AQA

AS
PHYSICS
7407/1

Paper 1

Mark scheme

June 2024

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246A7407/1/MS

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

No student should be disadvantaged on the basis of their gender identity and/or how they refer to the gender identity of others in their exam responses.

A consistent use of 'they/them' as a singular and pronouns beyond 'she/her' or 'he/him' will be credited in exam responses in line with existing mark scheme criteria.

Further copies of this mark scheme are available from aqa.org.uk

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Physics - Mark scheme instructions to examiners

1. General

The mark scheme for each question shows:

- the marks available for each part of the question
- the total marks available for the question
- the typical answer or answers which are expected
- extra information to help the Examiner make his or her judgement and help to delineate what is acceptable or not worthy of credit or, in discursive answers, to give an overview of the area in which a mark or marks may be awarded.

The extra information is aligned to the appropriate answer in the left-hand part of the mark scheme and should only be applied to that item in the mark scheme.

At the beginning of a part of a question a reminder may be given, for example: where consequential marking needs to be considered in a calculation; or the answer may be on the diagram or at a different place on the script.

In general the right-hand side of the mark scheme is there to provide those extra details which confuse the main part of the mark scheme yet may be helpful in ensuring that marking is straightforward and consistent.

2. Emboldening

2.1 In a list of acceptable answers where more than one mark is available 'any **two** from' is used, with the number of marks emboldened. Each of the following bullet points is a potential mark.
2.2 A bold **and** is used to indicate that both parts of the answer are required to award the mark.
2.3 Alternative answers acceptable for a mark are indicated by the use of **or**. Different terms in the mark scheme are shown by a / ; eg allow smooth / free movement.

3. Marking points

3.1 Marking of lists

This applies to questions requiring a set number of responses, but for which candidates have provided extra responses. The general principle to be followed in such a situation is that 'right + wrong = wrong'.

Each error/contradiction negates each correct response. So, if the number of errors/contradictions equals or exceeds the number of marks available for the question, no marks can be awarded.

However, responses considered to be neutral (often prefaced by 'Ignore' in the mark scheme) are not penalised.

3.2 Marking procedure for calculations

Full marks can usually be given for a correct numerical answer without working shown unless the question states 'Show your working'. However, if a correct numerical answer can be evaluated from incorrect physics then working will be required. The mark scheme will indicate both this and the credit (if any) that can be allowed for the incorrect approach.

However, if the answer is incorrect, mark(s) can usually be gained by correct substitution/working and this is shown in the 'extra information' column or by each stage of a longer calculation.

A calculation must be followed through to answer in decimal form. An answer in surd form is never acceptable for the final (evaluation) mark in a calculation and will therefore generally be denied one mark.

3.3 Interpretation of 'it'

Answers using the word 'it' should be given credit only if it is clear that the 'it' refers to the correct subject.

3.4 Errors carried forward, consequential marking and arithmetic errors

Allowances for errors carried forward are likely to be restricted to calculation questions and should be shown by the abbreviation ECF or *conseq* in the marking scheme.

An arithmetic error should be penalised for one mark only unless otherwise amplified in the marking scheme. Arithmetic errors may arise from a slip in a calculation or from an incorrect transfer of a numerical value from data given in a question.

3.5 Phonetic spelling

The phonetic spelling of correct scientific terminology should be credited (eg fizix) **unless** there is a possible confusion (eg defraction/refraction) with another technical term.

3.6 Brackets

(…..) are used to indicate information which is not essential for the mark to be awarded but is included to help the examiner identify the sense of the answer required.

3.7 Ignore / Insufficient / Do <u>not</u> allow

'Ignore' or 'insufficient' is used when the information given is irrelevant to the question or not enough to gain the marking point. Any further correct amplification could gain the marking point.

'Do **not** allow' means that this is a wrong answer which, even if the correct answer is given, will still mean that the mark is not awarded.

3.8 Significant figure penalties

Answers to questions in the practical sections (7407/2 – Section A and 7408/3A) should display an appropriate number of significant figures. For non-practical sections, an A-level paper may contain up to 2 marks (1 mark for AS) that are contingent on the candidate quoting the **final** answer in a calculation to a specified number of significant figures (sf). This will generally be assessed to be the number of sf of the datum with the least number of sf from which the answer is determined. The mark scheme will give the range of sf that are acceptable but this will normally be the sf of the datum (or this sf −1).

An answer in surd form cannot gain the sf mark. An incorrect calculation **following some working** can gain the sf mark. For a question beginning with the command word 'Show that…', the answer should be quoted to **one more** sf than the sf quoted in the question eg 'Show that X is equal to about 2.1 cm' –

answer should be quoted to 3 sf. An answer to 1 sf will not normally be acceptable, unless the answer is an integer eg a number of objects. In non-practical sections, the need for a consideration will be indicated in the question by the use of 'Give your answer to an appropriate number of significant figures'.

3.9 Unit penalties

An A-level paper may contain up to 2 marks (1 mark for AS) that are contingent on the candidate quoting the correct unit for the answer to a calculation. The need for a unit to be quoted will be indicated in the question by the use of 'State an appropriate SI unit for your answer'. Unit answers will be expected to appear in the most commonly agreed form for the calculation concerned; strings of fundamental (base) units would not. For example, 1 tesla and 1 Wb m^{-2} would both be acceptable units for magnetic flux density but 1 kg m^2 s^{-2} A^{-1} would not.

