OCR
Oxford Cambridge and RSA

Higher

GCSE

Physics B Twenty First Century Science

J259/02: Depth in physics (Foundation Tier)

General Certificate of Secondary Education

Mark Scheme for June 2023

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of candidates of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, Cambridge Nationals, Cambridge Technicals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

MARKING INSTRUCTIONS

PREPARATION FOR MARKING

RM ASSESSOR

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *RM 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 available in RM Assessor.

3. Log-in to RM Assessor and mark the **required number** of practice responses ("scripts") and the **required number** of standardisation responses.

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 RM Assessor 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 RM Assessor messaging system.

5. **Crossed Out Responses**

   Where a candidate has crossed out a response and provided a clear alternative then the crossed out response is not marked. Where no alternative response has been provided, examiners may give candidates the benefit of the doubt and mark the crossed out response where legible.

Rubric Error Responses – Optional Questions
Where candidates have a choice of question across a whole paper or a whole section and have provided more answers than required, then all responses are marked and the highest mark allowable within the rubric is given. Enter a mark for each question answered into RM assessor, which will select the highest mark from those awarded. *(The underlying assumption is that the candidate has penalised themselves by attempting more questions than necessary in the time allowed.)*

Multiple Choice Question Responses
When a multiple choice question has only a single, correct response and a candidate provides two responses (even if one of these responses is correct), then no mark should be awarded (as it is not possible to determine which was the first response selected by the candidate).
When a question requires candidates to select more than one option/multiple options, then local marking arrangements need to ensure consistency of approach.

Contradictory Responses
When a candidate provides contradictory responses, then no mark should be awarded, even if one of the answers is correct.

Short Answer Questions (requiring only a list by way of a response, usually worth only **one mark per response**)
Where candidates are required to provide a set number of short answer responses then only the set number of responses should be marked. The response space should be marked from left to right on each line and then line by line until the required number of responses have been considered. The remaining responses should not then be marked. Examiners will have to apply judgement as to whether a 'second response' on a line is a development of the 'first response', rather than a separate, discrete response. *(The underlying assumption is that the candidate is attempting to hedge their bets and therefore getting undue benefit rather than engaging with the question and giving the most relevant/correct responses.)*

Short Answer Questions (requiring a more developed response, worth **two or more marks**)
If the candidates are required to provide a description of, say, three items or factors and four items or factors are provided, then mark on a similar basis – that is downwards (as it is unlikely in this situation that a candidate will provide more than one response in each section of the response space.)

Longer Answer Questions (requiring a developed response)
Where candidates have provided two (or more) responses to a medium or high tariff question which only required a single (developed) response and not crossed out the first response, then only the first response should be marked. Examiners will need to apply professional judgement as to whether the second (or a subsequent) response is a 'new start' or simply a poorly expressed continuation of the first response.

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 stamp 'seen' to confirm that the work has been seen.

7. Award No Response (NR) if:

    - there is nothing written in the answer space.

    Award Zero '0' if:

    - anything is written in the answer space and is not worthy of credit (this includes text and symbols).

    Team Leaders must confirm the correct use of the NR button with their markers before live marking commences and should check this when reviewing scripts.

8. The RM Assessor **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 RM Assessor messaging system, or email.

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, using the Level descriptors to help you decide whether it is a strong or weak answer. The indicative scientific content in the Guidance column indicates the expected parameters for candidates' answers, but be prepared to recognise and credit unexpected approaches where they show relevance. Using a 'best-fit' approach based on the skills and science content evidenced within the answer, first decide which set of level descriptors, Level 1, Level 2 or Level 3, best describes the overall quality of the answer.

Once the level is located, award the higher or lower mark:

The higher mark should be awarded where the level descriptor has been evidenced and all aspects of the communication statement (in italics) have been met.

The lower mark should be awarded where the level descriptor has been evidenced but aspects of the communication statement (in italics) are missing.

In summary:

The skills and science content determines the level.

The communication statement determines the mark within a level.

