Qualification Accredited

Oxford Cambridge and RSA

AS LEVEL

Examiners' report

PHYSICS A

H156
For first teaching in 2015

H156/01 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 H156/01 series overview

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

H156/02 component is characterised by its in-depth questions and includes two level of response (LoR) questions.

Overview of performance in Paper 1

The positive attributes of the candidates in this component were:

- Generally well-structured solutions with clear manipulation of equations, good substitution and expressing the final answers to appropriate significant figures.
- Generally good comprehension of command terms such as *describe*, *explain*, *show* etc.
- Good use was made of the spaces provided in the multiple-choice questions; rough calculations were done and calculators used efficiently.

There were some missed opportunities in this component, and candidates can maximise marks in future examinations by doing the following:

- Underline or circle key data within a question to aid calculations.
- Do **not** round, or truncate numbers in the middle of long calculations. Retain numbers on the calculator for subsequent stages of the calculations. This is the main cause of errors in calculations.
- Make good use of technical and scientific vocabulary in descriptions and explanations. For example, in **25(b)(iii)**, it would have been appropriate to use the term *path difference* rather than *phase difference* – they are not the same.
- Do not to use labels (e.g. *A*, *R*, etc.) in explanations and descriptions - named quantities (e.g. *amplitude*, *total resistance*, etc.) are much better at communicating ideas.
- Use bullet points if it is easier to get your physics across. This would have been the ideal way to answer questions such as **24(a)(ii)** and **26(b)**.
- Finally, be aware of the information available on the Data, Formulae and Relationship booklet. In some questions, you need data from this booklet. For example, in **27(b)(ii)**, you need the value for the Planck constant *h* and the speed of light in vacuum *c* to calculate the energy of the photon. These values are readily available, there is no need to recall them under the pressure of examination.

Section A overview

Section A contains 20 multiple-choice questions (MCQs) from topics across the four modules.

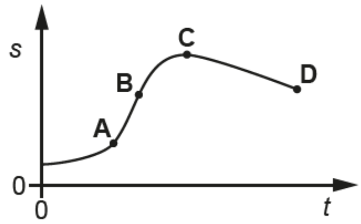
Space is provided on the question paper for any analysis or jottings. It is important for candidates to insert their correct response in the square box provided.

All questions showed a positive discrimination, and the less able candidates could access the easier questions. MCQs require careful scrutiny. Candidates can underline or circle key information to make the questions accessible. No detailed calculations are expected on the pages, so any shortcuts, or intuitiveness, can be employed to get to the correct answers.

Questions **1**, **4**, **6** and **18** proved to be particularly straightforward, allowing most of the candidates to demonstrate their knowledge and understanding of physics. At the opposite end of the spectrum, Questions **3**, **9**, **10** and **11**, proved to be more challenging.

Question 1

1 The graph below shows the variation of displacement *s* with time *t* for an object.

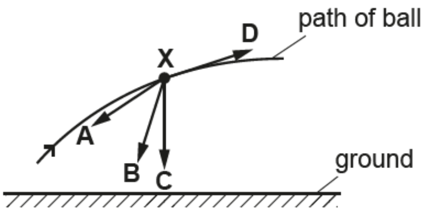


At which point, **A**, **B**, **C** or **D**, does the object have maximum velocity?

Your answer ☐ **[1]**

Question 3

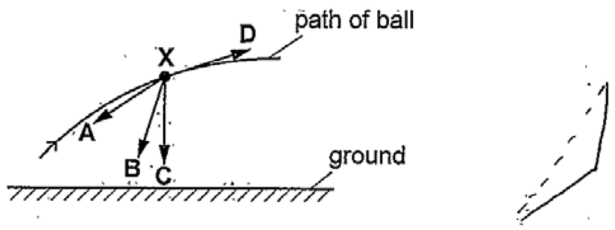
3 A ball is thrown through the air. The ball experiences a small amount of drag compared to its weight.
At a particular time the ball is at point **X**.
Which arrow best represents the direction of the resultant force on the ball when it is at **X**?



Your answer [ ] **[1]**

The question requires knowledge and understanding of the forces acting on the ball in flight and resultant force. The path of the ball is shown. At **X**, the ball is travelling in the direction shown by the **D** arrow. The drag force will be in the opposite direction. Weight is other force acting on the ball – vertically downwards. Vectorially adding the weight and the small drag will produce a resultant in the direction shown by the **B** arrow. The answer (key) is therefore is **B**. The most popular distractors were **A** and **D**.

Exemplar 1



Your answer [B] **[1]**

The right-hand side of the exemplar has the jottings of a candidate and it does help to visualise the problem. This would certainly not qualify as an acceptable answer in Section B, but here, it demonstrates excellent technique; a vertical line for the *weight* and a slanting line for the *drag* and both being added to give the dotted line for the *resultant force*. This matches the arrow **B**.

Question 4

4 An object **P** is travelling to the right with a momentum of $40\,\text{kg m s}^{-1}$. It collides with another object **Q** travelling to the left along the same path.

The final momentum of **P** is $10\,\text{kg m s}^{-1}$ to the right.

What is the change in the momentum of **Q**?

