice question.

Section B overview

Section B consists of 6 structured questions of a variety of styles. Assessment techniques include calculations and explanations using fundamental physical principles. 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 ray of orange light being refracted at an air-water boundary.

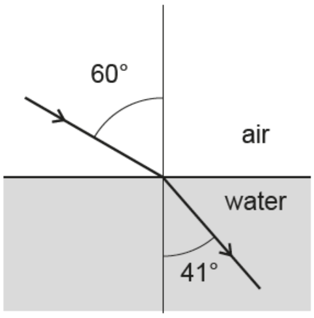


Fig. 21

(a) Show that the refractive index *n* of the water is less than 1.4 using the angles shown on Fig. 21.

n = ... **[2]**

The vast majority of candidates were able to score full marks on this. With a "show that" question it is important that candidates demonstrate a clear understanding and method to get to their solution. Many candidates did show a full method and working to get to the correct answer. It is also generally important to show several significant figures in any final answer. Some candidates made a transcription error of 40°, presumably being used to using these numbers. There were relatively few simple "60 / 41" type calculations.

Question 21(b)

(b) The refractive index of water for violet light is 0.02 more than the refractive index for the orange light calculated in **(a)**.
State and explain any changes in refraction when violet light enters water at the same angle of incidence of 60°.

....

....

....

....

.... **[2]**

Many candidates were able to state that greater refraction would occur, but were unable to give a clear explanation. The anticipated explanation was due to changes in speed although candidates could score full marks by carrying out a further calculation, or by discussing how the variables change. Some candidates got into difficulty by stating greater refraction led to a greater angle of refraction, or vice versa, which is a contradiction. With a "state and explain" question it is important that candidates do exactly that and separate the two parts of their response.

Exemplar 6

State and explain any changes in refraction when violet light enters water at the same angle of incidence of 60°.

$r = \sin^{-1}\left(\frac{\sin i}{n}\right) = \sin^{-1}\left(\frac{\sin 60}{1.34}\right) = 40.2°$

The angle of refraction has decreased because the ~~higher~~ wavelength of violet light allows it to pass through water more quickly than orange light. [2]

n = 1.32 [2]

Exemplar 7

As the refractive index will be slightly higher, it means that the light wave will in effect slow down more and therefore decrease the angle in the water towards the normal. [2]

n = 1.35 [2]

Exemplar 8

State and explain any changes in refraction when violet light enters water at the same angle of incidence of 60°.

The light refracts less (40.26° degrees) because n has become larger. This is because violet light slows down in the water more than the orange light. [2]

n = 1.32 [2]

Question 22

22 Tom runs on the circular track of radius 24 m shown in Fig. 22. He starts at point **X** and stops at point **Y**, which is one-quarter of the way around the track.

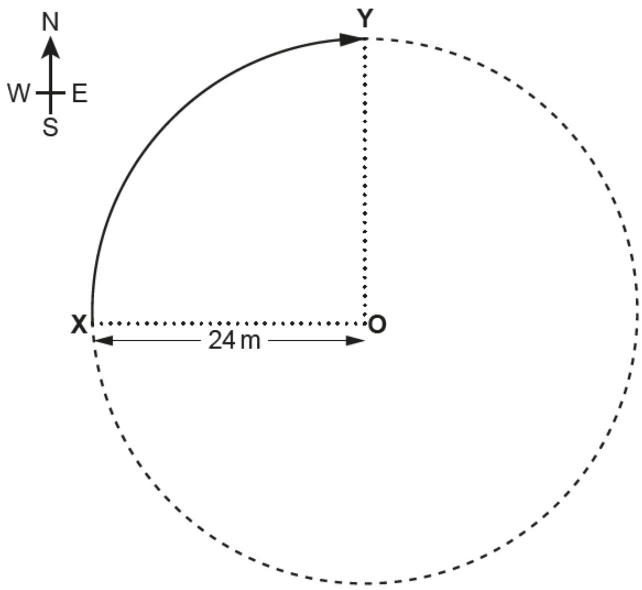


Fig. 22

Calculate Tom's **displacement** from **X** to **Y**. Show your working.

magnitude .... m

direction ....

[3]

This was correctly done by a majority of candidates who had a clear understanding of the term displacement. Words are emboldened in questions to assist candidates and they should pay particular care when a word is written in bold. The question clearly states "show your working" and this is important for a candidate who may make an arithmetic error to be credited for a method mark, or for those who leave their response in the form of a surd which is not accepted for a final evaluation mark. It was noticed in this question that several candidates calculated a distance travelled from a quarter of the circumference, misunderstanding distance and displacement. The direction was generally well done by all candidates, and a wide variety of responses were accepted, although a simple arrow showing the direction would not be accurate enough.

Exemplar 9

Calculate Tom's **displacement** from **X** to **Y**. Show your working.

Total Circumference / 4 = Tom's displacement = $\frac{d\pi}{4} = \frac{48\pi}{4} = 12\pi$

= 37.7m

= 38m

magnitude ......38......m

direction ......NE......

