

AS Level Physics B (Advancing Physics)
H157/02 Physics in depth
Sample Question Paper

Date – Morning/Afternoon

Version 2.0

Time allowed: 1 hour 30 minutes

You must have:

- the Data, Formulae and Relationships Booklet

You may use:

- a scientific or graphical calculator



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First name

Last name

Centre
number

Candidate
number

INSTRUCTIONS

- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Where appropriate, your answers should be supported with working. Marks may be given for a correct method even if the answer is incorrect.
- Write your answer to each question in the space provided.
- Additional paper may be used if required but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the bar codes.

INFORMATION

- The total mark for this paper is **70**.
- The marks for each question are shown in brackets [].
- Quality of extended responses will be assessed in questions marked with an asterisk (*).
- This document consists of **20** pages.

SECTION A

Answer **all** the questions.

- 1** This question is about driving a cylinder into the ground. A block of mass of 200 kg is released from rest at a height of 4.5 m above a steel cylinder already in the ground. The cylinder is driven into the ground a further 8.0 cm by the falling block. It is assumed that the mass of the block is far greater than that of the cylinder.

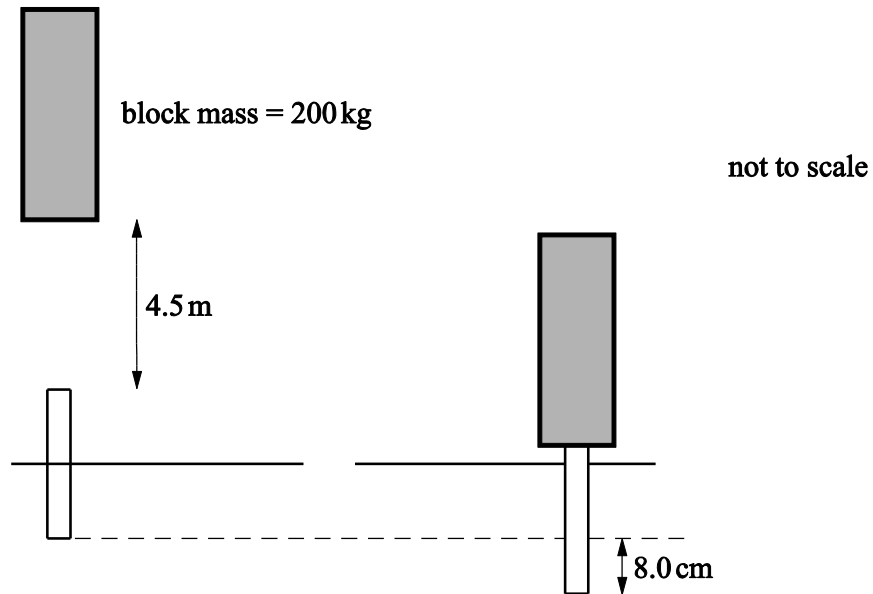


Fig.1.1

- (a) Calculate the change in potential energy of the block from release point to the point it comes to rest.

change in potential energy = J [2]

- (b) Use your answer to (a) to calculate the average force exerted on the block by the cylinder as it decelerates.

average force = N [2]

- (c) The process is repeated and the cylinder is pushed into the ground by a further 6.0 cm. Suggest and explain why the depth did **not** increase by 8.0 cm.

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..... [2]

2 This question is about momentum and impulse.

- (a) The impulse of a force is given by the equation $impulse = force \times time$
 Show that the units of impulse are equivalent to $kg\ m\ s^{-1}$.

[2]

- (b) Fig. 2.1 shows a collision between two balls. Ball A has mass 0.60 kg, ball B has mass 0.40 kg.

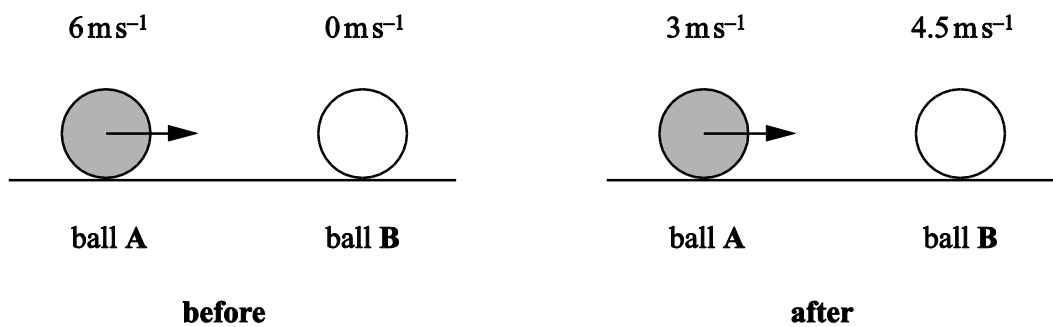


Fig. 2.1

- (i) Calculate the total momentum **before** the collision.

momentum = $kg\ m\ s^{-1}$ [2]

- (ii) Show that kinetic energy is **not** conserved in the collision.