Level of response questions on this paper are **5** and **13b**

11. Annotations available in RM Assessor

Annotation	Meaning
	Correct response
	Incorrect response
	Omission mark
	Benefit of doubt given
	Contradiction
	Rounding error
	Error in number of significant figures
	Error carried forward
	Level 1
	Level 2
	Level 3
	Benefit of doubt not given
	Noted but no credit given
	Ignore

12. Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

Annotation	Meaning
/	alternative and acceptable answers for the same marking point
✓	Separates marking points
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

13. **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.

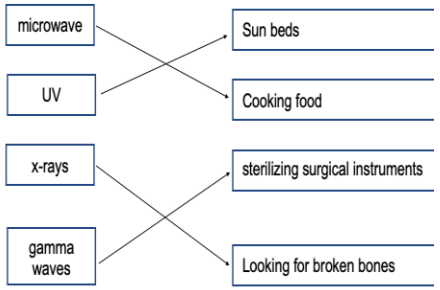
You should ensure that you have copies of these materials.

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.

The breakdown of Assessment Objectives for GCSE (9-1) in Physics B:

	Assessment Objective
AO1	**Demonstrate knowledge and understanding of scientific ideas and scientific techniques and procedures.**
AO1.1	Demonstrate knowledge and understanding of scientific ideas.
AO1.2	Demonstrate knowledge and understanding of scientific techniques and procedures.
AO2	**Apply knowledge and understanding of scientific ideas and scientific enquiry, techniques and procedures.**
AO2.1	Apply knowledge and understanding of scientific ideas.
AO2.2	Apply knowledge and understanding of scientific enquiry, techniques and procedures.
AO3	**Analyse information and ideas to interpret and evaluate, make judgements and draw conclusions and develop and improve experimental procedures.**
AO3.1	Analyse information and ideas to interpret and evaluate.
AO3.1a	Analyse information and ideas to interpret.
AO3.1b	Analyse information and ideas to evaluate.
AO3.2	Analyse information and ideas to make judgements and draw conclusions.
AO3.2a	Analyse information and ideas to make judgements.
AO3.2b	Analyse information and ideas to draw conclusions.
AO3.3	Analyse information and ideas to develop and improve experimental procedures.
AO3.3a	Analyse information and ideas to develop experimental procedures.
AO3.3b	Analyse information and ideas to improve experimental procedures.

Question			Answer	Marks	AO element	Guidance
1			Microwave – cooking food Ultraviolet – sun beds X-rays – looking for broken bones Gamma rays – sterilising surgical instruments ✓✓✓	3	1.1	3 or 4 correct = 3 marks 2 correct = 2 marks 1 correct = 1 mark 

Question			Answer	Marks	AO element	Guidance
2	(a)		Balance ✓	1	1.2	**ALLOW** Any unambiguous indication
	(b)		**First check the answer on answer line** **If answer = 8 (cm^3) award 2 marks** 33 ✓ 33 – 25 = 8 (cm^3) ✓	2	2.2	
	(c)		**First check the answer on answer line** **If answer = 2 (g/cm^3) award 2 marks** Correct substitution: density = 24/12 ✓ Density = 2 (g/cm^3) ✓	2	2.1	

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>AO element</th><th>Guidance</th></tr>
<tr><td>3</td><td></td><td></td><td>
<table>
<tr><th>Bar</th><th>A magnet</th><th>Not a magnet</th></tr>
<tr><td>1</td><td></td><td>✓</td></tr>
<tr><td>2</td><td>✓</td><td></td></tr>
<tr><td>3</td><td></td><td>✓</td></tr>
</table>
✓✓
</td><td>2</td><td>3.2b</td><td>All three rows correct = 2 marks
Two rows correct = 1 mark
One row correct = 0 marks</td></tr>
</table>

