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OCR
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AS LEVEL

Examiners' report

PHYSICS A

H156

For first teaching in 2015

H156/01 Summer 2022 series

Version 1

Contents

Introduction

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

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

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

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

Advance Information for Summer 2022 assessments

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

Paper 1 series overview

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

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

Due to the disruption caused by the pandemic centres were issued with advance information to help support all teachers and students with revision for the Summer 2022 exams.

The information in the advance information for H156/01:

- 4.4 Waves (includes practical skills)
- 4.5 Quantum physics (includes practical skills)
- 4.2 Energy, power and resistance
- 3.1 Motion
- 4.3 Electrical circuits
- 3.5 Newton's laws of motion and momentum
- 3.4 Materials (includes practical skills)

Candidates who did well on this paper generally did the following:	Candidates who did less well on this paper generally did the following:
The positive attributes of the candidates in this component were: • answering most of the multiple choice questions and making good use of the spaces provided to do any rough analysis or calculations • good use of calculators, especially handling values given in standard form • well-structured solutions with clear manipulation of equations, good substitution and expressing the final answers to appropriate significant figures and units even though units were given on the answer line • good comprehension of command terms such as describe, explain, show, etc • generally, good use of information and data given whether in graphically or displayed in a table.	There were some missed opportunities in this component. Candidates are reminded that they can maximise marks in future examinations by following some of the procedures below: • underline or circle key data within a question to help with the calculations. If a question specifically asks to refer to information/data in a figure it must be used/manipulated in candidate responses • do not round up, or down, numbers in the middle of long calculations. Try to retain all the digits on your calculator for subsequent stages of a calculation. Truncating numbers in the middle of calculations may result in the loss of marks • make good use of technical and scientific vocabulary in descriptions and explanations. Using words like time period, node and antinode, etc. can help you to succinctly get your physics across • do not confuse mass and weight as these quantities are not interchangeable • convert values into SI units, e.g. cm to m, mm^2 to m^2 to avoid power of ten errors • finally, be aware of the information available on the Data, Formulae and Relationship Booklet.

Section A overview

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

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

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

Questions 7,12, 17 and 20 proved to be particularly straightforward, allowing most of the candidates to demonstrate their knowledge and understanding of physics. At the opposite end, Questions 1, 6, 11 and 15, proved to be more challenging, and as such, were only accessible to the top-end candidates.

Question 1

1 Which of the following could be the wavelength of ultraviolet radiation?

A 3×10^{-5} m

B 1×10^{-10} m

C 4×10^{2} m

D 2×10^{-7} m

Your answer ☐ **[1]**

This should have been a straightforward starting question for all the candidates in determining a possible wavelength for ultraviolet radiation but only half of the candidates got the correct answer D. The most common distractor was B.

Question 2

2 Which term is **not** used in either of Kirchhoff's two laws?

A charge

B current

C electromotive force

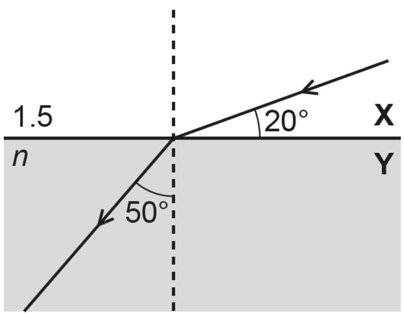
D potential difference

Your answer [1]

This question assessed candidates understanding of Kirchhoff's two laws with most candidates applying their knowledge that current and potential difference were used in the laws. This meant that most candidates answered A correctly but C was a common distractor.

Question 3

3 The diagram below shows the refraction of light at the boundary between two transparent materials **X** and **Y**.



The refractive index of material **X** is 1.5 and the refractive index of material **Y** is n.

Which of the following expressions is correct?

A $n \times \sin 70° = 1.5 \times \sin 50°$

B $n \times \sin 20° = 1.5 \times \sin 40°$

C $1.5 \times \sin 70° = n \times \sin 50°$

D $1.5 \times \sin 20° = n \times \sin 40°$

Your answer [1]

Most candidates identified the answer as C by correctly applying Snell's law to the boundary of the two materials X and Y.

Question 4

4 A student is carrying out the Young double-slit experiment using visible light.
The distance between the slits and the screen is kept constant.
The wavelength of light is λ and the separation of the slits is a.

The following results are collected by the student.

	λ/nm	**a/mm**
A	450	0.20
B	510	0.15
C	550	0.25
D	610	0.30

Which combination of λ and a will give the **largest** separation between the adjacent bright fringes?

Your answer ☐ **[1]**

Most candidates identified the answer as B by correctly applying $\lambda = a\,x / D$ and the relationship between λ, a and x when D is constant.

Question 5

5 A car of mass 1000 kg is travelling on a straight and horizontal road.
The driver applies the brakes.
The speed of the car decreases from $20\,\text{m}\,\text{s}^{-1}$ to $15\,\text{m}\,\text{s}^{-1}$ in 2.4 s.
What is the average power dissipated by the brakes?

A 1.0×10^{3} W

B 5.2×10^{3} W

C 3.6×10^{4} W

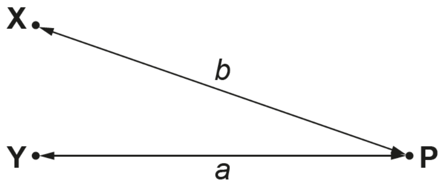
D 8.3×10^{4} W

Your answer ☐ **[1]**

Candidates did not perform as well on this question with just a small majority of candidates calculating the correct answer C. If candidates did show working out it was evident that they understood that power = energy / time but they did not calculate the difference in kinetic energy to calculate the power dissipated in the time given.

Question 6

6 Two coherent waves are emitted from the sources **X** and **Y**.



The diagram is not to scale.
The waves at **X** and **Y** are in phase.
The waves have wavelength 4.0 cm.
The phase difference of the two waves meeting at point **P** is 270°.

Which row gives possible distances for *a* and *b*?