A $0\,\text{kg m s}^{-1}$

B $10\,\text{kg m s}^{-1}$

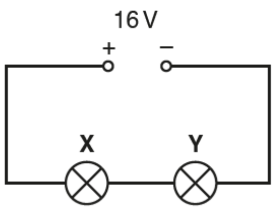
C $30\,\text{kg m s}^{-1}$

D $50\,\text{kg m s}^{-1}$

Your answer ☐ **[1]**

Question 6

6 Two filament lamps **X** and **Y** are connected in series with a 16 V d.c. supply. The supply has negligible internal resistance.



Lamp **X** emits a power of 2.0 W and lamp **Y** emits a power of 6.0 W.

What is the potential difference across the lamp **X**?

A 1.0 V

B 4.0 V

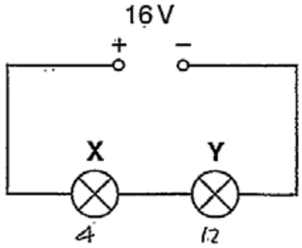
C 12 V

D 16 V

Your answer ☐ **[1]**

Candidates answered this question well. A range of techniques could be used to get to the correct answer **B**. This is illustrated by the two exemplars below.

Exemplar 2



Lamp **X** emits a power of 2.0 W and lamp **Y** emits a power of 6.0 W.

What is the potential difference across the lamp **X**?

A 1.0 V

B 4.0 V

C 12 V

D 16 V

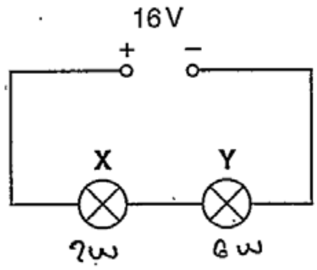
$P = IV$

$P \propto V$

Your answer B

This shows the thought processes of a top-end candidate. The current in the series circuit is constant, hence the potential difference must be proportional to the power dissipation. These two lines is all it took for this candidate to identify the correct answer **B**.

Exemplar 3



Lamp **X** emits a power of 2.0 W and lamp **Y** emits a power of 6.0 W.

What is the potential difference across the lamp **X**?

A 1.0 V

B 4.0 V

C 12 V

D 16 V

$P = IV$

$\frac{8}{16} = I$

$\frac{1}{2} = I$

$P = IV$

$V = \frac{P}{I}$

$= \frac{2}{\frac{1}{2}}$

$= 4v$

Your answer B

Here's another equally valid technique, which may have been a bit time-consuming for this grade D candidate. The total power dissipated has been used to determine the current in the circuit. The correct value of 4.0 V across lamp **X** has been calculated using this current and the equation $P = VI$. It is worth noting the sensible approach of annotating the figure. This would have helped to steer away from the popular distractor **C**.

Question 8

8 A student determines the power P dissipated in a resistor. The measured values of the current I in the resistor and the resistance R of the resistor are:

$$I = (4.0 \pm 0.2)\,\text{A and } R = (3.0 \pm 0.3)\,\Omega$$

The equation $P = I^2R$ is used to calculate P.
What is the percentage uncertainty in the value of P?

A 15%

B 20%

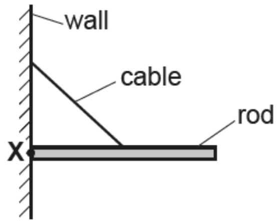
C 25%

D 30%

Your answer ☐ **[1]**

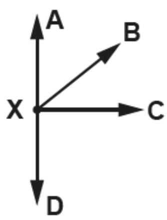
Question 9

9 The diagram shows a uniform rod at rest in a horizontal position.



The rod is hinged at point **X**. A cable is attached to a vertical wall and the midpoint of the rod.

Which arrow best represents the direction of the force on the rod at point **X**?



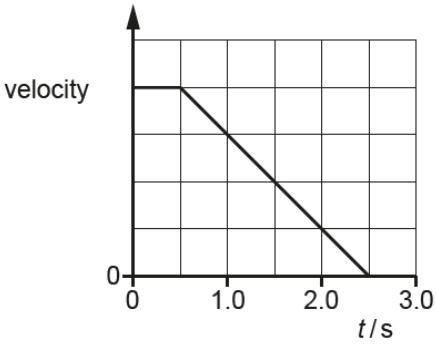
Your answer ☐ **[1]**

This proved to be challenging for most, except for the very top-end candidates.

All the distractors were equally popular, and just over a third of the candidates got the correct answer **C**. Many of the scripts from the successful candidates had the term key *uniform* underlined or circled. The centre of gravity of the rod and the point of contact of the cable to the rod were the same. For equilibrium, the contact force from **X** had to pass through this same point – which only left arrow **C** as the correct answer.

Question 10

10 A car is driven at constant velocity until the driver sees an obstruction ahead at time t = 0. The velocity against time graph below shows the motion of the car as the driver brings it to a stop.



The thinking distance is 10 m.
What is the stopping distance for the car?