[3]

- (iii) The balls are in contact for 40 ms. Calculate the average force exerted on ball A as it decelerated from 6 m s^{-1} to 3 m s^{-1} . Suggest why this is an average value.

[3]

3 This question is about a phone capturing and sending a digital photograph.

Here are some data about the photograph and the broadband system the phone uses.

The image is 640×960 pixels.

Each pixel is coded for three colours. Each colour is coded by 8 bits.

The broadband speed is 5×10^6 bits per second.

(a) Calculate the time required to send the uncompressed photograph.

time = s [2]

(b) The phone's camera can record video at 30 frames per second. The phone can store 6.2 gigabytes of data. Calculate how many seconds of video recording the phone can store if each frame has the same data requirement as a still photograph.

recording time = s [2]

(c) Digital images can be compressed to reduce the number of bits required to represent the image and they may be manipulated in other ways to edit or change the image. The modified images and videos may then be posted to social media websites. Give a reason for processing images in one of these ways and identify the benefits or any risk associated with this.

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..... [3]

SECTION B

Answer **all** the questions.

4 This question is about different models of light.

A coherent beam of light passes through two slits and forms a pattern on a distant screen. The slit spacing is 2.5×10^{-4} m. The distance from the slits to the screen is 2.3 m.

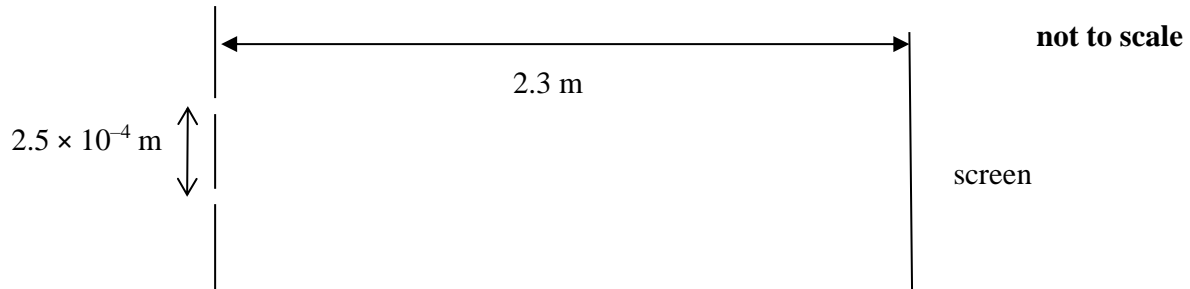


Fig. 4.1

(a) Explain what the term *coherent* means in this context.

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..... [1]

(b) **Fig. 4.2** represents the pattern of bright fringes on the screen.

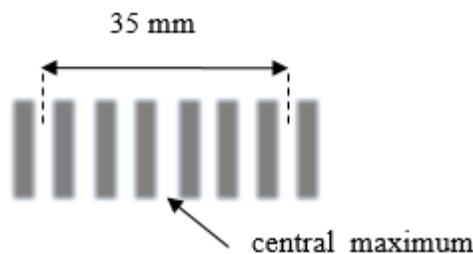


Fig. 4.2

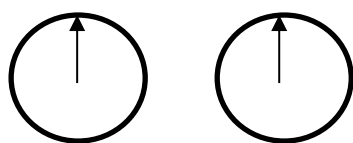
Use the data below and information from **Fig. 4.2** to calculate the wavelength of the light passing through the slits.

slit spacing = 2.5×10^{-4} m

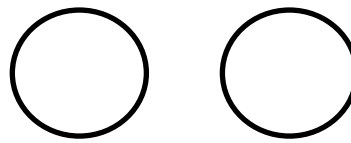
distance from the slits to the screen = 2.3 m.

wavelength = m [3]