[3]

Exemplar 10

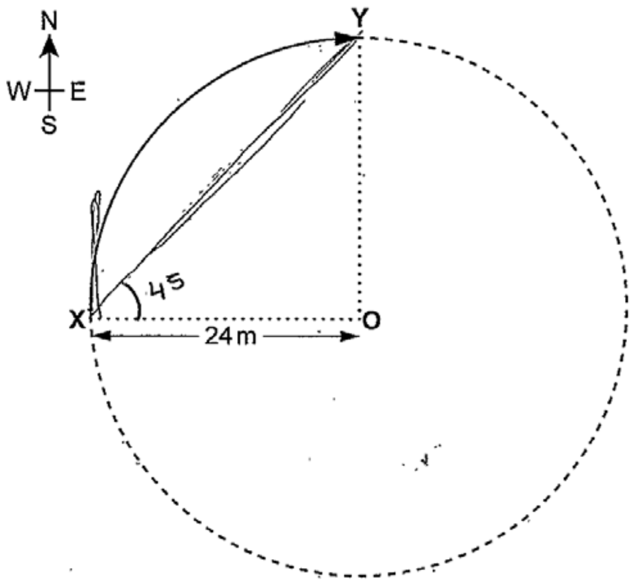


Fig. 22

Calculate Tom's **displacement** from **X** to **Y**. Show your working.

c 24 b

a 24

opp 24

24 adj

SOH CAH TOA

$\tan\theta = \frac{24}{24}$

$\tan\theta = 1$

$\tan^{-1} = 45°$

$a^2 + b^2 = c^2$

$(24)^2 + (24)^2 = c^2$

$576 + 576 = c^2$

$c^2 = 1152$

$c = 24\sqrt{2}$

magnitude ......$24\sqrt{2}$......m

direction ......Bearing of 045°......

[3]

Question 23(a)

23 Forces can be resolved into components.

(a) Fig. 23 shows a weight vector *W* acting on a climber on an ice slope.
The slope is at 50° to the horizontal.

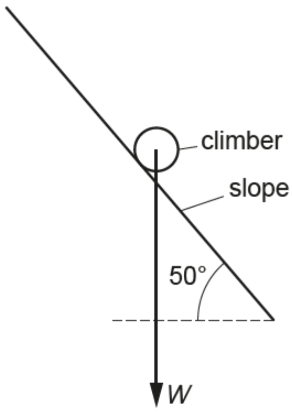


Fig. 23

Add to Fig. 23 two vector arrows to show the components of *W*, parallel to and perpendicular to the slope.

Your diagram should show that the components add up to make the *W* vector. **[1]**

A large number of candidates were able to show the correct components in terms of direction, but many did not follow the "show that the components add up" instruction. It is suspected in many cases that this has not been read of fully processed by candidates and it is very important that candidates carefully read each part of the question to make sure that it is answered completely. There were a number of candidates who tried to show some form of equilibrium by drawing vectors up and perpendicular away from the slope. It was a little further complicated by candidate using the diagram to assist in their calculation of 23(b), but credit was given to correct responses where it was clear.

Question 23(b)

(b) The climber of weight $W = 600\,\text{N}$ is held in equilibrium by a rope parallel to the slope.

Calculate the magnitude of the tension in the rope.

magnitude of tension = ... N **[2]**

Less than half of the candidates were able to correctly calculate this tension. Some addition to the diagram, or at the side of it, seemed to allow candidates to form the correct equation for solution, and it is always recommended that a diagram be drawn in this form of calculation. Candidates at this level do find this a challenging skill and a noticeable number divided 600N by sin 50° which could not be credited. It was felt that an incorrect component (600 x cos 50°) could be given a single mark for a method by incorrect use of the trigonometrical function. Around 10% of candidates did this.

Question 24(a)

24 A sound system records signal frequencies from 200 Hz up to 11.5 kHz.

The sound is to be digitally sampled.

(a) State the minimum rate of sampling that should be used.

minimum sampling rate = ... Hz **[1]**

This was well done by the majority of candidates and it is good to see that this was understood. Although it says "state" a small calculation needs to be carried out and many candidates did show this, which is good practice. Several candidates simply subtracted the two values or did some lengthy calculation leading to an incorrect value. There were few candidates who made mistakes due to the k prefix, and some wrote the answer "23" changing the unit to kHz, which is perfectly acceptable. However, if the unit is to be changed, it must be made very clear.

Question 24(b)

(b) In this system the $\frac{\text{total signal variation (including noise)}}{\text{noise variation}} = 3000$.

Calculate the number of bits that should be used per sample for this system.

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

This is a potentially difficult calculation and it was very pleasing to see that the majority of candidates were able to carry out the calculation correctly. It was also noted that this was left blank by some candidates who may be less familiar with type of calculation. Nearly all correct responses came for a log calculation rather than a power one. Around 20% of candidates calculated 11.6 bits correctly but then did not round up to the next integer which would not gain the second mark and candidates are to be reminded that the number of bits should be a whole number.

Question 25(a)

25 Fig. 25.1 shows a transmission electron microscope (TEM) image of a metal from the year 2010 with a scale marker of 1 nm.