A 20 m

B 30 m

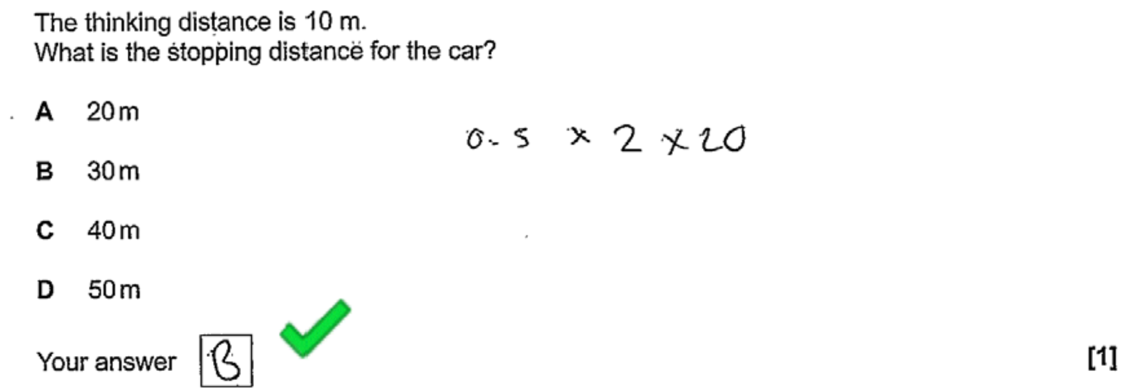
C 40 m

D 50 m

Your answer **[1]**

This question required understanding of *thinking*, *braking* and *stopping* distances together with an appreciation of the learning outcome 3.1.1(d). The total area under this velocity-time graph is equal to stopping distance. The area of the 'rectangle' is equal to thinking distance and the area of the 'triangle' is equal to the braking distance. The correct answer is **B**. The popular distractor was **A**, which just represented the braking distance.

Exemplar 4



The thinking distance is 10 m.
What is the stopping distance for the car?

A 20 m

B 30 m

C 40 m

D 50 m

0.5 × 2 × 20

Your answer B **[1]**

This exemplar illustrates how minimal work in a multiple-choice answer can produce dividends. The candidate has used the thinking distance and the 'reaction time' of 0.5 s to determine the initial speed of the car (20 m s^{-1}). This has then been used to calculate the braking distance. No interim values of distances are shown, but the candidate has done all the hard work by the substitution shown and labelling the vertical axis. A model answer from this high performing candidate.

Question 11

11 A javelin thrower exerts a force of 100 N on a javelin for a time of 0.30 s.
The javelin has a mass of 0.80 kg.

What is the rate of change of the momentum of the javelin?

A 24 kg m s^{-2}

B 30 kg m s^{-2}

C 100 kg m s^{-2}

D 125 kg m s^{-2}

Your answer ☐ **[1]**

There was a significant amount of working shown by candidates across the ability spectrum. Most of the time, the answers put down were the distractors. This question is about Newton's second law of motion. The force on the javelin is equal to the rate of change of its momentum. Therefore, the answer is simply **C**. The kg m s^{-2} is equivalent to the newton N.

Question 17

17 Electromagnetic radiation is incident on a metal. The radiation has constant wavelength with each photon having an energy of 5.0 eV. The work function of the metal is 3.0 eV.

Which of the following **cannot** be the kinetic energy of an emitted photoelectron?

A 0 eV

B 1.0 eV

C 2.0 eV

D 3.0 eV

Your answer ☐ **[1]**

Slightly more than half of the candidates got the correct answer **D** in this question on the photoelectric equation. No detailed calculations were necessary here. The maximum kinetic energy of a photoelectron had to be 2.0 eV (difference between photon energy of 5.0 eV and the work function of the metal 3.0 eV), which made the value of 3.0 eV impossible. The most popular distractor was **A**.

Section B overview

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

Question 21(a)

21 A trolley is placed on a long ramp and is released from rest from the top of the ramp. It travels to the bottom of the ramp with a constant acceleration.

(a) Describe how a metre rule and a stopwatch can be used to determine the **final** velocity v of the trolley at the bottom of the ramp.

....

....

....

.... **[2]**

Most candidates struggled to gain full marks in this opening question. The first mark, for using a ruler to measure the length of the ramp and the stopwatch for the time taken to travel the length of the ramp, was gained by just over half of the candidates. The second mark required a clear statement that the **final** velocity was twice the **mean** velocity of the trolley. Equivalent statements were allowed. Unfortunately, many candidates opted to describe light-gates arrangements or using inappropriate equations of motion.

Question 21(b)(i)

(b) A motion sensor is used to determine the velocity of the trolley at points **X** and **Y**, as shown in Fig. 21.

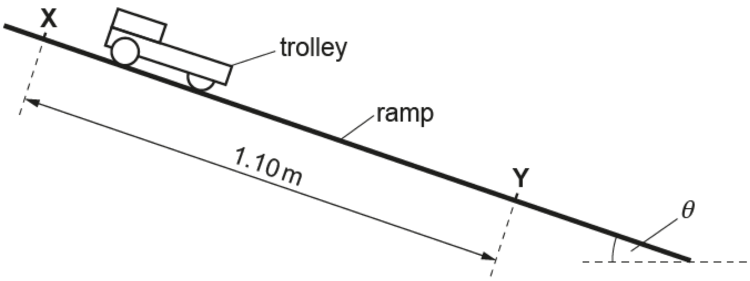


Fig. 21 (not to scale)

The distance between **X** and **Y** is 1.10 m. The trolley has velocity 1.3 m s^{-1} at **X** and velocity 2.5 m s^{-1} at **Y**.