Question			Answer	Marks	AO element	Guidance
4	(a)		C ✓	1	3.2a	**ALLOW** 2.5 (g/cm^3)
	(b)		Good/best conductor /small(est) resistance ✓	1	3.1a	**IGNORE** references to density
	(c)		The data can be shared, used and discussed ✓	1	1.1	
	(d)		**3 marks maximum** (When the graph is a straight line:) Extension increases when force increases ✓ **OR** force and extension proportional / $F = kx$ obeyed ✓✓ (When graph curves/at a certain point/plateaus:) Extension increases more (for the same force) / plastic deformation occurs / it is no longer elastic ✓ **OR** force and extension no longer proportional / $F = kx$ no longer obeyed / Spring stretches more than proportionally for each specific increase in force **/** There is a large increase in extension for a small increase in force. ✓✓	3	2.1	**ALLOW** extension increases with force or force increases with extension **ALLOW** relationship is linear / Hooke's Law is obeyed / gradient constant / gradient = spring constant **IGNORE** positive correlation **IGNORE** force slows down / stops / decreases **DO NOT ALLOW** extension stays the same **/** stops increasing **/** slows down / decreases /is less /idea that 'plateau' is because material has broken **ALLOW** relationship is now non-linear / Hooke's Law no longer obeyed / Force stays the same while extension increases
	(e)		Elastically deformed: Idea that (once force removed), elastically deformed graphene can return to its original shape AW✓ Plastically deformed: Idea that (when the force is too large) plastically deformed graphene is permanently deformed AW✓	2	1.1	**ALLOW** deformation is reversible **IGNORE** plastic is snapped/broken

Question			Answer	Marks	AO element	Guidance
5*			Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. **Level 3 (5–6 marks)** Describes some details of the trends in thinking distance (TD) and braking distance (BD) as the speed increases and describes other factors that affect TD and BD. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** A limited description of the trends in TD or BD as the speed increases or describes other factors that affect TD or BD. *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1–2 marks)** An attempt to describe the trend in TD or BD as the speed increases or describes a factor that affects TD or BD. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** No response or no response worthy of credit.	**6**	**3 x 1.1** **3 x 3.1a**	**AO1.1 demonstration of knowledge of factors that affect distance required for cars to come to rest** Speed affects distance a vehicle travels ($s = vt$): • after driver has applied the brake (braking distance, BD) • in the time it takes for driver to realise they need to stop and apply the brakes (thinking distance, TD) Other factors that increase BD: • more mass in vehicle (extra passengers), braking force required larger ($F = ma$) • poor/wet/icy road surface = less friction between tyres and road • badly maintained tyres or brakes = less friction between brakes and wheels Other factors that increase TD: • Longer reaction time, longer TD • Examples leading to longer reaction time: Alcohol / drugs, distractions, old age, tiredness **AO3.1a – analysis and interpretation of data from table** • TD increases linearly with speed or increases by 3m for each speed increase of 10 mph. • BD increases non-linearly with speed. The increase in BD gets greater for every 10 mph increase in speed. • TD doubles with speed. Example quoted. • BD quadruples with speed. Example quoted. • BD and TD both increase with speed. Example quoted. • BD increases more with speed than TD with example. • Stopping distance = TD + BD. Example quoted.

Question			Answer	Marks	AO element	Guidance
6	(a)	(i)	$^{4}_{2}He$ ✓	1	2.2	**ALLOW** Any unambiguous indication
		(ii)	4 ✓ 2 ✓	2	2.2	**ALLOW** Any unambiguous indication
	(b)		Half-life is the (average) time taken for half the radioactive nuclei in a sample to decay. ✓	1	1.1	**ALLOW** radioactive substance/material/element in a sample **ALLOW** Half-life is the (average) time taken for a (radioactive) element to reduce by half **ALLOW** half-life is the (average) time for the activity of a radioactive sample to halve.
	(c)	(i)	Decay is random ✓	1	2.2	**ALLOW** (Ling's sample is small while) expected graph is for large sample **ALLOW** Some nuclei take longer to decay than others **ALLOW** Decay is not constant / Could happen faster or slower **DO NOT ALLOW** outliers/anomalies/ inaccurate results/errors
		(ii)	**Any two from:** Minimise time of exposure/AW ✓ Wear device that tells you when you've been exposed for too long ✓ Store it in lead-lined box / use shielding ✓ wear lead/aluminium apron/clothing / wear gloves ✓ not to touch it (if solid) /use tongs / maximise distance / wash hands ✓ Do not point sources directly at people / keep samples as small as possible ✓	2	3.3a	**ALLOW** example of shielding e.g. lead screen **ALLOW** breathing apparatus/mask (if airborne) hazmat suit / radiation suit **IGNORE** goggles unless qualified **IGNORE** wear lead unless qualified