Fig. 25.2 shows the approximate resolution of TEM technology against time.

lines of atoms

Item removed due to third party copyright restrictions

Fig. 25.1

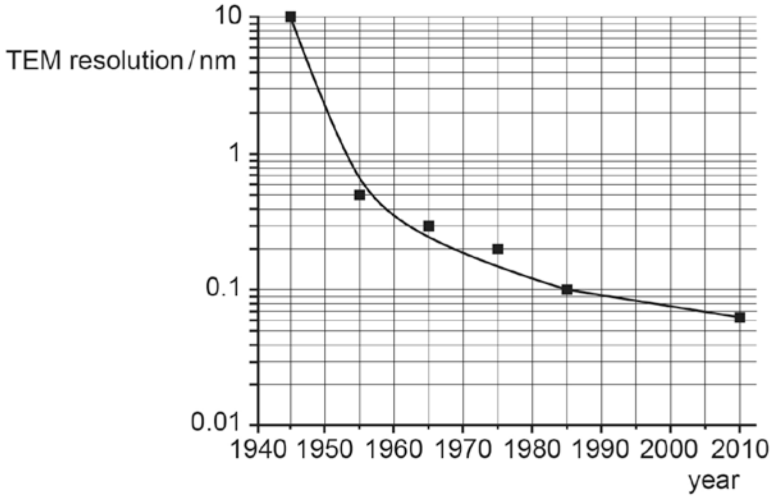


Fig. 25.2

(a) Name the feature represented by the lines of atoms added to the image in Fig. 25.1.

name of feature .... **[1]**

This was correctly identified by a large number of candidates. Candidates should make sure that they aim to use a scientific term rather than a simple description when answering this style of question.

Question 25(b)

(b) Using Fig. 25.2 determine the factor by which TEM resolution has improved between the years 1945 and 2010.

factor = ... **[1]**

Around 40% of candidates were able to correctly calculate this as a factor. Most seemed to be familiar with log graphs and able to take the correct value from the graph at 2010. Although some candidates made a misread, there can be no credit for a method in a single mark answer. Working is always helpful in cases of ambiguity.

Question 26(a)

26 This question applies Newton's laws of motion to a test flight of an aircraft.

The test flight starts with straight level flight at constant velocity. Fig. 26 shows the four initial forces acting on the aircraft.

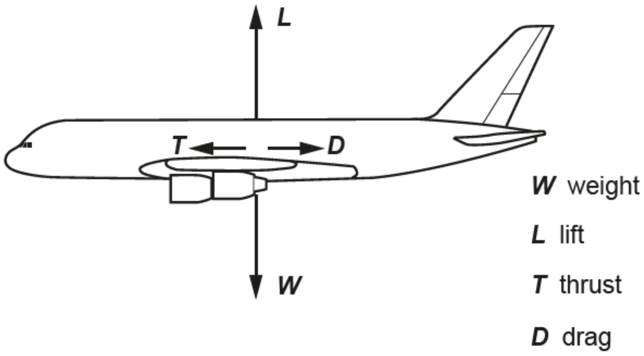
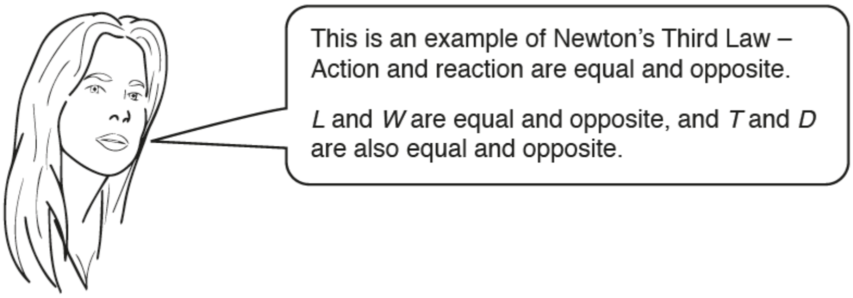


Fig. 26

The lift force L depends on the velocity v of the aircraft – as v increases, L also increases.

(a) One student has an incorrect interpretation of this diagram.



Using **one** of the two pairs of forces she mentions (L and W **or** T and D), explain why she is wrong.

....

....

....

....

.... **[2]**

This question was about Newton's 3rd law, which is a commonly misunderstood law and really tested the understanding of this law in a reasonably familiar situation. It was hoped that candidates would state why this is a misapplication of the law and go into further detail explaining why the statement is wrong. Only a small number of candidates gave a really clear explanation this way; as well as knowing Newton's laws of motion, it is important for candidates to understand the way in which they apply. Candidates could also explain the answer by criticising the statement in terms of it not being valid in all situations and the consequences of that. Although this does not strictly answer the question in the way it was expected, (and really applies Newton's second law) it does show some understanding of the how forces on a body act and was worth full credit if clearly followed through. As always, good physics will be credited appropriately.

Exemplar 11

The student is wrong as when L increases, W ~~always~~ will always stay the same meaning L and W on the plane are not always equal and opposite, otherwise the plane would never leave the ground **[2]**

Exemplar 12

The opposite force of weight is the force of the plane pulling the earth towards ~~them~~ it. Lift is proportional to the velocity of the plane and so cannot be the equal and opposite force to weight. **[2]**

Exemplar 13

W is not the reaction of L, as W would be the same no matter what and L is dependent on velocity so they ~~it is only when the velocity is constant that the force L becomes equal to W~~ are not equal and opposite actions and reactions. **[2]**

Question 26(b)

(b) The engines are stopped and the thrust *T* becomes zero. The aircraft continues flying.

Explain, using Newton's Laws, how the aircraft will move once the engines have been stopped.

....

....

....

....