- (c) Phasors can be represented by rotating arrows. The phasors representing the waves from the two slits reaching the screen at a bright patch at one instant of time are shown in **Fig. 4.3**.



bright patch

Fig. 4.3

dark patch

Fig. 4.4

- (i) On **Fig. 4.4** draw arrows representing phasors arriving at the same instant of time, for light from the two slits, at a **dark patch** on the screen. [1]
- (ii) **Fig. 4.5** shows two pairs of phasor arrows meeting at the screen. Draw a scale diagram showing the resultant phasor arrow in both cases.

case 1:

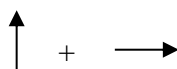
phasor arrows:



resultant phasor arrow:

case 2:

phasor arrows



resultant phasor arrow:

Fig. 4.5

- (iii) Use the relationship *probability of arrival of photon \propto (phasor amplitude)²* to find the ratio of the probabilities of arrival of photons for the two resultant phasors. [2]

$$\text{ratio } \frac{\text{probability of arrival of photons in case 1}}{\text{probability of arrival of photons in case 2}} =$$

[2]

When interference patterns were first observed in the nineteenth century they were interpreted as evidence for the wave picture of light. Early in the twentieth century, Albert Einstein showed that light interacts as small quanta of energy, photons. This idea is supported by images such as **Fig. 4.6**. This shows an image of a girl's face gradually building up as more light falls on the photographic film. Image (1) is the least exposed and (6) the most. In the early stages of building up an image the pattern is quite random.

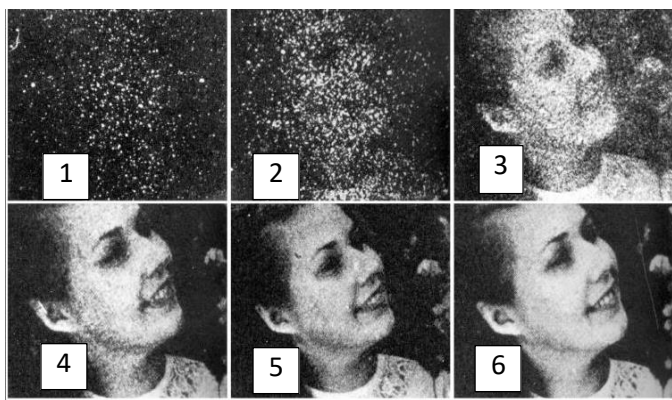


Fig. 4.6

Photons can be modelled as small quanta of energy that have a probability of arrival at a point. This probability is found by using phasors to combine the amplitude and phase for all possible paths to that point.

- (d)* Describe how this phasor model can explain the gradual build-up of images such as **Fig. 4.6** and also explain two-slit interference. In your description you should also explain why a wave model cannot explain the effect shown in **Fig 4.6** and why a simple particle model cannot explain interference effects. [6]

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Additional answer space if required.

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- 5 This question is about the properties and microscopic structure of metal wire. **Fig. 5.1** shows a graph of force against extension for a steel wire.

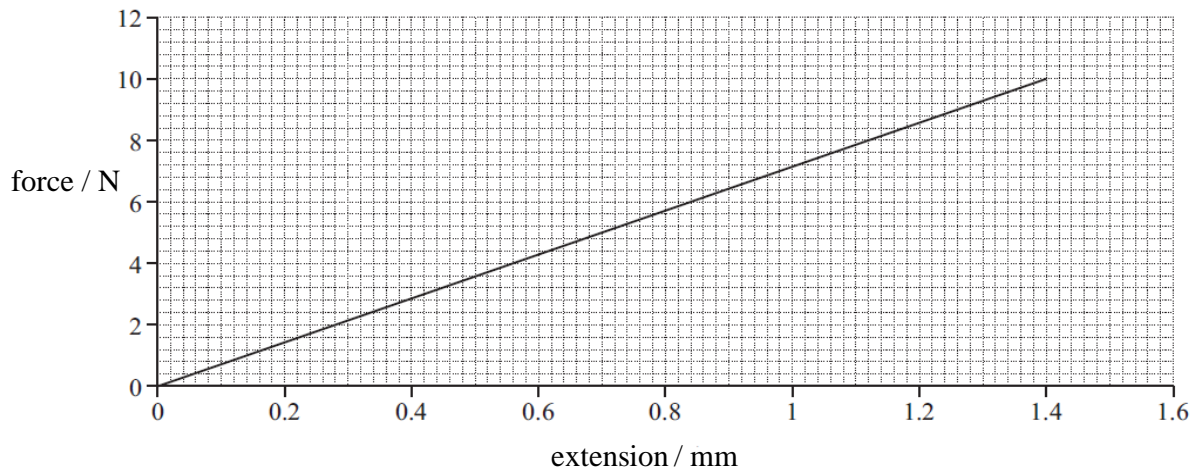


Fig. 5.1

- (a) State how the graph shows that the wire is behaving elastically.