(i) Calculate the acceleration a of the trolley.

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

Most candidates demonstrated excellent understanding and application of equations of motion. The solutions were often well represented, calculations done correctly and the answer written to the correct number of significant figures (SF). A variety of routes were possible, but the most popular method was using the equation $v^2 = u^2 + 2as$.

Exemplar 5

(i) Calculate the acceleration *a* of the trolley.

$s = 1.1$
$u = 1.3$
$v = 2.5$
$a = ?$
$t = ?$

$$v^2 = u^2 + 2as$$

$$a = \frac{v^2 - u^2}{2s}$$

$$\frac{2.5^2 - 1.3^2}{2 \times 1.1} = 2.1\ ms^{-2}$$

a = 2.1 ms^{-2} **[2]**

This exemplar from a grade E candidate shows flawless technique. The known and unknown quantities are written on the left-hand side. The equation is clear, as is the substitution and the final answer for the acceleration.

Question 22(a)

22 Fig. 22 shows two identical springs supporting an object.

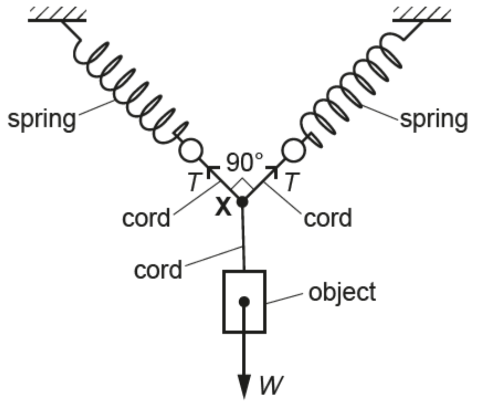


Fig. 22

Three short lengths of cord are tied together at point **X**. The other ends of the cords are attached to the ends of the springs and the object as shown in Fig. 22. The angle between the central axes of the springs is 90°.
The tension in each spring is the same and equal to *T*. The weight *W* of the object is 4.8 N.
The point **X** is in equilibrium.

(a) State and explain the magnitude and the direction of the resultant force at **X** due to the two forces exerted by the extended springs.

....

....

....

.... **[2]**

Question 22(b)

(b) Sketch a **labelled** triangle of forces diagram for the three forces acting at point **X**.
You do not need to draw this diagram to scale.

[2]

Question 22(c)

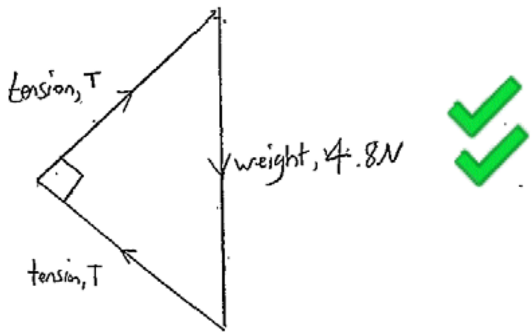
(c) Show that the tension T in each extended spring is 3.4 N.

[2]

This question was good discriminator, where the top-end candidates could demonstrate their powers of analysis. The success in **(c)** was very much dependent on a well-annotated triangle of forces in **(b)**. Most triangle of forces were workable but lacked detail. Missing labels and incorrect direction of the force arrows were the main misdemeanours. As expected, candidates used a range of methods to show the force in the extended spring was 3.4 N. In order of popularity, the techniques were using Pythagoras' theorem, using trigonometry, resolving forces in the vertical direction and sine (or cosine) rule. It is sensible to show the final answer to more significant figures than required in a 'show' question.

Exemplar 6

(b) Sketch a **labelled** triangle of forces diagram for the three forces acting at point **X.**
You do not need to draw this diagram to scale.



(c) Show that the tension T in each extended spring is 3.4 N.

$T^2 + T^2 = 4.8^2$

$2T^2 = 23.04$

$T^2 = 11.52$

$T = 3.39\,N$

~~3.4N~~

$\rightarrow 3.4N$

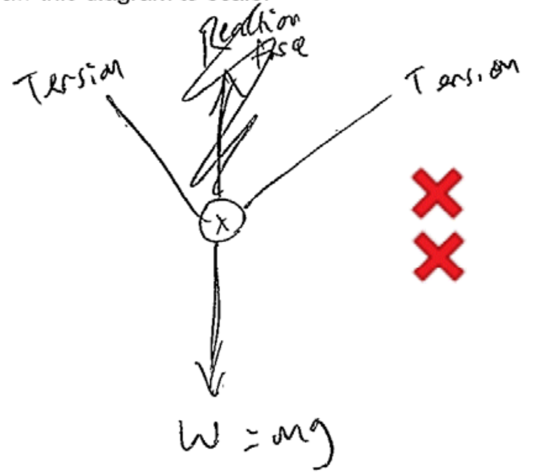
This exemplar illustrates a flawless answer from a top-end candidate.