	***a* / cm**	***b* / cm**
A	20.0	26.0
B	20.0	22.0
C	15.0	18.0
D	10.0	14.0

Your answer [ ] **[1]**

Candidates did not perform as well on this question with just a small majority of candidates determining the correct answer C. For A, B and D the path difference between *a* and *b* corresponds to either a whole or a half number of wavelengths so the waves must either be in phase or anti-phase.

Question 7

7 A resistor of resistance 12 Ω is connected in **parallel** with another resistor of resistance *R*.
The total resistance of the circuit is 4.0 Ω.

What is the value of *R*?

A 0.17 Ω

B 6.0 Ω

C 8.0 Ω

D 16 Ω

Your answer ☐ **[1]**

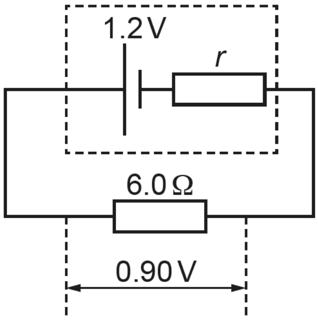
Candidates performed well on this question by correctly calculating the resistance *R* using the formula:

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$$

To give the correct answer B.

Question 8

8 A cell of electromotive force (e.m.f.) 1.2 V is connected to a wire of resistance 6.0 Ω.



The potential difference across the wire is 0.90 V.

What is the internal resistance *r* of the cell?

A 0.15 Ω

B 0.30 Ω

C 2.0 Ω

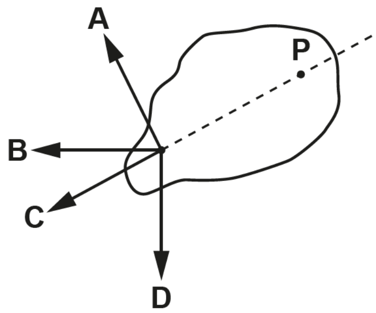
D 8.0 Ω

Your answer **[1]**

Most candidates performed well and correctly selected the equation; $\mathcal{E} = V + Ir$ and applied Ohm's Law to give the answer C. The most common distractor was answer D where candidates had correctly calculated the current but carried out the calculation for the internal resistance r = 1.2 V / 0.15 A = 8 Ω.

Question 9

9 A thin metal plate is free to rotate in the vertical plane about the point **P**.
Four forces **A**, **B**, **C** and **D** act at the same point on the plate, as shown below.



The diagram above is drawn to scale.
All the forces are in the vertical plane.
The forces have the same magnitude but act in different directions.

Which force will produce the **greatest** moment about point **P**?

Your answer [ ] **[1]**

Most candidates performed well as they applied that the greatest moment is produced from force × perpendicular distance of the line of action of the force from P to give the correct answer A.

Question 10

10 A total of 3.8×10^{7} electrons flow through a wire in a time of 1.2 μs.

What is the current in the wire?

A 6.1×10^{-12} A

B 7.3×10^{-12} A

C 5.1×10^{-6} A

D 3.2×10^{13} A

Your answer [ ] **[1]**

This question was generally answered well but candidates had to use the charge of an electron to calculate the total charge of the electrons flowing in the wire. If candidates missed this step in their working, they weren't able to access the correct value for the current.

Question 11

11 An electric motor is used to lift a weight of 4.0 N through a vertical height of 0.90 m in 1.8 s.
The efficiency of the motor is 20%.

What is the electrical power supplied to the motor?

A 0.40 W

B 2.0 W

C 3.6 W

D 10 W

Your answer ☐ **[1]**

Only half of candidates answered this question correctly, D, with the most common distractor being answer B. This response demonstrated that they had calculated the correct work done in lifting the motor and then calculated the useful power rather than the power supplied to the motor.

Question 12

12 Plane polarised light is incident perpendicular to a vertical polarising filter.
The polarising filter is rotated about the horizontal axis.

Which property of the transmitted light changes as the filter is rotated?

A frequency

B intensity

C speed

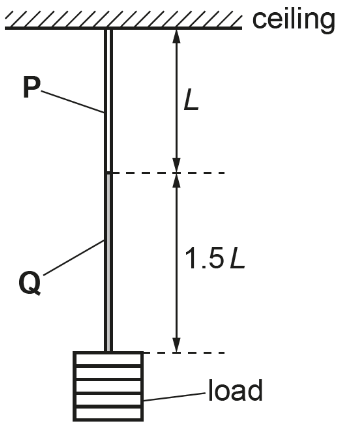
D wavelength

Your answer ☐ **[1]**

Most candidates answered this well as they were able to identify that the intensity was the property that changed when the polarising filter was changed which demonstrated their understanding of plane polarised light.

Question 13

13 A load is suspended from two wires **P** and **Q** as shown below.



Both wires have the same diameter.

The table below shows some data for these two wires.

	Original length of wire	**Young modulus of wire's material**	**Extension of wire / mm**
P	L	E	4.0
Q	$1.5L$	$3.0E$	

What is the extension of the wire **Q**?

A 2.0 mm

B 4.0 mm

C 6.0 mm

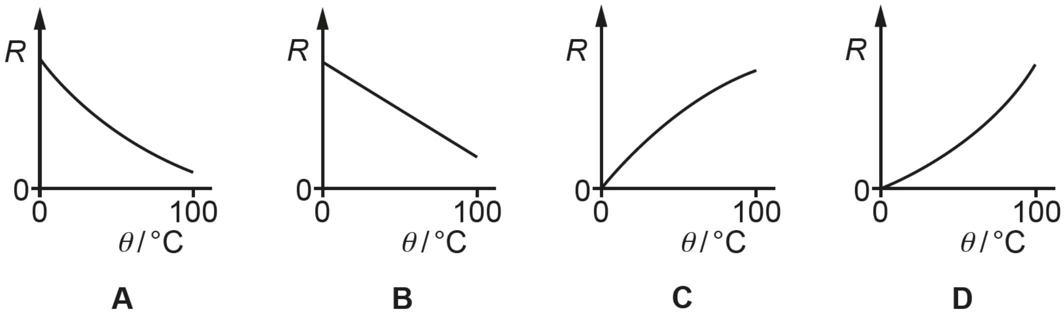
D 8.0 mm

Your answer **[1]**

Candidates performed less well on this question, answer A. The most common distractor was answer D where candidates had doubled the extension rather than using and applying $E = \sigma / \varepsilon$ correctly.