.... **[2]**

It was expected that candidates would apply Newton's second law and explain its consequence. Many candidates were able to state that the aircraft slows or falls and give reasons, but for full credit the idea of resultant forces was needed rather than just a change in one force. A large number of candidates attempted to apply Newton's 1st law and stated that the aircraft would remain in its state of motion, which is not worth any credit. It is always helpful in this type of question to state the law first and then go on to explain the effects it has in a given situation.

Question 26(c)

(c) The mass of the aircraft when its engines are stopped is 4.0×10^5 kg and the drag *D* is 1.2 MN.

Calculate the deceleration of the aircraft just after the engines are stopped.

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

This question was correctly answered by the majority of candidates. Relatively few did not include the MN factor although a reasonable majority did multiply the value together. The magnitude of this answer should alter candidates to an error, and candidates are encouraged to consider the physical reality of their calculations. Many candidates included a negative sign, which was not required as the term deceleration rather than acceleration was used.

Section C overview

Section C consists of 3 longer structured questions, expected to assess candidates understanding of principles and how different areas of physics can be applied to a particular concept in a synoptic style. 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. Section C also includes a practical based question, in this case pd across a thermistor at different temperatures, which assesses candidates understanding of experiment techniques and uncertainty analysis.

Question 27(a)(i)

27 The Cassini-Huygens spacecraft took images of Saturn's moon Enceladus when the spacecraft was about 6000 km from Enceladus. One such image is shown in Fig. 27.1.

Item removed due to third party copyright restrictions

Fig. 27.1

(a) (i) The image is 1024 × 711 pixels. The original data transmitted for this image was 5.8 Mbits.

Calculate the number of bits per pixel in the original data.

bits per pixel = ... **[1]**

This calculation was done well by the majority of candidates but many lost the mark by not converting the answer to an integer. Candidates need to make sure that any bit calculations are checked to make sure that they are a whole number.

Question 27(a)(ii)

(ii) The 5.8 Mbits was downloaded to an Earth receiver at a rate of 110 kbit s^{-1}.
Calculate the time taken to download this data.

time taken = ... s **[1]**

This question was well answered by the vast majority of candidates who had little problem with the prefix conversions. Candidates who set out the calculation clearly are more likely to avoid a prefix mistake.

Question 27(b)(i)

(b) **(i)** Two radii of the moon Enceladus have been added to Fig. 27.1. The resolution of the image is 330 m per pixel.
Show that the diameter of Enceladus is less than 500 km.

[3]

Although this was potentially a challenging calculation, nearly two thirds of candidates were able to achieve full marks. There are various methods to solve this and it is important that full explanations are given at each stage so that it is clear what the candidates are doing, to allow for marks in case of transcription or arithmetic errors. Most candidates continued with a large number of significant figures at each stage of the calculation which meant that their final value was more accurate although there were no penalties for rounding to 2sf at each point. A range of values was accepted, but this did require the candidates to generally make measurements from the diagram within 1mm. In cases such as this, candidates should take care in any measurement. Following through units in the answer could have been challenging, but seemed to provide little problem to most. There was some confusion between radius and diameter, but in general this will only have cost candidates one mark.

Question 27(b)(ii)

(ii) The image was taken with a sensor of square pixels of width 5 μm. Fig. 27.2 shows the formation of this image (not to scale).

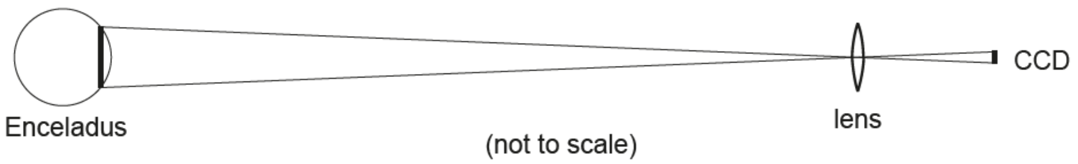


Fig. 27.2

Estimate the focal length of the camera lens that produced the image using data from earlier in the question.
Make your method clear.

focal length = ... m **[2]**

This was a difficult calculation and only a small percentage of candidates were able to achieve full marks. Most attempted to start to follow a lens formula route but will have not got very far without any calculation of magnification. The diagram should have given a clue to the use of similar triangles as the easiest route and those who tended to label values on the diagram were usually more successful.

Question 28(a)(i)

28 This question is about a high-tensile steel cable used by a tugboat to tow large ships. Fig. 28 shows the force F against extension x graph for the steel cable up to the breaking point.

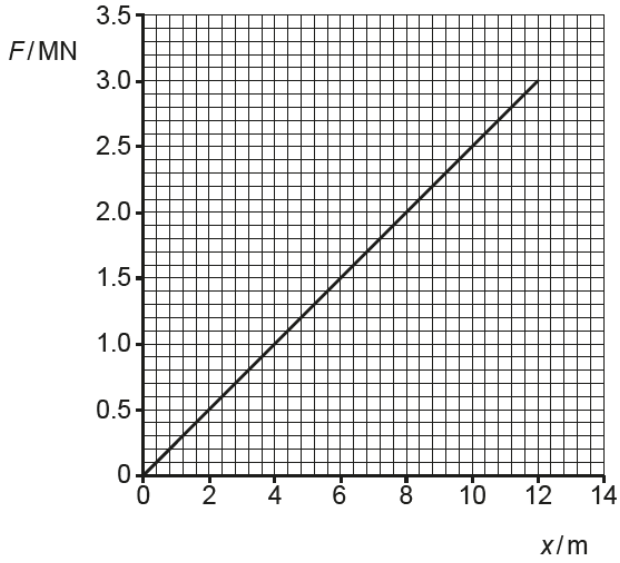


Fig. 28

(a) **(i)** Calculate the force constant $k = \frac{F}{x}$ in MN m^{-1} for this cable.

force constant k = ... MN m^{-1} **[1]**

Most candidates had few problems performing this simple calculation. The units did not provide a difficulty for most as they were consistent from the graph however a few did attempt to calculate the value in N m^{-1}. Candidates should always look at the given units and make appropriate power of ten adjustments if necessary.