The triangle of forces of perfect – all labels clear and the pivotal angle 90° between the two tensions marked. The calculation in **(c)** makes an excellent use of this triangle to show that the force is 3.39 N and hence 3.4 N.

Contrast the above excellent solution with the exemplar shown below from a grade C candidate.

Exemplar 7

(b) Sketch a **labelled** triangle of forces diagram for the three forces acting at point **X**.
You do not need to draw this diagram to scale.



(c) Show that the tension T in each extended spring is 3.4 N.

$4.8 \sin(45) = 3.39\ N$

$\approx 3.4\ N$

The triangle of forces in **(b)** is simply not right.

However, in **(c)**, the analysis is correct and shows another plausible method for securing the 2 marks. Again, it is good to see the penultimate value for the force given to **more** than two significant figures.

Question 23(a)

23 This question is about **upthrust** and other forces acting on a sealed hollow tube in water.

One end of a string is attached to the bottom of the tube and the other end of the string is attached to the bottom of the container. The string exerts a downward force *F* on the tube.
At time $t = 0$, the tube is half submerged in the water, as shown in Fig. 23.1.

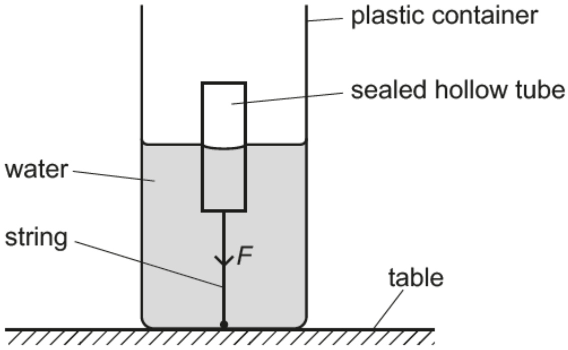


Fig. 23.1

The container is slowly filled with water at a constant rate until the container is full.
Fig. 23.2 shows the graph of *F* against time *t*.

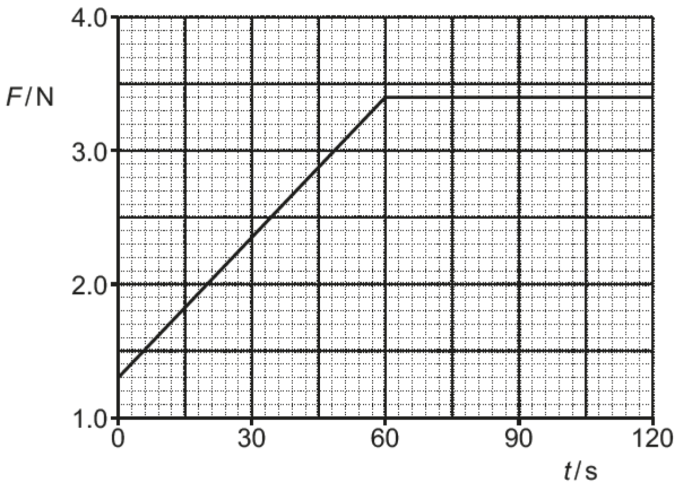


Fig. 23.2

(a) By considering the forces acting on the tube, explain the general shape of the graph shown in Fig. 23.2.

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....

....

....

....

.... **[3]**

This question required understanding of upthrust and Archimedes principle. Many candidates gave explanation without mentioning any of the forces acting on the tube. Those candidates who read and focussed on the requirements of the question did better, but there were too many misconceptions and missed opportunities.

The most common missed opportunities and errors were:

- Not mentioning any of the two of the forces from the list of three (upthrust, tension and weight)
- Stating Archimedes principle without reference to this specific question
- Confusing mass and weight in the description of upthrust ?
- Confusing the tension in the string with upthrust ?

Key

? **Misconception**

Exemplar 8

There is a constant increase in force from 0–60 seconds. This is because as the water levels rise, the upthrust on the sealed hollow tube increase ✓ At this point the weight of the tube + the force in the string is greater than the upthrust. After 60 seconds, the hollow tube is in equilibrium as the upthrust is equal to the force on the string + weight ✓ **[3]**

✓

This exemplar illustrates how correct use of technical language can score full marks. Here the marks were credited for

- Identifying a minimum of two forces acting on the tube (weight and upthrust) ✓
- Mentioning that upthrust increases as the water level rises ✓
- Explanation that upthrust is equal to the force on the string (tension) and weight ✓

(The last mark was the toughest mark to gain, so this candidate has shown good understanding of this difficult topic.)

Question 23(b)

(b) The container is now full of water.
The string is cut and the tube accelerates vertically upwards through the water.
The weight of the tube is 0.80 N and the upthrust on the tube is 4.2 N.

Calculate the **initial** upward acceleration *a* of the tube.

a = ... ms^{-2} **[3]**

The majority of the candidates scored full marks. Most answers showed good structure and reasoning. The data is given to two significant figures (SF). Answers given to more significant figures were condoned. However, if the answer was given to one SF, then this would have been penalised once only in the entire paper.