Question 14

14 Which graph best represents the way in which the resistance R of a negative temperature coefficient (NTC) thermistor depends on its temperature θ in °C?

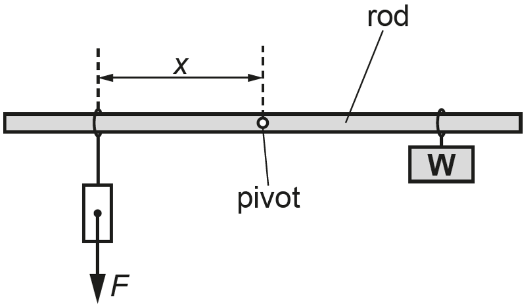


Your answer **[1]**

Generally, candidates performed well on this question as they used and applied their knowledge that resistance decreased non-linearly with temperature. The most common distractor was answer B.

Question 15

15 A student balances a uniform metal rod horizontally.



The rod is pivoted at its middle. The position of weight **W** is kept constant.
The distance of the weight F from the pivot is x. The student changes F and then adjusts x so that the rod remains balanced.

Which statement is correct?

A A graph of F against x will be a straight line through the origin.

B The upward force at the pivot is equal to F.

C The weight of **W** is equal to Fx.

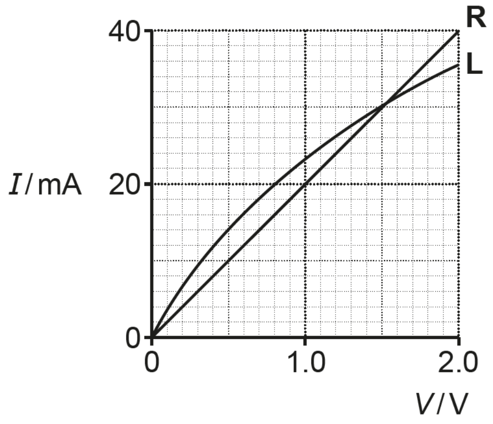
D x is inversely proportional to F.

Your answer [ ] **[1]**

Candidates performed less well on this question. By equating moments, candidates could determine that $x \propto 1/F$. The most common distractor was answer C where candidates incorrectly equated the weight of W to the moment of force F.

Question 16

16 The I-V characteristics of two components **R** and **L** are shown below.



Which statement is correct?

A **R** and **L** are both filament lamps.

B **R** and **L** have the same resistance at 1.5 V.

C The resistance of **L** is independent of potential difference V.

D The resistance of **R** increases as the potential difference V increases.

Your answer [ ] **[1]**

This question was generally answered well with candidates correctly using the I–V graph to determine that **R** and **L** had the same resistance when the two lines intersected at 1.5 V. The most common distractor was answer D.

Question 17

17 The photoelectric effect can be demonstrated using a gold-leaf electroscope.
The zinc plate of the electroscope is negatively charged.
Ultraviolet radiation incident on the zinc collapses the gold leaf.

What is removed from the zinc plate by the incident radiation?

A electrons

B ions

C photons

D protons

Your answer [ ] **[1]**

Candidates performed well on this question as most gave the correct answer A as they identified that electrons are removed from the zinc plate.

Question 18

18 What is the total energy E gained by N electrons travelling through a potential difference V?

A $E = N \times V$

B $E = V \times 10^{-19}$

C $E = V \times 1.60 \times 10^{-19}$

D $E = N \times V \times 1.60 \times 10^{-19}$

Your answer [ ] **[1]**

This question was generally answered well with candidates giving the correct answer D by selecting and applying the equation $W = VQ$ and that the charge of one electron is 1.60×10^{-19} C.

Question 19

19 A student is experimenting with sound waves of wavelength 3.0 cm and electromagnetic waves also of wavelength 3.0 cm.

Which statement is correct about **both** of these waves?

A They can be polarised.

B They can form stationary waves.

C They have the same frequency.

D They have the same speed.

Your answer ☐ **[1]**

Candidates performed well on this question as most gave the correct answer B by recognising that sound is an example of a longitudinal wave and electromagnetic waves are an example of transverse waves but that they can both form stationary waves.

Question 20

20 A laser emits a uniform beam of light.

What two quantities alone are required to calculate the intensity of the beam of light?

A amplitude, frequency

B cross-sectional area, power

C energy, time

D frequency, wavelength

Your answer ☐ **[1]**

Candidates performed well on this question as most gave the correct answer B as they correctly selected and applied the equation $I = P/A$.

Section B overview

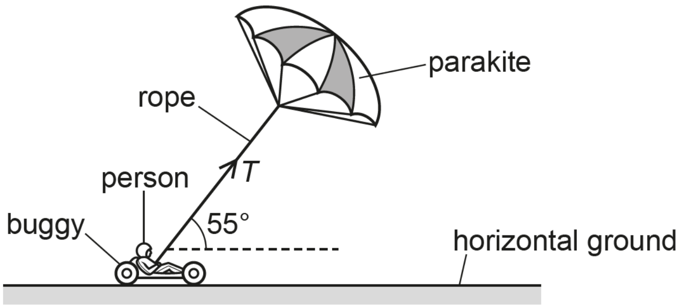
Section B includes short-answer style questions, problem solving, calculations and practical. This section is worth 50 marks and you are expected to spend about 1 hour 5 minutes.

Information provided to centres in the advance information was mostly based on the content assessed in questions in Section B.