Question 28(a)(ii)

(ii) Use algebraic reasoning to show that the force constant k is related to the Young modulus E of the steel by the equation:

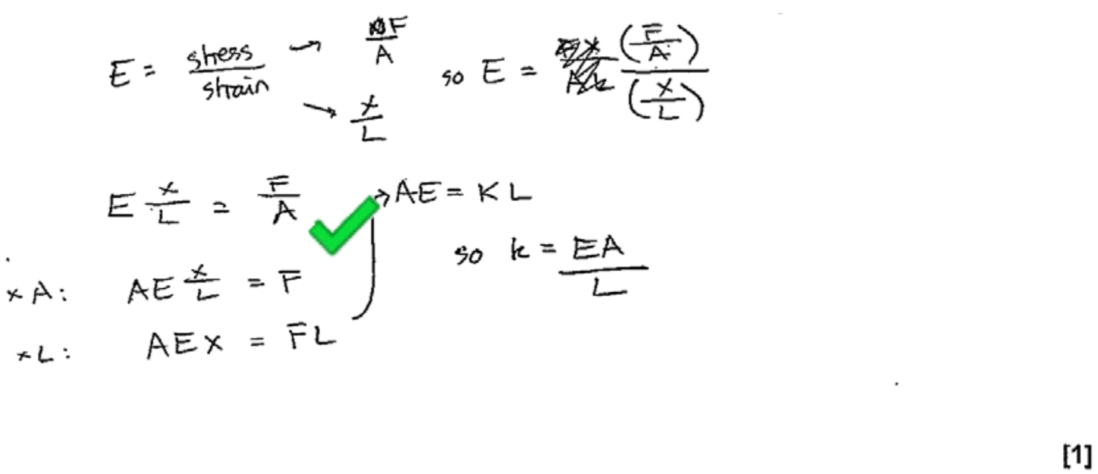
$$k = \frac{E\,A}{L}$$

where A is the cross-sectional area of cable and L is the length of cable.

[1]

Although this is reasonably simple rearrangement of formulae, candidates had difficulties in showing the relationship. There were, as expected, few difficulties with the actual algebra but the challenge came from finding a suitable starting point. Candidates were expected to take formulae from the data booklet with substitutions and cancellations to reach the required equation. The very best candidates gave written explanations or stated what they were doing at each stage and this is recommended as it helps to inform the candidates' thinking.

Exemplar 14



Question 28(a)(iii)

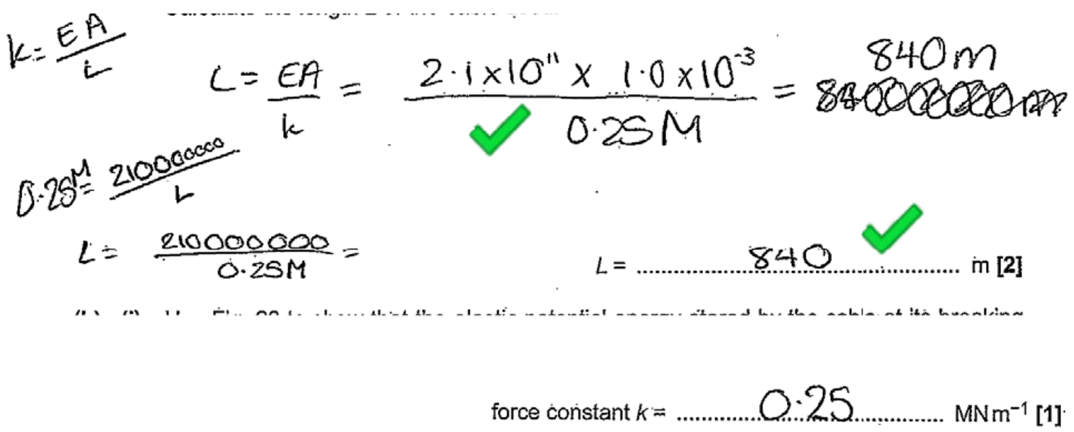
(iii) For the cable in the graph, $E = 2.1 \times 10^{11}$ Pa and $A = 1.0 \times 10^{-3}\,\text{m}^2$.

Calculate the length L of the cable used.