Exemplar 9

are equal .

(b) The container is now full of water.
The string is cut and the tube accelerates vertically upwards through the water.
The weight of the tube is 0.80 N and the upthrust on the tube is 4.2 N.

Calculate the **initial** upward acceleration *a* of the tube.

$\cancel{4.2} \quad 4.2 - 0.8 = \cancel{3.2}\ 3.4N$

$F = ma \qquad \frac{0.80}{9.81} = 0.0815kg$

$\cancel{3}\ RF = ma$

$\frac{3.4}{0.0815} =$

a = ...41.6925...... ms^{-2} **[3]**

This exemplar illustrates a decent solution from a grade C candidate.

The physics is very easy to follow – resultant force determined, mass calculated from the weight and then the final value for the acceleration. As mentioned earlier, the answer is not given to two SF, but this was allowed in this specific question.

Question 24(a)(i)

24 **(a)** A student is investigating an unidentified component found in the laboratory.
The table shows the results from the lab book of the student.

V/V	**I/mA**
− 5.0	− 5.0
+ 5.0	+ 5.0
+ 10.0	+ 30.0

The potential difference across the component is V and the current through it is I.

(i) Calculate the power dissipated by the component when V is +10.0 V.

power = ... W **[1]**

Question 24(a)(ii)

(ii) Analyse the data in the table and hence identify the component.

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....

....

.... **[3]**

The question was effective in two parts. Use the data to determine the resistance of the component at different potential difference, and then use this data to make judgement in identifying the component. Most candidates gained two or more marks. Some descriptions went astray with mention of Ohm's law or I-V characteristics. A significant number of candidates gave good reasoning but spoilt their answers by opting for a diode, an LDR or a filament lamp.

Exemplar 10

(ii) Analyse the data in the table and hence identify the component.

~~A filament lamp~~ A thermister. as the potential difference increases it would get hotter, loweing the resistance, as the resistance lowers the current increases.

This exemplar illustrates how a brief answer can score maximum marks. This answer is from a grade C candidate. Answers from top-end candidates were verbose and supported by values of resistances.

Question 24(b)

(b) Fig. 24 shows a circuit with a battery and two resistors.

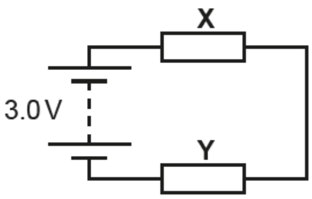


Fig. 24

The resistor **X** has length 8.0×10^{-3} m, cross-sectional area $1.2\,mm^2$ and is made of a material of resistivity $1.5 \times 10^{-2}\,\Omega m$. The battery has e.m.f. 3.0 V and negligible internal resistance. The resistor **Y** has resistance 68 Ω.

Calculate the current I in the circuit.

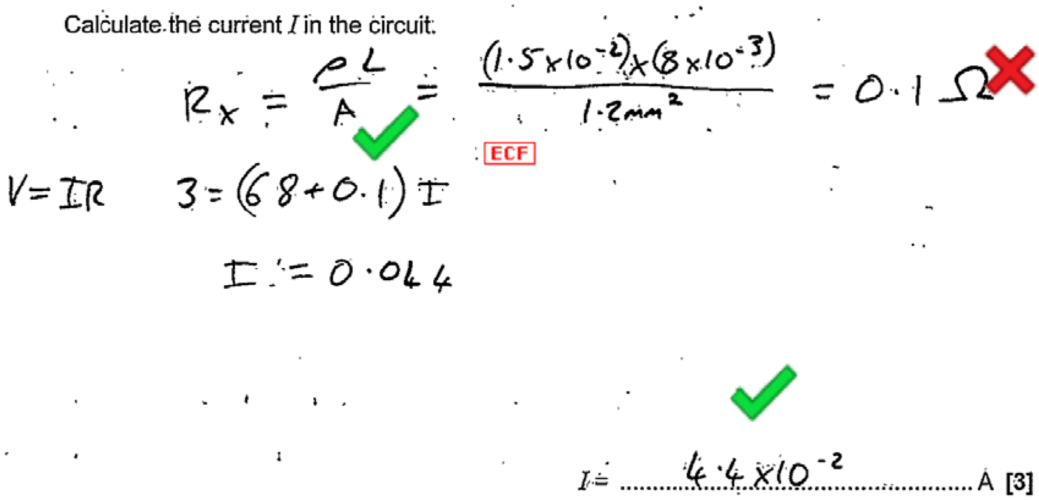
I = ... A **[3]**

There were several challenges in this question. Success was dependent on knowledge of resistivity and series circuit. There was also the added complication of converting the 12 mm^2 to $12 \times 10^{-6}\,m^2$.

The most common error was with powers of ten, with the resistance calculated as 0.1 Ω instead of 100 Ω - where 1 mm^2 was being taken as $10^{-3}\,m^2$ rather than $10^{-6}\,m^2$.

A significant number of candidates scored 2 marks through the error carried forward (ECF) rule. A small proportional of the candidates attempted to calculate the total resistance using the parallel resistors' equation.

Exemplar 11


Calculate the current I in the circuit.