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 [1]

- (b) The wire has a diameter of 0.40 mm. The original length of the wire is 3.85 m.
 Use data from **Fig. 5.1** to calculate the Young modulus of the steel.

Young modulus = N m^{-2} [4]

- (c) **Fig. 5.2** shows a stress–strain graph of the same material, obtained from a tensile testing machine.

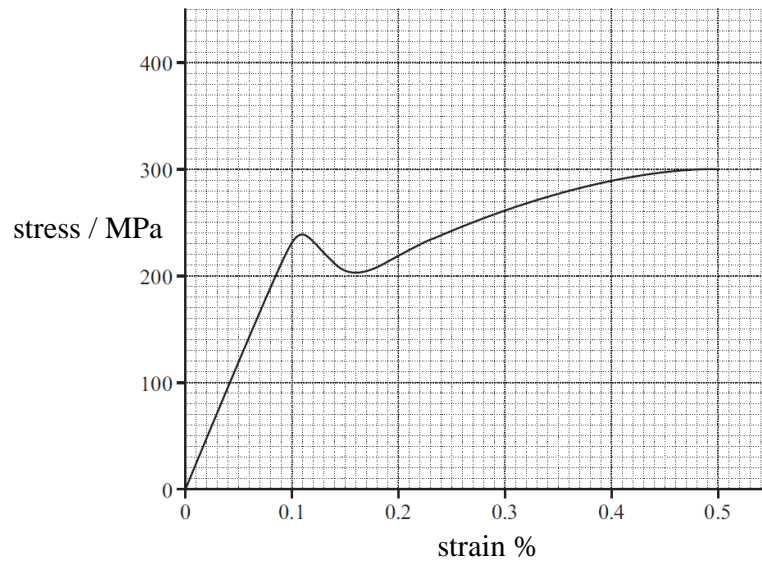


Fig. 5.2

- (i) Mark with an X the point on the graph in **Fig. 5.2** where plastic deformation begins. [1]

- (ii) State the feature of the graph that represents the stiffness of the material and describe how the stiffness varies between a strain of 0.2% and 0.5%.

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 [2]

- (d)* Steel is an alloy. Its main constituent is iron. Using ideas about dislocations and metallic structure explain why the steel first shows elastic behaviour (up to point X) and then shows plastic behaviour (beyond point X). Explain how the presence of atoms other than iron makes the resulting metal harder and less plastic than pure iron. [6]

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Additional answer space if required.

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Section C begins on page 14

SECTION C

Answer **all** the questions.

- 6 This question is about an experiment performed in AS physics to determine the internal resistance of a battery (two cells combined in series). The experiment can be set up as shown in **Fig. 6.1**.

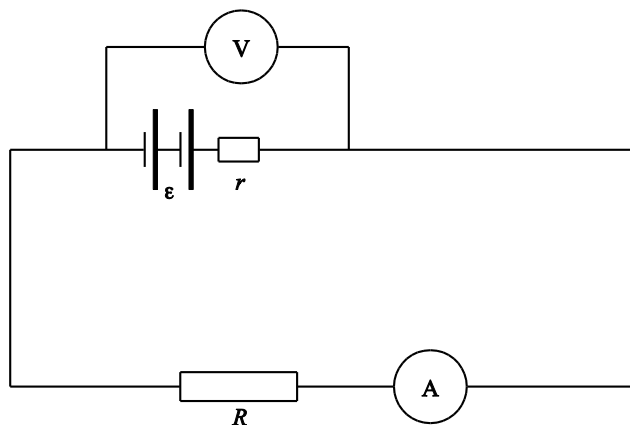


Fig. 6.1

Measurements of p.d. V and current I for a range of values of resistors R are taken in order to determine a value for the combined internal resistance of the cells.

In planning the experiment it is important to select suitable equipment.

- (a) Explain why the following equipment was chosen

- A voltmeter with very high internal resistance.
- An ammeter with negligible internal resistance.

.....