- 4.4 Waves (includes practical skills)
- 4.5 Quantum physics (includes practical skills)
- 4.2 Energy, power and resistance
- 3.1 Motion
- 4.3 Electrical circuits
- 3.5 Newton's laws of motion and momentum
- 3.4 Materials (includes practical skills)

Question 21 (a)

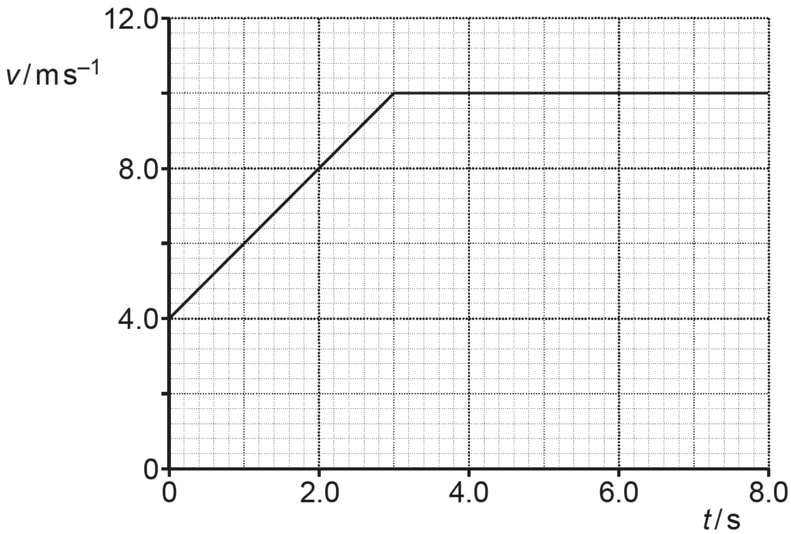
21 A person in a buggy is attached to a large parakite by a rope, as shown below.



Strong wind acting on the parakite moves the buggy along horizontal ground.

The rope makes an angle of 55° to the horizontal. The total mass of the buggy and person is 150 kg.

The velocity *v* against time *t* graph for the buggy is shown below.



(a) Calculate the horizontal distance travelled by the buggy from $t = 0$ to $t = 8.0$ s.

horizontal distance = ... m **[3]**

Most candidates performed well on this question by achieving at least 1 or 2 marks for either correctly identifying that the distance travelled = area under the graph and/or attempting to calculate a distance from the area. Nearly two thirds of candidates scored 3 marks for correctly calculating the total distance travelled.

Question 21 (b) (i)

(b) At t = 1.0 s the buggy is accelerating.

(i) Use the graph to show that the acceleration of the person at t = 1.0 s is 2.0 m s^{-2}.

[1]

Candidates had to show that the acceleration was 2.0 m s^{-2} which 90% of candidates demonstrated successfully by using values from the graph and calculating a gradient value which equalled the acceleration. To be given this mark, candidates had to clearly show their working out using values taken from the graph.

Question 21 (b) (ii)

(ii) At t = 1.0 s the tension T in the rope is 680 N and the total **horizontal** resistance acting on the buggy and person is R.

Calculate R by resolving the tension in the rope horizontally.

R = ... N **[3]**

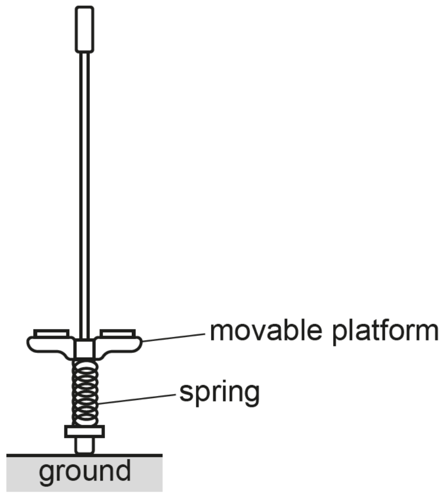
Candidates performed less well on this question as it was mostly only the most successful responses that were given 3 marks for resolving the horizontal component of the tension in the rope to correctly calculate the horizontal resistance R.

About 40% of candidates were given 1 mark for either correctly resolving the horizontal component of the tension to give 390 N or calculating the resultant force ($F = ma$) to give 300 N.

It would have helped candidates understand the question to draw a free body force diagram to identify the forces acting on the buggy and direction and magnitude of the resultant force.

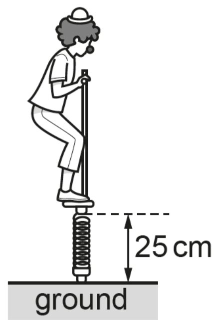
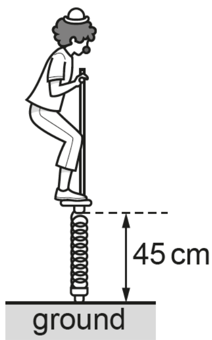
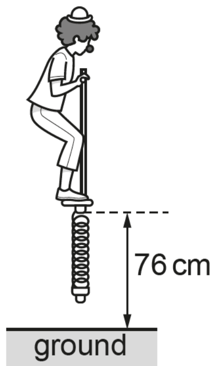
Question 22 (a)

22 A pogo stick is a spring-based toy used by a circus clown for jumping vertically up and down. A **compression** spring is fixed to the bottom of the pogo stick. The upper end of the spring is attached to a movable platform.



The force constant of the spring is $1.7 \times 10^4\,\text{N m}^{-1}$.
The mass of the clown is 68 kg.
The mass of the pogo stick is negligible compared with the mass of the clown.

The table below shows the state of the spring and the clown in three different positions.

	Position A	**Position B**	**Position C**
			
State of spring	fully compressed	original length	original length
State of clown	stationary	Moving vertically upwards at maximum speed	stationary
Height of platform above the ground / cm	25	45	76

(a) Describe how the force constant of the compression spring in the pogo stick can be verified in the laboratory.

....

....

....