$R_x = \frac{\rho L}{A} = \frac{(1.5\times10^{-2})\times(8\times10^{-3})}{1.2mm^2} = 0.1\ \Omega$

ECF

$V=IR \quad 3=(68+0.1)I$

$I = 0.044$

I = 4.4×10^{-2} A [3]

This exemplar illustrates how even top-end candidates can lose a mark.

The error in the powers of ten has been penalised by the examiner. This incorrect value has then been allowed through subsequent calculations. Two marks have been gained even though the final answer is incorrect. It is worth remembering the knowing your physics will always pay dividends.

Question 25(a)

25 (a) An oscilloscope is connected to a microphone. The oscilloscope is used to determine the frequency of sound waves emitted from a loudspeaker.
Describe how the trace on the oscilloscope screen can be used to determine the frequency *f* of the sound waves.

....

....

....

....

....

....

.... **[2]**

The modal mark here was one, mainly through quoting the equation frequency = period^{-1}. Most candidates were baffled with the oscilloscope and could not effectively communicate how the period was determined from the trace on the oscilloscope screen. A significant number of candidates mentioned *wavelength* of the trace instead of *period*. Unfortunately, this led many candidates to quote $v = f\lambda$ as the equation for determining the frequency *f*.

Question 25(b)(i)

(b) Fig. 25.1 shows two loudspeakers $\mathbf{L_1}$ and $\mathbf{L_2}$ connected to the same signal generator. The loudspeakers emit sound of the same wavelength but with different amplitudes. The points **P** and **Q** are at different distances from the loudspeakers.

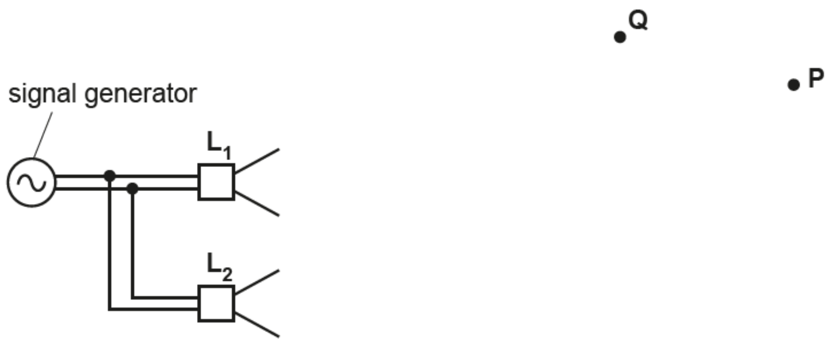


Fig. 25.1

The sound at point **P** from $\mathbf{L_1}$ alone has displacement x_1. The sound from $\mathbf{L_2}$ alone has displacement x_2. Fig. 25.2 shows the variation of x_1 with time t.

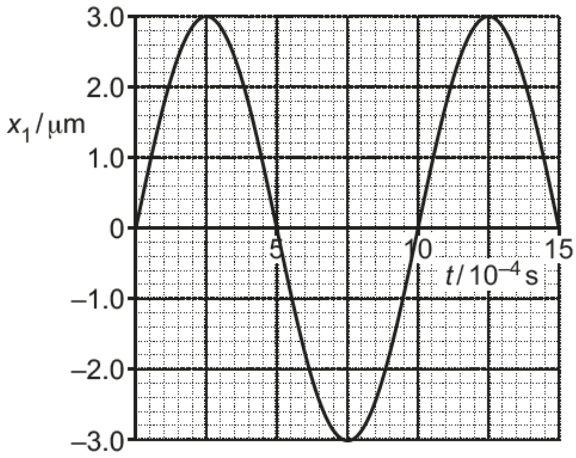


Fig. 25.2

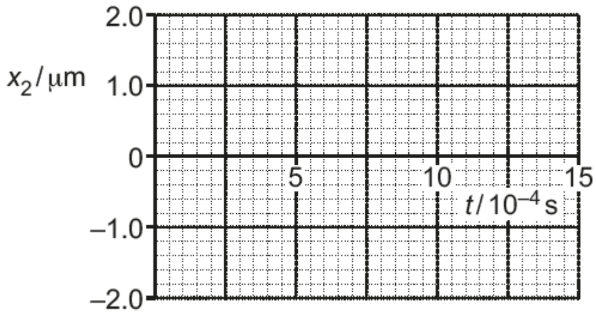


Fig. 25.3

The sound from $\mathbf{L_2}$ alone at point **P** has amplitude 1.0 µm, a phase difference of 180° compared with the sound from $\mathbf{L_1}$ and the same frequency as the sound from $\mathbf{L_1}$.

(i) On Fig. 25.3, draw the variation of x_2 with time t at point **P**. **[1]**

Question 25(b)(ii)

(ii) Explain why the intensity at **P** due to the sound from both L_1 and L_2 is not the same as the intensity of the sound at **P** from only L_1.

....

....

....

.... **[2]**

Question 25(b)(iii)

(iii) The wavelength of the sound is 34 cm. The distance L_1Q is 200 cm and the distance L_2Q is 217 cm.
Explain the type of interference occurring at point **Q**.