 [2]

- (b) A student suggests that using much higher value resistors will improve the quality of measurements by reducing the uncertainty in the current readings.

Comment on this suggestion. Explain your reasoning.

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 [3]

(c) Data obtained from the experiment on page 12 is given in the table below

p.d. / V	I / mA
2.86	286
2.82	352
2.78	462
2.66	666
2.40	1200

Plot a graph of the values on **Fig. 6.2**. Draw a suitable line.

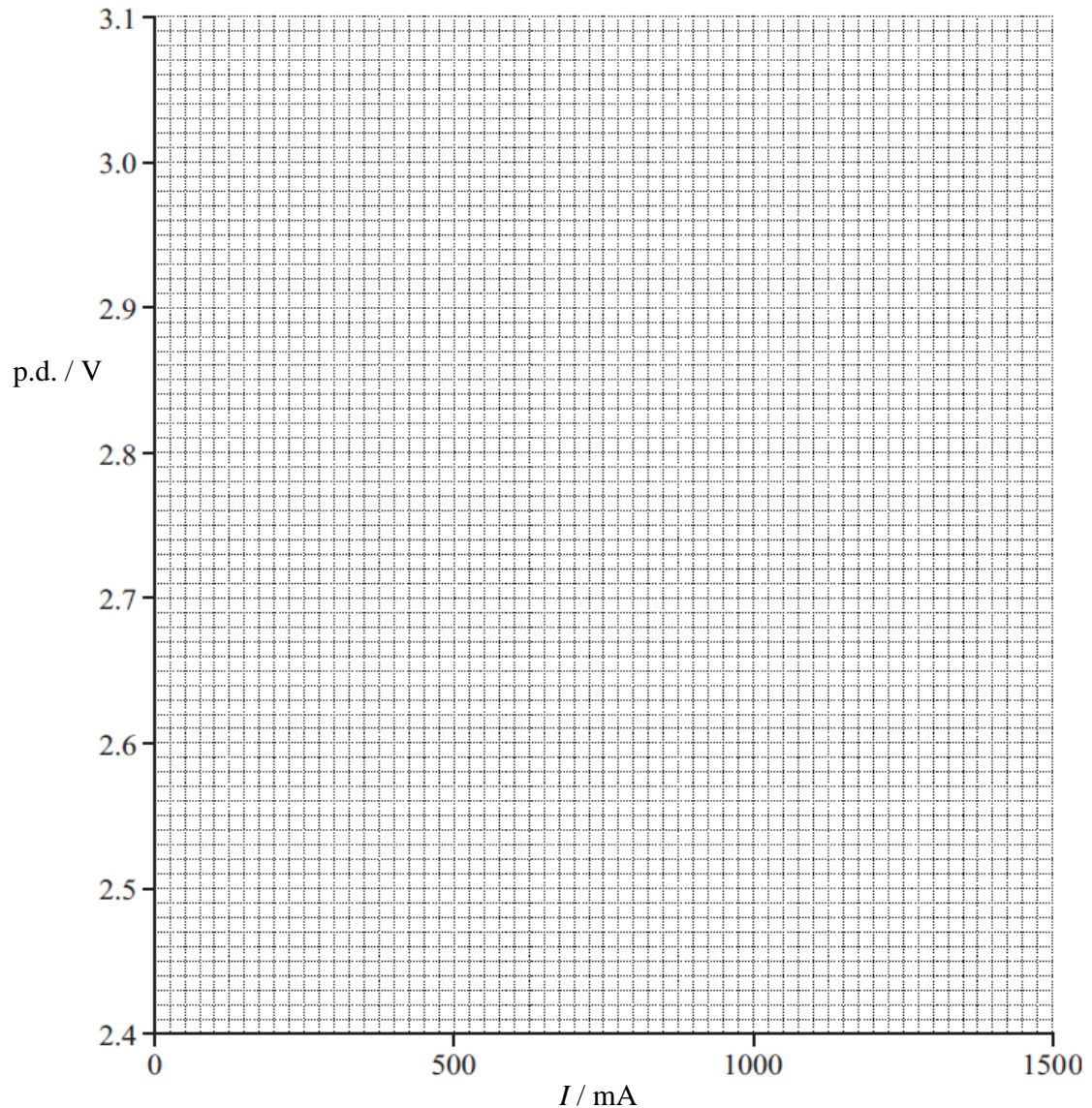


Fig. 6.2

[2]

The equation relating p.d. V and current is

$$V = \mathcal{E} - Ir$$

Where \mathcal{E} is the e.m.f. of the battery and r is the internal resistance of the battery.