Question			Answer	Marks	AO element	Guidance
7	(a)		(kinetic) energy of products/particles/neutrons/nuclei **OR** idea that particles move (more) ✓ (emission of ionising) radiation / gamma (rays) ✓	2	1.1	**ALLOW** (as) kinetic (energy) / (as) thermal (energy) / (as) heat **IGNORE** neutrons emit energy **ALLOW** when new neutrons / nuclei are released / emitted **ALLOW** reference to conversion of mass to energy
	(b)		**Any two from:** More uranium nuclei divide/split ✓ Number of (emitted) neutrons increases ✓ More neutrons collide with nuclei / more nuclei hit by neutrons ✓ Number of fission reactions increases ✓ Fission reactions continue to occur ✓	2	1.1	**ALLOW** More/other neutrons emitted **IGNORE** one neutron collides with another and so on **ALLOW** over and over again /this carries on for nuclear reactions, not for collisions. **ALLOW** by example with 2, 3 etc e.g. 3 absorbed by 3 nuclei, which all release 3, (1 mark) giving 9 and so on (1 mark)

Question			Answer	Marks	AO element	Guidance
8	(a)	(i)	There is a source of potential difference / p.d. / voltage ✓ There is a complete circuit ✓	2	1.2	**ALLOW** (p.d./voltage from) battery/cell **IGNORE** power/energy **ALLOW** because there is an (electric) circuit **IGNORE** switch is closed
		(ii)	**First check the answer on answer line** **If answer = 240 C award 2 marks** Charge = 120 x 2 ✓ = 240 (C) ✓	2	2.1	 **ALLOW** 2A × 2 minutes
	(b)	(i)	Decreases ✓ Stays the same ✓	2	2.1	
		(ii)	(lamps dimmer because): p.d. across each lamp is reduced / shared between the two lamps / power of lamps is reduced ✓ Resistance of circuit increases with 2nd lamp ✓ (therefore) current through lamps decreases ✓	3	2.1	**IGNORE** power/energy is shared between lamps **ALLOW** less voltage for each **DO NOT ALLOW** current is decreased because split/shared between lamps
	(c)	(i)	Circuit diagram including two lamps in parallel and a source of pd ✓	1	1.2	**IGNORE** extra symbols **DO NOT ALLOW** Short circuits
		(ii)	Stays the same ✓	1	2.2	

Question			Answer	Marks	AO element	Guidance
9	(a)		7 ✓	1	2.2	
	(b)		1 ✓	1	2.2	
	(c)		**First check the answer on answer line.** **If answer = 2 m/s^2 award 2 marks** 6 – 0 / 3 – 0 ✓ = 2 (m/s^2) ✓	2	2.2	
	(d)		Steeper line drawn from (0,0) ✓ Max speed value over whole of 8s = 7 m/s. ✓	2	3.2b	Must be white space visible between 2 lines at 1s. After 1s any slope is acceptable, can be non-linear Must reach 7 m/s at some point. **ALLOW** less than one small square above 7 m/s **ALLOW** line that stops when it reaches 7m/s Example: Steeper line from start plateaus at 7 m/s

Question			Answer	Marks	AO element	Guidance
10	(a)		**First check the answer on answer line** **If answer = 250 m/s^2 award 2 marks** Acceleration = 25/0.1✓ = 250 (m/s^2) ✓	**2**	**2.1**	
	(b)		**First check the answer on answer line** **If answer = 150 000 N award 2 marks** Force = 1000 x150 ✓ = 150 000 (N) ✓	**2**	**2.1**	
	(c)		The crumple zone (must) increase the time (of impact) (compared to not having a crumple zone) ✓ So that less deceleration (due to *a* = change in speed / time) ✓ so less force on the driver/passengers/occupants (due to *F* = *ma*) ✓	**3**	**2.1**	**ALLOW** more time for deceleration / for force to act **ALLOW** decreases deceleration / acceleration **ALLOW** decreases force / force not as bad **IGNORE** idea that crumple zone absorbs force or is damaged instead of occupants **IGNORE** idea that crumple zone is a protective barrier **IGNORE** slows down the car **ALLOW** alternative 3 marks:: The crumple zone (must) increase the time (of impact) (compared to not having a crumple zone) So that rate of change of momentum is less