.... **[2]**

Most candidates accessed this question and were given 1 mark for either describing a method to measure the compression (extension) of a spring or using these measurements to determine the spring constant either from the gradient of a force–extension graph or manipulation of $F = kx$. Candidates often were not given the first marking point as even though they described a correct practical procedure in adding masses they did not qualify this by multiplying the mass by g to obtain the weight compressing the spring as it is this quantity along with the compression that is used to verify the force constant. Also, candidates did not always describe their method that could suitably be carried out in the lab as they described adding the 'clown' or a 'person' to the spring and then measuring the compression (extension).

Question 22 (b)

(b) Describe the energy changes taking place between positions **B** and **C**.

....

.... **[1]**

Only half of candidates answered this question correctly by recognising that when the spring was at position B the spring had returned to its original length and hence had no store of elastic potential energy. Often, candidates described the energy changes at A, B and C but were not explicit in identifying the position of the spring, so it was assumed that responses described positions B and C and hence no marks were given. Candidates must be specific in their responses so there is no ambiguity in their understanding of the question.

Question 22 (c)

(c) Calculate the maximum energy *E* stored in the compressed spring.

E = ... J **[2]**

Candidates were required to select the equation $E = \frac{1}{2} kx^2$ which about a half of candidates did to calculate the energy stored in the compressed spring when the clown jumped vertically on the pogo stick but about a third of candidates dropped 1 mark for not converting cm to m for the value of compression.

Question 22 (d)

(d) A student uses the following expression to determine the maximum speed *v* of the clown in position **B**:

maximum energy *E* stored in the compressed spring = $\frac{1}{2} \times 68 \times v^2$.

Explain why this expression is incorrect. You are not expected to do any calculations.

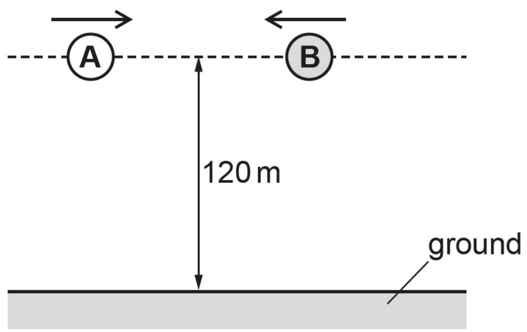
....

.... **[1]**

Only about 10% of candidates accessed this question correctly to be given 1 mark for responses describing energy transfers to the gravitational potential energy store of the spring. Most responses described energy transfers as energy losses to increase the thermal store of the surroundings.

Question 23 (a)

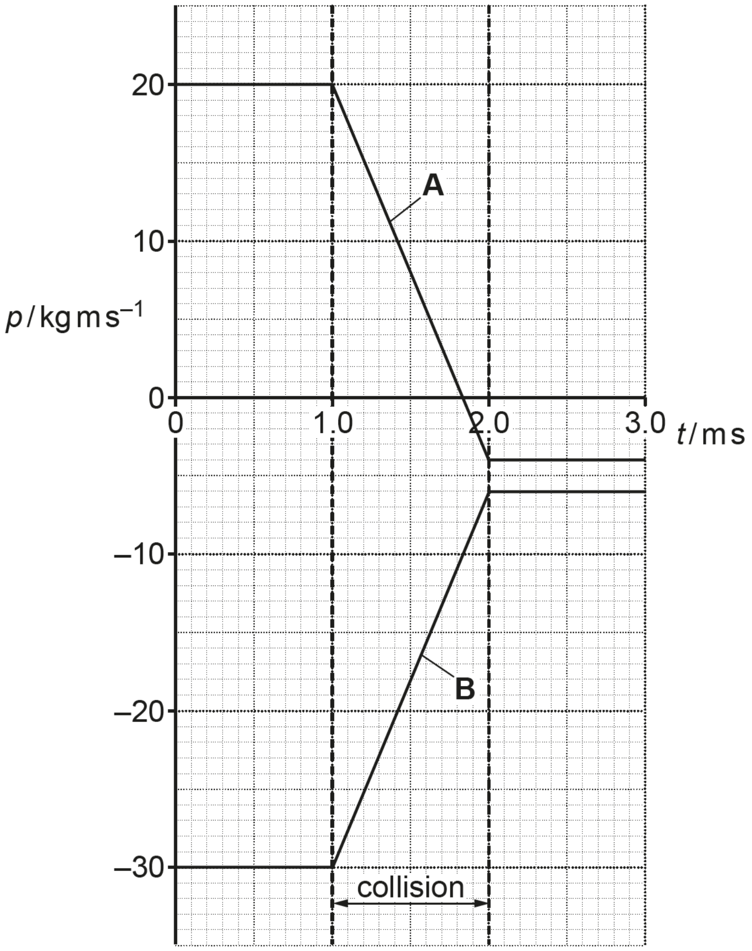
23 Two objects **A** and **B** are travelling horizontally and in opposite directions. The objects collide in mid-air at a height of 120 m above the horizontal ground, as shown below.



The mass of **A** is 2.0 kg and the mass of **B** is 3.0 kg.

After the collision the objects are joined together.

The momentum *p* against time *t* graphs for each object before, during and after the collision are shown below.



(a) Explain how the graphs demonstrate Newton's third law during the collision.

....

....

.... **[2]**

Candidates performed less well on this question as half of candidates were not given any marks. To access both marks candidates had to refer to the graph but very few candidates applied their knowledge of Newton's Laws to determine that the gradient of the graph represented the force acting on objects A and B during the collision. Some candidates referred to the graph but only in terms of the change in momentum with no reference to time. If candidates made no reference to the graph, they could access 1 mark for giving a correct definition of Newton's 3rd Law for the two objects but quite often the definition was vague and incomplete (see misconceptions) so no marks were given.

Exemplar 1

As $F = \frac{\Delta p}{\Delta t} \rightarrow p = Ft$, the gradient of the graph is equal to the force experienced. The 2 gradients A and B are equal, but opposite in sign. This shows that A experienced a force that is equal to B, but in the other direction. **[2]**

This response demonstrates a clear understanding of Newton's 3rd Law and that the force acting during the collision is the gradient of the graph. This exemplar demonstrates a middle range and higher end response from candidates.