(d) Use the graph to determine a value for the e.m.f. \mathcal{E} for the cells. Include the unit in your answer.

e.m.f. $\mathcal{E} = \dots\dots\dots$ [2]

(e) Determine a value for the internal resistance.

internal resistance = $\dots\dots\dots \Omega$ [3]

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END OF QUESTION PAPER

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Summary of updates

Date	Version	Change
October 2020	2.0	Updated copyright acknowledgements.

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...day June 20XX – Morning/Afternoon

AS Level Physics B (Advancing Physics)

H157/02 Physics in depth

SAMPLE MARK SCHEME

Duration: 1 hour 30 minutes

MAXIMUM MARK 70



This document consists of 16 pages

MARKING INSTRUCTIONS**PREPARATION FOR MARKING****SCORIS**

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *scoris assessor Online Training*; *OCR Essential Guide to Marking*.
2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are posted on the RM Cambridge Assessment Support Portal <http://www.rm.com/support/ca>
3. Log-in to scoris and mark the **required number** of practice responses (“scripts”) and the **required number** of standardisation responses.

YOU MUST MARK 10 PRACTICE AND 10 STANDARDISATION RESPONSES BEFORE YOU CAN BE APPROVED TO MARK LIVE SCRIPTS.

MARKING

1. Mark strictly to the mark scheme.
2. Marks awarded must relate directly to the marking criteria.
3. The schedule of dates is very important. It is essential that you meet the scoris 50% and 100% (traditional 50% Batch 1 and 100% Batch 2) deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.
4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone, email or via the scoris messaging system.

5. Work crossed out:
- a. where a candidate crosses out an answer and provides an alternative response, the crossed out response is not marked and gains no marks
 - b. if a candidate crosses out an answer to a whole question and makes no second attempt, and if the inclusion of the answer does not cause a rubric infringement, the assessor should attempt to mark the crossed out answer and award marks appropriately.
6. Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there then add a tick to confirm that the work has been seen.
7. There is a NR (No Response) option. Award NR (No Response)
- if there is nothing written at all in the answer space
 - OR if there is a comment which does not in any way relate to the question (e.g. 'can't do', 'don't know')
 - OR if there is a mark (e.g. a dash, a question mark) which isn't an attempt at the question.

Note: Award 0 marks – for an attempt that earns no credit (including copying out the question).

8. The scoris **comments box** is used by your Team Leader to explain the marking of the practice responses. Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**
- If you have any questions or comments for your Team Leader, use the phone, the scoris messaging system, or e-mail.
9. Assistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

10. For answers marked by levels of response:

- Read through the whole answer from start to finish.
- Decide the level that **best fits** the answer – match the quality of the answer to the closest level descriptor.
- To select a mark within the level, consider the following:
 - Higher mark:** A good match to main point, including communication statement (in italics), award the higher mark in the level
 - Lower mark:** Some aspects of level matches but key omissions in main point or communication statement (in italics), award lower mark in the level.

Level of response questions on this paper are **4d, 5d, and 6f**.

11. Annotations

Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
()	Words which are not essential to gain credit
—	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

12. Subject-specific Marking Instructions

INTRODUCTION

Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

You should ensure that you have copies of these materials.

You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New Examiners**.

Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

Section A

Question		Answer	Marks	Guidance
1	(a)	$mg\Delta h = 4.58 \times 9.8 \times 200 \checkmark$ $= 8980 \text{ (J)} \checkmark$	2	No sf penalty.
	(b)	Force = $8980/0.08 \checkmark$ $= 1.1(2) \times 10^5 \text{ N} \checkmark$	2	ecf from (a) or equivalent
	(c)	Force acting on cylinder from ground has increased \checkmark Sensible reason, e.g. increased friction, compression of soil. \checkmark	2	Can gain second mark from discussing energy transfer; if a greater force is acting on the cylinder the same work is done over a shorter distance. AW
Total			6	