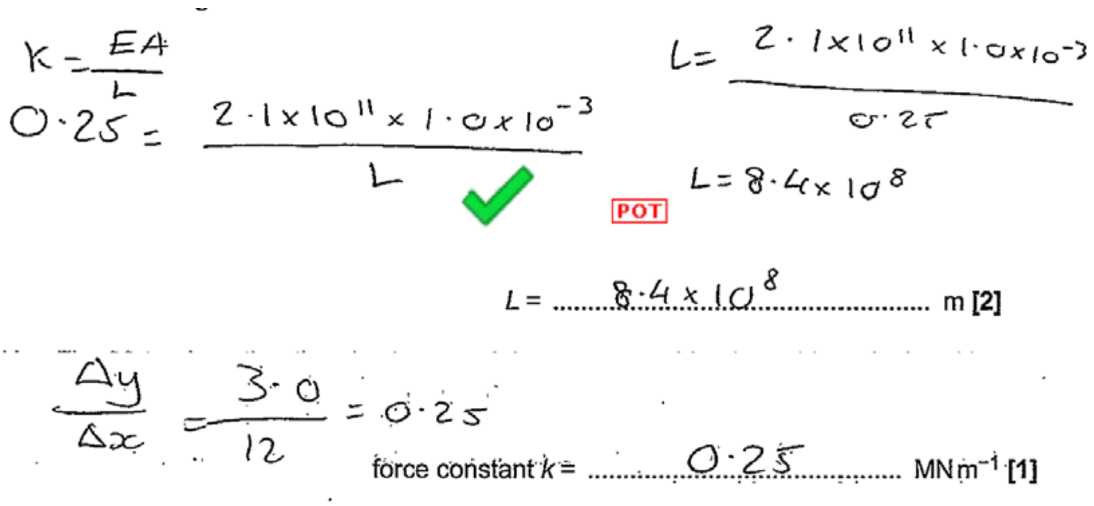
L = ... m **[2]**

There were few problems with the calculation overall although several candidates did not use the previously derived formula. Candidates should remember that when a "show that" has been given, it is likely that that value (or in this case equation) will be used in subsequent questions. A power of ten error was applied for a candidate not appreciating that that the force constant was in N m^{-1} was applied in around a third of the answers, which did lead to a very long length of 8.4 x 10^6 m. Some better candidates realised that this was unfeasible and corrected their error.

Exemplar 15



Exemplar 16



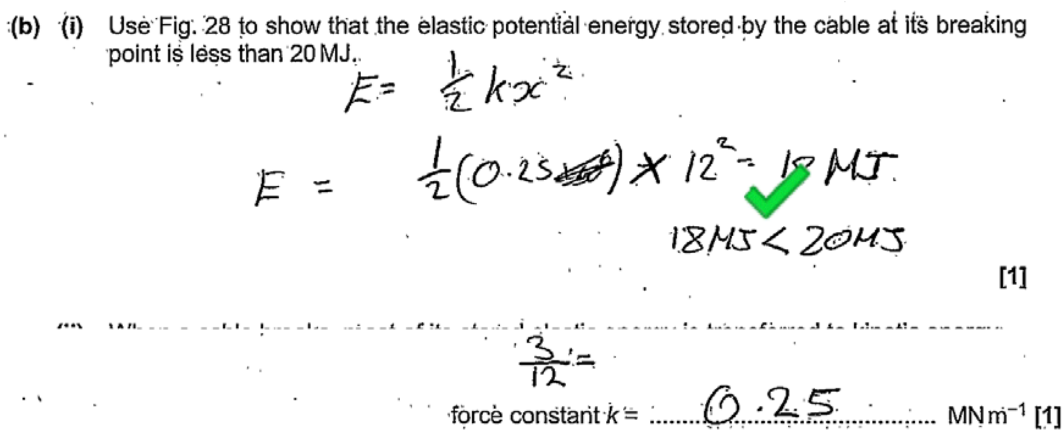
Question 28(b)(i)

(b) (i) Use Fig. 28 to show that the elastic potential energy stored by the cable at its breaking point is less than 20 MJ.

[1]

There were a number of routes to this answer but around 80% of candidates were able to do this successfully. That the answer was given in MJ made it less likely that a power of ten error would occur. With a "show that" it is important that the actual final value is calculated, in this case 18MJ, rather than round to the value that was given in the question. It is important that candidate does show the calculation has been carried out.

Exemplar 17



(b) (i) Use Fig. 28 to show that the elastic potential energy stored by the cable at its breaking point is less than 20 MJ.

$E = \frac{1}{2}kx^2$

$E = \frac{1}{2}(0.25)\times 12^2 = 18\ MJ$

$18MJ < 20MJ$

[1]

$\frac{3}{12} =$

force constant k = ...0.25...... MN m^{-1} **[1]**

Question 28(b)(ii)

(ii) When a cable breaks, most of its stored elastic energy is transferred to kinetic energy. Estimate the speed that the cable would reach, assuming all its mass moves at the same speed.

density, $\rho = \frac{\text{mass}}{\text{volume}} = 7.9 \times 10^3\,\text{kg}\,\text{m}^{-3}$ for steel

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

This was a challenging calculation with several steps needed to be taken to reach the final answer. There was a significant number of candidates who did not apply the conservation of energy and so could not score any marks despite being guided by the working of the question. Of the candidates who made a reasonable attempt many were able to follow through the calculation correctly and error carried forward (particularly from 28(a)(iii)) was applied. There was a power of ten error in several responses, due to missing out of the cross sectional area. With an extended calculation such as this, candidates are advised to structure their solutions carefully and look for data within the whole question rather than just in that part. As usual, error carried forward (ecf) from the value of length will be applied.