....

....

.... **[2]**

In **(b)(i)**, the majority of the candidates drew the correct curve of amplitude 1.0 μm and a phase difference of 180°.

Many candidates in **(b)(ii)** did not mention intensity at all in their description. Instead, the focus was on destructive interference without reference to their answer in **(b)(i)**. A very small proportion of candidates did realise that the smaller amplitude of the signal at **P** meant the intensity was reduced because intensity is directly proportional to amplitude^2.

(b)(iii) was demanding. It was only the top-end candidates realising that the path difference of half a wavelength (17 cm) meant that the interference was destructive at point **Q**. Too many answers did not make any use of the information given in the question. Generic comments on interference prevented marks being gained in this question.

Question 26(a)(i)

26 (a) Fig. 26.1 shows an arrangement used to demonstrate a particular wave phenomenon.

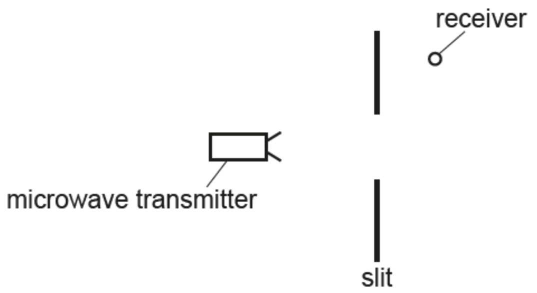


Fig. 26.1

A metal sheet with a wide slit is placed between a microwave transmitter and a receiver. The microwaves have a frequency of 11 GHz.

(i) Calculate the wavelength λ of the microwaves.

λ = ... m **[1]**

Question 26(b)

(b) Light travels from air to water. The refractive index of water is greater than the refractive index of air.
Compare the speed, frequency and wavelength of light in air and in water.

....

....

....

....

.... **[3]**

Most candidates gained two or more marks. Many candidates were aware that the speed of light was less in water than in air. A significant number of candidates also knew that the frequency of light remains constant and successfully argued the fate of the wavelength using the wave equation $v = f\lambda$.

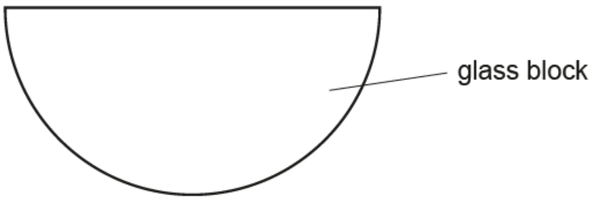
Exemplar 12

In air the light will travel at nearly the speed of light. It will decrease in speed when it goes into water. The frequency will stay constant through both mediums. The wavelength will decrease as it travels into the water. [3]

This exemplar illustrates a flawless answer from a top-end candidate. It had all the main ingredients for scoring 3 marks. The answers matched well with the marking points – the examiner had no issues with following the text.

Question 26(c)

(c) A student is given a semi-circular glass block.
Describe with the aid of a ray diagram how an experiment can be conducted to accurately determine the critical angle for light within the glass block and hence the refractive index of the glass.



....

....

.... **[3]**

The range of marks was poor in this practical question on refraction and critical angle. Most candidates did score a mark for selecting the correct expression for critical angle and refractive index from the Data, Formulae and Relationships booklet. The ray diagram lacked clarity and often showed incorrect critical angle in the air, rather than within the block. There were many missed opportunities here. No credit could be given for generic PAG-type description involving a rectangular block and plotting sin*i* against sin*r* graph.

Question 27(b)(i)

(b) Procyon is a star of radius 1.4×10^9 m. The total output power of the electromagnetic radiation from its surface is 2.7×10^{27} W. The average wavelength of the electromagnetic waves from Procyon is 5.0×10^{-7} m.

(i) Show that the surface intensity of the radiation from Procyon is $1.1 \times 10^8\ \mathrm{W\,m^{-2}}$.

[2]

This was a demanding question designed for middle and top-end candidates. The radiant intensity is equal to the power transmitted per unit cross-sectional area. The area being that of a sphere of radius 1.4×10^9 m. The equation $4\pi R^2$ was appropriate here. The common errors, mainly from the low-scoring candidates, were using πR^2 and $\frac{4}{3}\pi R^3$. All the key steps in the calculations had to be structured well for marks to be scored.

Question 27(b)(ii)

(ii) Calculate the energy of a photon of wavelength 5.0×10^{-7} m.

energy = ... J **[2]**

Most candidates were familiar with the equation for the energy of the photon. Answers were generally well-structured and calculations were undertaken without much error in either rearranging the equation or powers of ten. The answer to two significant figures was 4.0×10^{-19} J, as in the general rule with such answers, 4×10^{-19} J was acceptable without any significant figure penalty.

Question 27(b)(iii)

(iii) Estimate the total number of photons emitted per second from the surface of Procyon.

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

This was a successful end for the top-end candidates, who correctly divided the total output power of Procyon of 2.7×10^{27} W by the energy of each photon from **(b)(ii)**. The two common errors were dividing the intensity by the photon energy and changing the photon energy from joule (J) to electron-volt (eV).

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