Question		Answer	Marks	Guidance	
2	(a)	$Ns = kg\ m\ s^{-2} \times s \checkmark$ Clear cancelling of s to give stated units \checkmark	2	Must show clear working to gain both marks	
	(b)	(i)	total momentum before collision = $(0.6 \times 6) + (0 \times 6) \checkmark$ $= 3.6\ (kg\ ms^{-1}) \checkmark$	2	
		(ii)	Initial k.e = $\frac{1}{2} \times 0.6 \times 6^2 = 10.8\ (J) \checkmark$ Final k.e. = $2.7 + 4.05 \checkmark$ $= 6.75\ (J) \checkmark$	3	or '2.7 + 4.05 is less than 10.8 J' for third mark
		(iii)	Either: Impulse = $3.6 - 1.8 = 1.8\ Ns \checkmark$ Force = $1.8/40 \times 10^{-3} = 45\ N \checkmark$ Or: Force = $m \times a = 0.6 \times ((6 - 3)/40 \times 10^{-3}) = 0.6 \times 75 \checkmark$ $= 45\ N \checkmark$ Sensible reason eg balls compress on contact, force decreases as second ball starts moving \checkmark	3	
Total			10		

Question		Answer	Marks	Guidance
3	(a)	$640 \times 960 \times 8 \times 3 / 5 \times 10^6 \checkmark$ = 2.9 seconds \checkmark	2	
	(b)	$6.2 \times 10^9 \times 8 / (640 \times 960 \times 8 \times 3 \times 30) \checkmark$ = 112 s \checkmark	2	
	(c)	Form of processing: Digital compression reduces file size \checkmark Manipulating the original image to create a new image \checkmark Benefits of processing: Files require less data storage \checkmark Ability to Skype / rapid transmission of images \checkmark Posting to social media \checkmark Reducing "red-eye" \checkmark Creating artistic effects \checkmark Risks/disadvantages of processing: Manipulation of images to alter opinions \checkmark Reduction in resolution \checkmark Implications: Keeping families and friends in contact \checkmark Cyber bullying using manipulated photos \checkmark	3	Three marks can be gained by looking at implications, risks and benefits of a single facet.
Total			7	

Section B

Question		Answer	Marks	Guidance
4	(a)	(light at both slits) has constant phase relationship/difference ✓	1	AW
	(b)	fringe spacing = $35 \times 10^{-3}/6 = 5.8 \times 10^{-3}$ (m) ✓ $\lambda = 5.8 \times 10^{-3} \times 2.5 \times 10^{-4}/2.3$ ✓ $= 6.3 \times 10^{-7}$ m ✓	3	Or, from $n\lambda = d \sin\theta$ and calculating sine of the angle.
	(c)	(i)	1	two arrows of same length at 180° ✓
		(ii)	2	First pair showing simple addition ✓ Second pair showing right angled triangle ✓ Phasor arrows must be tip-to-tail.
		(iii)	2	Calculating relative amplitude ² of each phasor pair (= $4/2$) ✓ ratio given as 2 ✓ First mark can be via direct measurement and squaring or by simple proportion. Bald answer worth two marks.

Question	Answer	Marks	Guidance
4 (d)*	<p>Level 3 (5–6 marks) Marshals argument in a clear manner linking the problems of wave model or simple particle model with two pieces of evidence (interference pattern and developing picture) Recognises the crucial nature of the probabilistic interpretation in explaining both pieces of evidence with the phasor model.</p> <p><i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i></p> <p>Level 2 (3–4 marks) Considers at least two aspects of the argument. Includes some understanding of the role of probability.</p> <p><i>There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.</i></p> <p>Level 1 (1–2 marks) Makes at least two independent points that are relevant to the argument. Structuring of the answer may be poor.</p> <p><i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i></p> <p>0 marks No response or no response worthy of credit.</p>	6	<p>Indicative scientific points may include:</p> <p>Limitations of wave model:</p> <ul style="list-style-type: none"> • Image will always be the same variation of intensity as the final image. • The image will never show the random nature of the low exposures shown in the figure. <p>Limitations of particle model:</p> <ul style="list-style-type: none"> • Interference pattern requires superposition • (classical) particles cannot superpose • No interference pattern would be observed if (classical) particles passed through the slits. <p>Phasor model:</p> <ul style="list-style-type: none"> • Inteference pattern can be explained by adding phasors from the two slits. • Recap of phasor explanation of interference pattern using ideas from earlier in the question. • This gives a probability of arrival, not a (simple) wave amplitude. • Because the resultant amplitude gives a probability of arrival it explains the random nature of the early exposures.
	Total	15	