Exemplar 18

mass = $7.9 \times 10^3 \times 1.0 \times 10^{-3} \times 840000000 = 6.64 \times 10^{10}$

$18000000 = \frac{1}{2}(6.64 \times 10^{10}) v^2$

$v^2 = \frac{18000000}{\frac{1}{2}(6.64 \times 10^{10})} = 5.425$

ECF

$v = 0.023$ ms^{-1}

speed = 0.023 ms^{-1} [3]

Turn over

$L = \frac{}{0.25}$

L = 840000000 m [2]

Exemplar 19

Mass = $\rho \times$ Volume

$= 7.9 \times 10^3 \times 840 \times 1 \times 10^{-3}$

$= 6636$ kg

$E_k = \frac{1}{2} m v^2$

$v = \frac{\sqrt{2E_k}}{\sqrt{m}}$

$= \frac{\sqrt{2 \times 18 \times 10^6}}{\sqrt{6636}} = 73.7$

speed = 74 ms^{-1} [3]

Turn over

L = 840 m [2]

Question 29(a)

29 This question is about a temperature sensor.

It contains a thermistor in a potential divider circuit as shown in Fig. 29.1.
Fig. 29.2 shows the output p.d. V against temperature θ graph for the sensor.

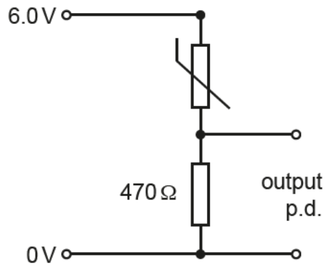


Fig. 29.1

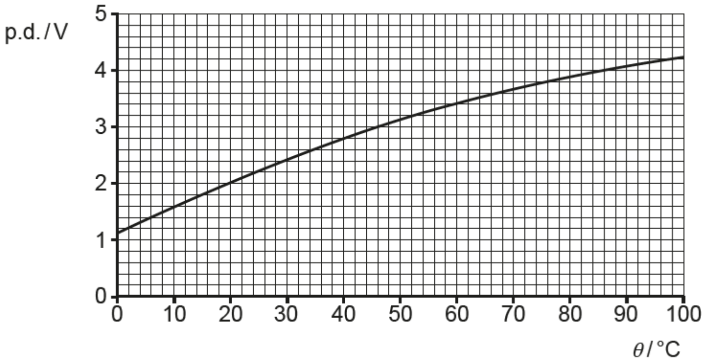


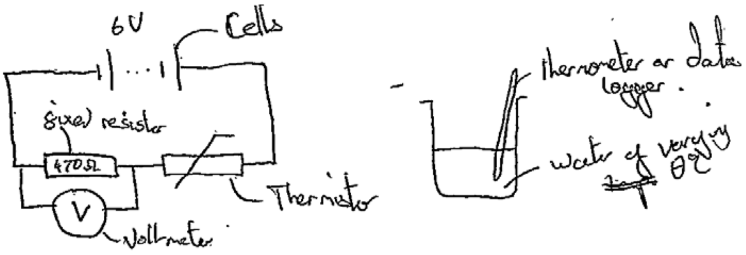
Fig. 29.2

(a) State suitable apparatus (other than indicated in Fig. 29.1) and describe how to use it to obtain the calibration graph shown in Fig. 29.2.
You may wish to include a labelled diagram in your answer.

.... **[4]**

This question was poorly attempted in general, mostly due to the candidates not attempting to answer the question, but one of their own. The main point was to describe an experiment to generate the p.d. against T graph that was given, which many may have done during their course of study. Many responses were short and vague and did not list any additional apparatus as required. There were a lot of answers using LDRs, which suggests that there is some confusion between the thermistor and an LDR. For full credit, a clear and consistent description was necessary with some experimental detail. Those candidates who were able to attempt the actual question were generally successful. It is likely that the final question on this unit will involve some practical based question and candidates should make sure that they read the question carefully before answering. Even if they have not completed the actual experiment given, they should have sufficient knowledge to make a good attempt.

Exemplar 20



BOD

Place thermistor in boiling water and measure the temperature (θ) with a thermometer, or digital data logger, at selected intervals of 5°C as the water cools down, record the output V across the Voltmeter, repeat this for 5°C temperature increments, plot results on a graph of p.d against θ.

Exemplar 21

You need a battery, thermometer, a voltmeter a thermistor and resistor.* ~~[illegible]~~ On the thermometer measure each degree upto 100 As well as a heat source such as a oven where you can set temperature S and plot the voltage show on the output across the potential divider

Exemplar 22

A volt meter would be used to measure the output P.d. A cell or battery would be used to constantly supply 6 volts into the circuit. A heat source and thermometer would then be used to adjust the heat in the thermistor. Then taking the value for the output P-D ~~and the~~ for the temperature to plot the graph

Question 29(b)

(b) The p.d. across the terminals of the power supply is 6.0 V and the resistance of the fixed resistor in the potential divider is 470 Ω.

Calculate the resistance of the thermistor at 46 °C. Make your reasoning clear.

resistance = ... Ω **[2]**

Many candidates were able to read correctly from the graph and to make use of this to calculate the correct value. The request of "make your reasoning clear" aims to make sure that the candidates show a reasonable level of working. Many candidates used a potential divider argument with good algebraic manipulation.

Question 29(c)(i)

(c) (i) The sensitivity of the sensor is the ratio $\dfrac{\text{change of output p.d.}}{\text{change in temperature}}$.

Describe how the sensitivity of the sensor varies between 0 °C and 100 °C. Explain your reasoning.