Misconception

? The most common definition for Newton's 3rd Law was 'every action has an equal and opposite reaction.'

Question 23 (b)

(b) Use the graphs to show that momentum is conserved in the collision.

[2]

Most candidates performed well on this question as they used the graph to show that the total momentum before and after the collision for objects A and B was conserved and that the values were the same. If marks were not given it was generally because candidates had not followed on with and carried out a simple calculation even though they had read the correct momentum values from the graph.

Question 23 (c)

(c) Calculate the magnitude of the horizontal velocity *v* of the combined objects immediately after the collision.

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

About half of candidates were given 2 marks for correctly calculating the velocity of objects A and B combined after the collision. Most candidates used an expression for the momentum of the combined objects (5*v*) and equated this to the total momentum of the two objects before the collision (10 $kg\,m\,s^{-1}$). A significant number of candidates did not apply the conservation of momentum correctly and used a momentum value from the graph or didn't use the combined mass of the objects A and B.

Question 23 (d)

(d) Air resistance has negligible effect on the motion of the objects.

Calculate the time taken for the combined objects to reach the ground after the collision.

time taken = ... s **[3]**

Candidates at the higher end performed better on this question as they were able to identify and apply the correct equation of motion and determine that the initial vertical component of the velocity was zero. Candidates at the lower end tended to either omit the question or make an incorrect attempt to use an equation of motion using a value for the initial velocity (usually the velocity calculated from part c).

Misconception

? Candidates did not realise that horizontal and vertical motion are independent to each other and hence that the initial vertical component of velocity for the falling objects was zero.

Question 24 (a)

24 (a) **Stationary** waves are formed on the surface of seawater in a harbour as incoming waves are reflected off the harbour wall.

An observer is looking at these stationary waves.

State how the observer can tell that these are stationary waves.

....

.... **[1]**

Most candidates did not perform well on this question as they did not use correct scientific terminology to state an observation of stationary waves and used simplistic and superficial language such as 'the waves were not moving' or they lacked the understanding and knowledge of the properties of a stationary wave and described the wave in terms of other properties, e.g. frequency and wave speed which were not credit worthy.

Question 24 (b) (i)

(b) A wire is fixed between two supports, as shown in **Fig. 24**.

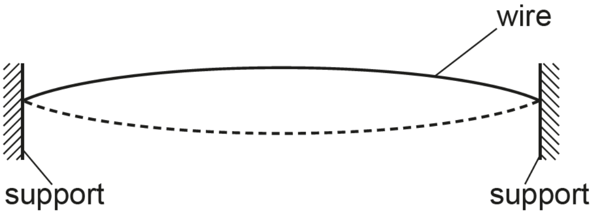


Fig. 24

The wire is plucked in the middle. A stationary wave of fundamental frequency *f* is formed on the stretched wire.

The tension *T* in the stretched wire is given by the expression $T = 4f^2mL$, where *f* is the frequency of the oscillating wire, *m* is the mass of the wire and *L* is the length of the wire.

A student is performing an experiment to determine the tension *T* in the wire. The measurements are shown in the table below.

Quantity	Measurement	Percentage uncertainty
f	58 Hz	2.5
m	9.7×10^{-4} kg	1.0
L	0.62 m	0.5

(i) Suggest how the student may have determined the fundamental frequency of the oscillating wire in the laboratory.

....

....

....

.... **[2]**

The advance information listed that practical skills would be assessed within topic 4.4 waves, but only some candidates were able to describe a simple method to determine the fundamental frequency of the oscillating wire. Marks were still given for a suitable method for determining the fundamental frequency of any oscillating wire, e.g. using a vibration generator and variable signal generator but few candidates developed their method to describe how they would obtain accurate measurements, e.g. measuring the time for 10 oscillations and then dividing by 10 to find the time period *T*, etc.

Candidates may not have had the opportunity to carry out this practical skill independently but they should be familiar with the procedure and how measurements are taken to accurately find the fundamental frequency of a stationary wave.

Exemplar 2

The wavelength at the fundamental frequency is 2L, so they could have used speed = wavelength × frequency to find fundamental frequency, as when the wavelength is at 2L the fundamental frequency will ~~appear~~ be shown. They had **[2]** to do $\frac{speed}{2L}$ to find the fundamental frequency of the wire. It will be the point where there are nodes only at the supports.

Exemplar 2 shows a typical middle range response. This response demonstrates a lack of knowledge and understanding of the practical skills required to measure the fundamental frequency as there is no description of a method to measure the time period of a stationary wave.

Question 24 (b) (ii) (1)

(ii) Use the data in the table to determine

1 the wavelength of the progressive waves on the stretched wire

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

Most candidates performed well on this question as they correctly applied that at the fundamental frequency $\lambda = 2L$. Candidates at the lower end did not recall the wavelength of the stationary wave in terms of the length of wire.

Question 24 (b) (ii) (2)

2 the speed of the progressive waves on the stretched wire

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

Nearly 80% of candidates correctly selected and applied the formula $v = f\lambda$. Where candidates had incorrectly determined the wavelength at the fundamental frequency, they were given marks for carrying out a correct calculation using their value.

Question 24 (b) (ii) (3)

3 the **absolute** uncertainty in the tension *T*. Write your answer to 2 significant figures.

absolute uncertainty in *T* = ... N **[2]**

About a third of candidates used the information given in the question to determine the percentage uncertainty of 6.5% and used this to find the absolute uncertainty. Some candidates used the maximum and minimum values of the tension to find the absolute uncertainty. Some candidates correctly calculated a value for the absolute uncertainty but did not give their answer to 2 significant figures as the question requested.

Question 25 (a)

25 (a) Potential difference (p.d.) and electromotive force (e.m.f.) can both be defined in terms of transfer of energy per unit charge.

State one other **similarity** between p.d. and e.m.f.

....

.... **[1]**

Most candidates performed well and correctly stated a similarity that p.d. and e.m.f have the same unit of the volt, V.