Question		Answer	Marks	Guidance	
5	(a)	Graph is straight line through origin/ force is proportional to extension. ✓	1		
	(b)	Suitable pair of values for F , x . ✓ Correct calculation of c.s.a = $1.26 \times 10^{-7} \text{ m}^2$ ✓ Substitution into equation using suitable pair of values ✓ Calculation to answer of $2.2 \times 10^{11} \text{ (N m}^{-2}\text{)}$ ✓	4	If diameter used rather than radius maximum of 3 marks are available.	
	(c)	(i)	X marked on 240, 0.115 +/- one small square ✓	1	
		(ii)	Ratio of stress: strain gives stiffness ✓ Stiffness decreases from 0.2% to 0.5 % ✓	2	Accept gradient

Question	Answer	Marks	Guidance
5 (d)*	<p>Level 3 (5–6 marks) Marshals argument in a clear manner giving clear reasoning at all points. Each part of the question fully covered and the connection made between elastic behaviour, plastic behaviour and allowing in microscopic terms.</p> <p><i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i></p> <p>Level 2 (3–4 marks) Covers at least two aspects of the argument. May not link the aspects together. Shows understanding of the basic model of a metal.</p> <p><i>There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.</i></p> <p>Level 1 (1–2 marks) Makes at least two independent points that are relevant to the argument. Structuring of the answer may be poor.</p> <p><i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i></p> <p>0 marks No response or no response worthy of credit.</p>	6	<p>Indicative scientific points may include:</p> <p>Elastic behaviour</p> <ul style="list-style-type: none"> • metal described as positive ions in a sea (AW) of free electrons • interatomic (interionic) spacing increasing as metal is put under tension • this increase in spacing is uniform (parallel to tension) • when tensile force removed atomic separation returns to initial values. • no energy lost in stretching and relaxing elastically. <p>Plastic behaviour</p> <ul style="list-style-type: none"> • planes of atoms slide (AW) over one another • dislocations allow plastic behaviour to occur at a lower stress. • dislocation allow bonds to be broken one bond at a time. <p>Effect of Alloying</p> <ul style="list-style-type: none"> • foreign/guest atoms pin down dislocations • this makes slip less likely/ planes move over shorter distances
	Total	14	

SECTION C

Question		Answer	Marks	Guidance
6	(a)	High resistance means that negligible current flows through the voltmeter ✓ Negligible resistance means that pd across the ammeter is minimal/reduced so that it does not affect the readings ✓	2	Or resistance of voltmeter-resistor pair is v. close to that of the resistor alone.
	(b)	(Suggestion is incorrect) Increased resistance gives lower current ✓ Constant absolute uncertainty ΔW ✓ with lower current values give a higher % uncertainty ✓	3	
	(c)	Points plotted correctly ✓ Correct line of best fit drawn ✓	2	
	(d)	3 (V) ✓ correct unit (V) ✓	2	Allow $\pm 0.1V$. ecf for their line of best fit.
	(e)	Correct method for calculating gradient ✓ x values $> 750 \text{ mA}$ ✓ 0.5Ω ✓	3	Allow $\pm 0.1\Omega$
	(f)*	Level 3 (5–6 marks) Constructs argument in a clear manner giving clear reasoning at all points. Each part of the question fully covered and the connection made with data on the graph. <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) Covers at least two aspects of the argument. May not link the aspects together. Shows understanding of the effect on uncertainties.	6	Indicative scientific points may include: Adding switch <ul style="list-style-type: none"> Idea of reducing heating effect No energy lost/draining of the battery/cells. Improved reliability Adding another cell <ul style="list-style-type: none"> Increase in pd \rightarrow increase in current Change to the overall resistance % uncertainty in current reading reduces Graph would have a steeper gradient and higher intercept Reversing the cell <ul style="list-style-type: none"> Reduces the pd \rightarrow reduces the current flow % uncertainty would increase.

Question	Answer	Marks	Guidance
	<p><i>There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.</i></p> <p>Level 1 (1–2 marks) Makes at least two independent points that are relevant to the argument. Structuring of the answer may be poor.</p> <p><i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i></p> <p>0 marks No response or no response worthy of credit.</p>		<ul style="list-style-type: none"> • Overall internal resistance would be the same • Would produce a lower intercept but same gradient.
	Total	18	

Summary of updates

Date	Version	Change
January 2019	2.0	Minor accessibility changes to the paper: i) Additional answer lines linked to Level of Response questions ii) One addition to the rubric clarifying the general rule that working should be shown for any calculation questions