Question			Answer	Marks	AO element	Guidance
						So less force on the driver/passengers/occupants (due to *F* = change in momentum / time)

Question			Answer	Marks	AO element	Guidance
11	(a)		Amount of energy required to raise temperature of 1kg of substance by 1°C ✓	1	1.1	**ALLOW** Change in internal energy / (mass × (change in) temperature)
	(b)	(i)	(A Transfer from) the named energy store of a named object to the named energy store of a named object **OR** Appropriate transfer from the named energy store of a named object **OR** Appropriate transfer to the named energy store of a named object ✓	1	2.1	Named objects and energy stores and transfers: **ALLOW** Stores transferred from: any power station with appropriate energy store e.g. coal – chemical, wind turbine – kinetic, nuclear – nuclear. **ALLOW** Stores transferred from or to: wires/circuit/block/heater/surroundings/particles **ALLOW** transfer by heating/ thermal transfer **ALLOW** transfer by electrical working / electric current **ALLOW** battery for power supply **DO NOT ALLOW** electrical energy **or** electrical energy store
		(ii)	move faster / move more **OR** Vibrate (more) ✓	1	1.1	**ALLOW** speed up / move quicker **IGNORE** start to move / move around more / move freely / collide more

Question			Answer	Marks	AO element	Guidance
	(c)	(i)	Improvements to Equipment **Any two pairs from:** Fully insulate block ✓ Which reduces transfer of energy to surroundings and wires ✓ Add drops of oil / ensure a tight fit ✓ for better thermal conductivity between thermometer and block ✓ place metal block on heatproof mat /insulator ✓ to reduce thermal energy lost to table surface by conduction ✓ put a lid on the apparatus ✓ to reduce thermal energy lost to surroundings ✓ Use a stopwatch ✓ To measure the time accurately / to the second ✓	**4**	**3.3b**	**ALLOW** improvements to equipment written in answer to **cii** **ALLOW** maximum of 3 marks for identifying improvements, with minimum of 1 mark for an explanation of one of these 3 **ALLOW** so heat not lost/wasted **ALLOW** use other suitable alternative to table e.g. ground/ work bench **ALLOW** to prevent damage to table / or it would damage table **ALLOW** use a data logger ✓ to reduce random error ✓
		(ii)	**Any one from:** Repeat experiment and take average/mean **OR** to see if it was an outlier/anomaly ✓ Take more results ✓ use graphical method (plotting energy against temperature) to calculate results ✓ record highest temperature it reaches 5 minutes after switching off heater ✓ take thermometer reading at eye level ✓ increase the time (so smaller percentage uncertainty in larger time and temperature measurements) ✓	**1**	**3.3b**	**ALLOW** improvements to method written in answer to **ci**

Question			Answer	Marks	AO element	Guidance
	(d)		**First check the answer on answer line** **If answer = 1069.20 (J/kg ^{o}C) award 5 marks** *E* = *IVt* ✓ *E* = 4.62 x 10.80 x 300 ✓ = 14968.80 ✓ *C* = 14968.80 / (1 x 14) ✓ = 1069.20 (J/kg ^{o}C) ✓	**5**	**2.1**	**ALLOW** *P* = 4.62 x 10.80 / *P* = 49.896 / *P* = 49.9 **ALLOW** answers correctly rounded to 2 or more sf **ALLOW ECF** if *E* is incorrect: **ALLOW** 2 or more sf if correctly rounded **ALLOW** 18 or 32 for 'temperature' instead of 14 **ALLOW** 5 marks for 831.6 (J/kg ^{o}C) or 467.775 (J/kg ^{o}C) **ALLOW** 2 or more sf if correctly rounded