Question 25 (b) (i)

(b) **Fig. 25.1** shows an electrical circuit.

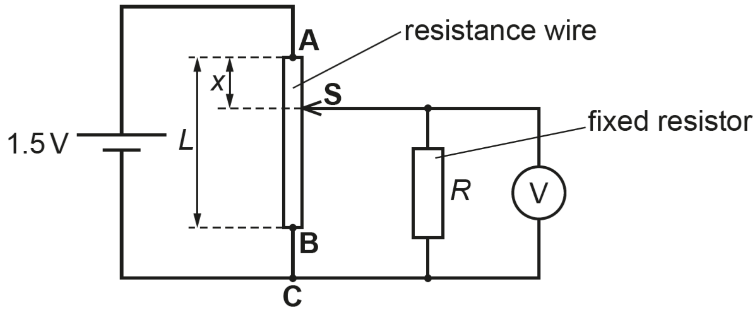


Fig. 25.1

The cell has e.m.f. 1.5 V and negligible internal resistance.

AB is a resistance wire of length *L*. The resistance of this wire is **equal** to the resistance *R* of the fixed resistor.
S is a sliding contact that can be moved on the resistance wire. The distance between **A** and **S** is *x*.
The p.d. across the fixed resistor is *V*.

(i) The distance *x* is changed by moving the slider from **A** to **B**.

On **Fig. 25.2**, show the variation of *V* with distance *x*.

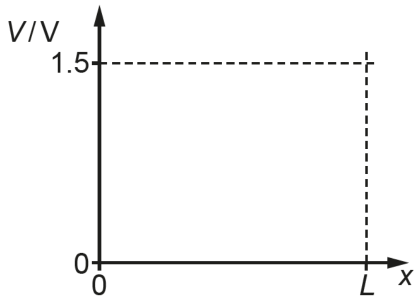


Fig. 25.2

[2]

Many candidates were given no marks for this question and there was a significant number of candidates who omitted the question. Typical incorrect responses were to draw a line showing a directly proportional relationship between *V* and *L*. Very few candidates were given 2 marks for correctly showing a decreasing gradient.

Question 25 (b) (ii)

(ii) The connecting wire **BC** is now removed. The rest of the circuit remains unchanged.

Explain the variation of *V* with distance *x* as **S** is moved from **A** to **B**.

....

....

....

.... **[2]**

Over half of candidates were given no marks for this question as they would often confuse the potential difference *V* across the fixed resistor with the potential difference across the resistance wire and because they had not determined that when the connecting wire BC was removed the resistance wire and fixed resistor were in series. If candidates were given 1 mark it was for correctly describing the relationship between *V* and *x* but with little or confused understanding of a potential divider.

Question 25 (c) (i)

(c) A power supply of electromotive force (e.m.f.) 14.4 V and negligible internal resistance is connected by two identical metal wires to two filament lamps, as shown in **Fig. 25.3**.

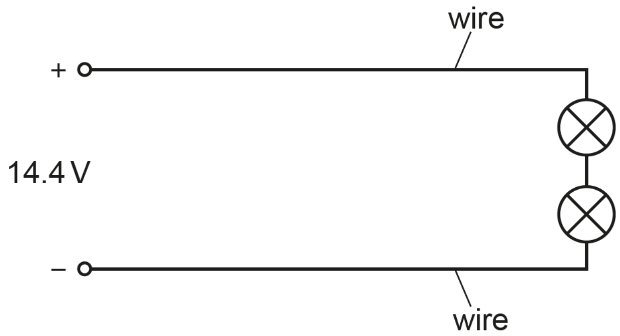


Fig. 25.3

The current in the circuit is 3.0 A.
The potential difference across **each** lamp is 6.0 V.
The **total** length of the metal wire is 25.0 m. The cross-sectional area of the wire is 0.54 mm^2.

(i) Calculate the resistivity ρ of the metal from which the wire is made.

ρ = ... Ω m **[4]**

Candidates did not perform well on this question as they did not understand what the question was asking candidates to calculate. The skill and understanding with this question were to first determine that the p.d. was shared across the two lamps and the metal wire which most candidates did not do and apply it to calculate a value of resistance of the metal wire. Candidates were able to select and carry out a correct calculation using $R = \rho L/A$ which demonstrated that they understood a value for resistance was required for the calculation but many used an incorrect value of R. Many candidates would calculate the resistance of the metal wire as R = 6.0 V / 3.0 A = 2 Ω (the resistance of one of the lamps) and would also not correctly convert the cross-sectional area into m^2.

Misconception

Candidates did not fully read the question that the resistivity of the metal wire **only** was to be calculated and that to calculate the resistivity correctly they had to determine the p.d. across the metal wire (p.d. across the wire = 14.4 V – (2 × 6.0 V)).

Conversion error as candidates did not convert mm^2 to m^2 for the cross-sectional area.

Question 25 (c) (ii)

(ii) The number of electrons per unit volume n in the metal wire is $8.5 \times 10^{28}\,m^{-3}$.

Calculate the mean drift velocity v of the electrons in the metal.

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

Most candidates were given at least 1 mark with half the candidates correctly calculating the drift velocity using the formula $I = Anev$. Less successful responses did not select the correct formula and some candidates had an incorrect or absent conversion of the cross-sectional area to m^2.

Question 26 (a) (i)

26 **(a)** The table below shows the work function ϕ of four metals.

Metal	**A**	**B**	**C**	**D**
ϕ/ eV	3.2	4.1	3.3	6.4

Electromagnetic radiation of wavelength 380 nm is incident on all the metals.
Photoelectrons are **just** emitted from metal **A**.

(i) Explain, in terms of the energy of photons, why metal **C** will **not** emit photoelectrons.

....

.... **[1]**

The highest 50% of candidates performed well on this question as they correctly referred to the 'energy of photons' while the bottom half tended to make vague and incomplete statements and hence did not compare the energy of photons to the work function of C.