....

....

....

.... **[2]**

Most candidates were able to explain that the sensitivity decreases with a temperature increase but fewer were able to explain why. The question suggested, by use of "change" that the gradient was the sensitivity and candidates should make sure that they use any additional information given in the question as a guide in their answer. A few candidates still state "the sensitivity changes" rather than giving the direction of the change and if there is a clear direction it should be given.

Exemplar 23

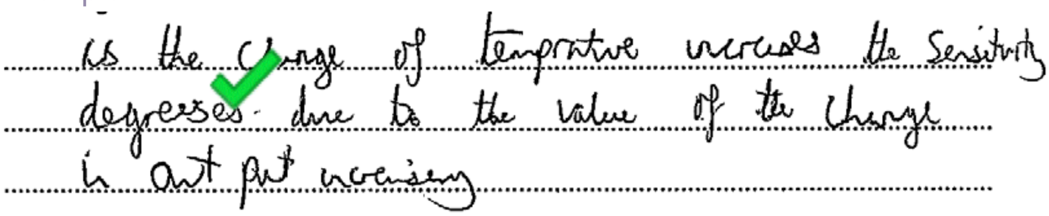
thermistor

(c) (i) The sensitivity of the sensor is the ratio $\dfrac{\text{change of output p.d.}}{\text{change in temperature}}$.

Describe how the sensitivity of the sensor varies between 0 °C and 100 °C. Explain your reasoning.

as sensitivity = the ratio $\dfrac{\Delta \text{ output p.d.}}{\Delta \text{ temperature}}$, sensitivity is equal to the gradient of the graph. The gradient is becoming less steep between 0°C and 100°C so the sensitivity of the sensor is decreasing **[2]**

Exemplar 24


is the change of temprature increases the Sensitivity degreses due to the value of the change in output increasing

[2]

Question 29(c)(ii)

(ii) Use Fig. 29.2 to estimate the sensitivity of the sensor at 50 °C.
Make your method clear.

sensitivity = ... V °C^{-1} **[3]**

Candidates were expected to draw a suitable tangent, take readings and calculate the gradient. The word estimate is used in this context as it is dependent on the accuracy of the candidates' tangent and a range of values will be accepted. Small tangents could score marks, as could readings either side of the 50°C value. However, for full marks a large tangent would need to be used; this is a common style of question and candidates should be encouraged to draw as large a tangent as possible. There was no credit for simply calculating the voltage divided by the temperature, which was a common response.

Question 29(d)

(d) The readings of p.d. for Fig. 29.2 were taken with a digital voltmeter.
Five consecutive values were recorded at each temperature.
The calculated mean output p.d. data for five of the temperatures are shown in the table with calculated uncertainty values.

temperature / °C		0	20	40	60	100
output p.d. / V	mean	1.127	2.041	2.795	3.389	4.097
	uncertainty	±0.003	±0.024	±0.020	±0.012	±0.003

Analyse and comment on the uncertainties in the data in the table.
Suggest a cause of the limitations in the data and what might be done to improve the procedure or apparatus used in the calibration to avoid the limitations.

....

....

....

....

....

....

....

....

.... **[4]**

This was another challenging question that was not answered well by a lot of candidates. Many find error and uncertainty questions difficult although there was plenty of guidance in this question to help them, for example a comment on a simple pattern would be worth a single mark. The main basis of this question was to do with the uncertainty in the exact temperature which leads to an uncertainty in the p.d. at that point although this point was missed by most candidates who thought that the voltmeter was the problem. Much of the detail in this question relies on an understanding of previous parts of question 29. For example, the low uncertainties at the extremities are due to the more certain temperatures and the reduction from 20°C to 60°C was due to the decrease in the sensitivity. Candidates are expected to have a more holistic view of this style of question and to look at the broader picture rather than basing their arguments around a single factor. Although the mark scheme contains plenty of information and detail about what is expected, alternative correct answers can gain credit. Candidates should aim to write fluently although the use of bullet points is perfectly acceptable if each point is clearly made and with good grammar.

Exemplar 25

The uncertainty in 0°C and 100°C are low which means more accurate results. This is because the student heats the water up too 100°C and cools it down to 0°C so the temperatures are almost certain. The uncertainties in 20 - 60°C is because some of the result can be under or above the given temperature. [4]

Exemplar 26

Uncertainty are greatest when t = 20°C and t = 40°C prehaps because these are the hardest temperatures to accurately achieve. This could be improved by using a waterbath for the thermistor to sit in where the temperature can be adjusted.

Recording at a greater variety of temperatures would improve this data - using a water bath or hot plate would reduce this as a greater range of temperatures can be achieved accurately [4]

Exemplar 27

At lower and higher temperatures, the uncertainties were very small due to it being the start and finish of the test (consistantly getting / starting at these temperatures) But closer towards the middle, the uncertainties are higher. this is due to the temperature being consistantly rising and thus it is hard to find the exact pd when it is a certain temperature. [4]

To improve this you could have the thermistor in a water bath

Exemplar 28

Relatively ~~low~~ high uncertainties in the data – the highest is 1.2%. One limitation is that resistors and wires naturally act as slight thermistors, increasing resistance as ~~voltage~~ temperature increases. This may skew the results. Another is that water quickly loses heat so it is a bargain between waiting for a result and maintaining accurate results **[4]**

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