Question			Answer	Marks	AO element	Guidance
12	(a)		Line showing refraction away from the normal on leaving the prism ✓	1	1.2	Ray down by eye
	(b)		Angle of refraction between 15° and 35° inclusive ✓	1	2.2	
	(c)		Line showing less refraction than blue on entering the prism✓ Line showing less refraction than blue on leaving the prism✓	2	1.2	View by eye ray of red light refracted towards the normal but above blue light **ALLOW** the red light parallel to incident beam of white light entering the prism at a different point **IGNORE** any incident rays at the same point on the LHS of the prism View refracted ray leaving the prism by eye **IGNORE** unlabelled emerging rays from the point where the blue light in incident on the boundary of the right side of the prism

Question			Answer	Marks	AO element	Guidance
13	(a)		Increase stretch/extension of the spring ✓ **Either** (providing) more elastic potential energy ✓ (so) providing more KE ✓ **OR** Providing more force/tension/force is proportional to the extension/$F=kx$ ✓ Force is proportional to acceleration/Force = mass x acceleration/$F=ma$ ✓	3	3.3a	**ALLOW** pull the trolley back further (to the right) **ALLOW** potential energy for elastic potential energy **IGNORE** ref. to reducing friction and air resistance **IGNORE** ref. to changing the number of coils or mass of the aeroplane **ALLOW** the greater force the greater the acceleration (for the same mass of aeroplane)
	(b)	(i)*	Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. **Level 3 (5–6 marks)** Description of how to safely use apparatus to get results for force and extension **AND** Description of a graphical/tabular method to calculate the work done/energy stored in the spring or a correct calculation *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Description of how to safely use apparatus to get results for force and extension **OR**	6	1.2	**Demonstration of knowledge and understanding of how to safely get data for *F-x* for the spring** • Hang spring on a clamp stand with hook attached and with clamp to ensure apparatus is stable • Measure spring's length using a ruler • Weigh masses • Add one mass to hook • Measure new length of spring, making sure spring isn't moving • Calculate extension by subtracting new length minus original length • A precaution (e.g. safe distance or safety goggles) away from masses if they fall or in case the spring snaps

Question			Answer	Marks	AO element	Guidance
			Description of a graphical/tabular method to calculate the work done/energy stored in the spring or attempt at a correct calculation *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1–2 marks)** Limited description of how to safely use apparatus to get results for force and extension **OR** Limited description of a graphical/tabular method to calculate the work done/energy stored in the spring or simple attempt at a calculation *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit.*			• make sure you're at eye level when measuring length of spring • add a pointer to help measure length of spring • keep the extension small **Calculation of work done** • Plot graph of force against extension • draw a line of best fit • work done = total area under the graph or by counting squares • work done = ½ x 20 x 0.32 = 3.2J • energy stored = work done • energy stored in a stretched spring (J) = ½ × spring constant (N/m) × (extension (m))^2 = ½ x 62.5 x (0.32)^2 = 3.2J • shape is a triangle, so height x base / 2 gives work done • graph is straight line so can calculate work done in stretching the spring up to maximum force used by student • straight line graph, so limit of proportionality not exceeded

Question			Answer	Marks	AO element	Guidance
		(ii)	(Jamal's conclusion is wrong because): (10 x 0.16)/2 = ✓ 0.8(J) work done in stretching spring by 0.16m (not minimum of 1J required) ✓ **OR** Spring constant k = 62.5 (N/m) ✓ $E = ½ kx^2 = 0.5 \times 62.5 \times 0.16^2 = 0.8$(J) (not minimum of 1J required) ✓	**2**	**3.2b**	Answer of 0.8(J) gets 2 marks
	(c)		**Any three from:** Use a single light gate (at bottom of ramp) ✓ (Use a ruler to) measure the length of trolley/card (attached to top of model aeroplane) ✓ Timer/datalogger records time whilst blocked ✓ Speed calculated by length of trolley/card divided by time ✓ **OR** Method of measuring distance (between light gates/start and finish) ✓ Timer/datalogger/video/light gates records time (start and finish) ✓ Method of calculating speed at the bottom of ramp ✓	**3**	**2.2**	**DO NOT ALLOW** speed = distance / time marking point in isolation unless there is reference to how distance and time is calculated Speed at bottom calculated by 2 x distance divided by time

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