Question 26 (a) (ii)

(ii) Calculate the maximum wavelength of the electromagnetic radiation in nm that will **just** eject photoelectrons from metal **D**.

maximum wavelength = ... nm **[1]**

Very few candidates realised that no use of $E = hc/\lambda$ was required to calculate the maximum wavelength as the work function of D was double of A so the maximum wavelength was half of 380 nm. Therefore, most candidates attempted to calculate the wavelength from the work function with a common error of not converting eV to J.

Question 26 (a) (iii)

(iii) The metal **B** is now exposed to electromagnetic radiation of a different wavelength. The energy of each incident photon is 5.3 eV.

Calculate the minimum de Broglie wavelength λ of the emitted photoelectrons.

λ = ... m **[3]**

Most candidates were able to convert eV to J but did not correctly use this to calculate the velocity of the photoelectrons as they did not apply the formula $\lambda = h/p$ to calculate the momentum. Only a few candidates correctly applied both formulae $hf = \phi + KE_{max}$ and $\lambda = h/p$ to calculate the de Broglie wavelength.

Exemplar 3 demonstrates typical responses from middle range candidates.

Misconception

Candidates did not apply the formula $hf = \phi + KE_{max}$ to determine the correct value for the KE and hence the momentum and used the value 5.3 eV given in the stem of the question.

Exemplar 3

$$\lambda = \frac{h}{p} = \frac{h}{MV}$$

$$E = hf \qquad f = \frac{E}{h} \qquad \frac{5.3 \times 1.6 \times 10^{-19}}{6.63 \times 10^{-19}} = f = 1.279$$

$$hf = \phi + KE_{MAX}$$

$$KE_{MAX} = hf - \phi$$

$$\lambda = \frac{h}{m(hf - \phi)}$$

$$\lambda = \frac{6.63 \times 10^{-34}}{1.6 \times 10^{-19}([6.63 \times 10^{-34} \ldots \times 1.279] - 4.1)}$$

$$\lambda = 1.01 \times 10^{-15}$$

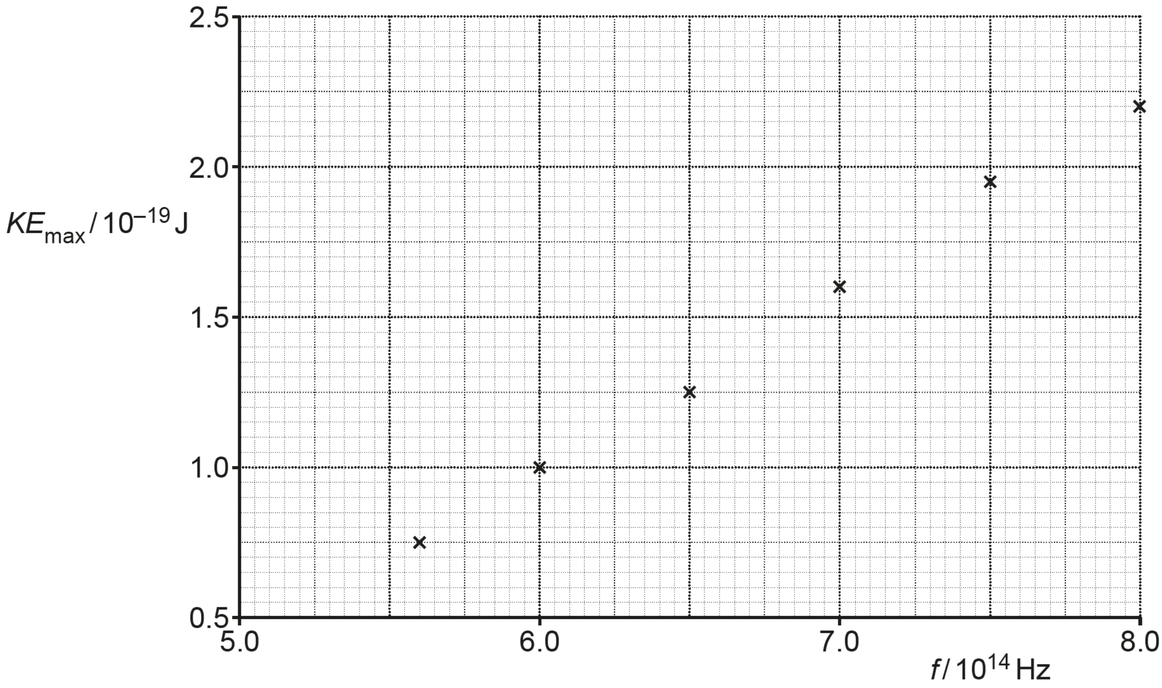
λ = 1.01×10^{-15} m **[3]**

This response demonstrates a lack of understanding of the photoelectric effect and use and application of the formula $hf = \phi + KE_{max}$. Candidates have selected the correct formula to calculate the de Broglie wavelength and have converted eV to J but have not understood that p is required to be calculated using v from the correct KE.

Question 26 (b) (i)

(b) A researcher is carrying out an experiment to determine the work function ϕ of a new material. The material is illuminated by electromagnetic radiation of frequency f and the maximum kinetic energy KE_{max} of the photoelectrons is determined.

The researcher plots the data points shown below.



(i) Draw a straight line of best fit through the data points. **[1]**

Most candidates performed well with this question as they correctly drew a line of best fit through the data points but a few candidates drew a line of best fit through the points (0.5, 5.0).

Question 26 (b) (ii)

(ii) Use the gradient of this line, and Einstein's photoelectric equation, to determine the work function ϕ of the material.

ϕ = ... J **[3]**

This question was assessing candidates' skill to calculate a gradient value from the graph and use this value in an expression for the equation of a straight line to determine a value for the work function of the material which was the y-intercept, therefore few candidates correctly calculated a value within a stated range. Candidates were not given marks for using the stated value of $h = 6.63 \times 10^{-34}$ J s as this did not assess the skill required by the question. Some candidates attempted to calculate a gradient value, so marks were given if they applied it in a correct expression of an equation for the straight line.

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