3.10 Level of response marking instructions

Level of response mark schemes are broken down into three levels, each of which has a descriptor. The descriptor for the level shows the average performance for the level. There are two marks in each level.

Before you apply the mark scheme to a student's answer read through the answer and annotate it (as instructed) to show the qualities that are being looked for. You can then apply the mark scheme.

Determining a level

Start at the lowest level of the mark scheme and use it as a ladder to see whether the answer meets the descriptor for that level. The descriptor for the level indicates the different qualities that might be seen in the student's answer for that level. If it meets the lowest level then go to the next one and decide if it meets this level, and so on, until you have a match between the level descriptor and the answer. With practice and familiarity you will find that for better answers you will be able to quickly skip through the lower levels of the mark scheme.

When assigning a level you should look at the overall quality of the answer and not look to pick holes in small and specific parts of the answer where the student has not performed quite as well as the rest. If the answer covers different aspects of different levels of the mark scheme you should use a best fit approach for defining the level and then use the variability of the response to help decide the mark within the level; ie if the response is predominantly level 2 with a small amount of level 3 material it would be placed in level 2.

The exemplar materials used during standardisation will help you to determine the appropriate level. There will be an answer in the standardising materials which will correspond with each level of the mark scheme. This answer will have been awarded a mark by the Lead Examiner. You can compare the student's answer with the example to determine if it is the same standard, better or worse than the example. You can then use this to allocate a mark for the answer based on the Lead Examiner's mark on the example.

You may well need to read back through the answer as you apply the mark scheme to clarify points and assure yourself that the level and the mark are appropriate.

Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other valid points. Students do not have to cover all of the points mentioned in the indicative content to reach the highest level of the mark scheme.

An answer which contains nothing of relevance to the question must be awarded no marks.

Question	Answers	Additional Comments/Guidance	Mark	AO
01.1	MP1 To conserve charge **OR** To conserve lepton number✓ MP2 Idea of how charge is conserved: e.g. LHS = $0 + 17$ RHS = $18 + (-1)$ **AND** Idea of how lepton number is conserved: e.g. LHS = $1 + 0$ RHS = $0 + 1$ ✓	Must have some detail in support of both conservation explanation for 2 marks. For charge conservation condone description of RHS only: idea of (extra) proton on RHS having charge of $+1$(e) and an electron of -1(e) (ν_e + n $\rightarrow$ p +e) Charge conservation or lepton number can be seen in the equation. Treat as neutral mention of conservation of: • momentum • baryon number	2	AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
01.2	Max 1 from: ✓ • use of specific charge = $\frac{\text{charge}}{\text{mass}}$ by substitution • determines charge of argon nucleus = $18 \times 1.6 \times 10^{-19}$ • determines the mass of argon nucleus = $37 \times 1.67 \times 10^{-27}$ 4.6×10^{7} to 4.7×10^{7} ($C\ kg^{-1}$) ✓	Condone their charge and their mass in the use of (including POT error) Charge = 2.88×10^{-18} (C) Mass = 6.2×10^{-26} (kg) For the mass of the nucleus, allow for example: • $37 \times 1.66(1) \times 10^{-27}$ • $18 \times 1.673 \times 10^{-27} + 19 \times 1.675 \times 10^{-27}$	2	1 × AO1 1 × AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
01.3	MP1: Exchange particle: W^+ ✓ MP2: Effect on baryon: Proton changes to a neutron / charge decreases by (+)1(e) ✓ Max 2 from the following reasons: ✓✓ • it is the weak interaction. • this is electron capture. • quark changes flavour / up quark changes to a down quark / uud changes to dud • lepton changes flavour / electron changes to a neutrino • idea of charge conservation at a vertex	Do not allow W^+ meson or W. Condone idea of W^- being emitted by electron. Can see proton to neutron in diagram. Accept positive baryon changes to neutral baryon. Allow weak force or weak nuclear force. Where quark change is quoted must be correct. Can see up to down in diagram. Treat other conservations as neutral.	4	AO3

<table>
<tr><th>Question</th><th>Answers</th><th>Additional Comments/Guidance</th><th>Mark</th><th>AO</th></tr>
<tr><td>01.4</td><td>The mark scheme gives some guidance as to what statements are expected to be seen in a 1- or 2-mark (L1), 3- or 4-mark (L2) and 5- or 6-mark (L3) answer. Guidance provided in section 3.10 of the 'Mark Scheme Instructions' document should be used to assist marking this question.

<table>
<tr><th>Mark</th><th>Criteria</th></tr>
<tr><td>6</td><td>All three areas (as outlined alongside) covered with at least two aspects covered in some detail.
6 marks can be awarded even if there is an error and/or parts of one aspect missing.</td></tr>
<tr><td>5</td><td>A fair attempt to analyse all three areas. If there are several errors or missing parts then 5 marks should be awarded.</td></tr>
<tr><td>4</td><td>Two areas successfully discussed, or one discussed and two others covered partially. Whilst there will be gaps, there should only be an occasional error.</td></tr>
<tr><td>3</td><td>One area discussed and one discussed partially, or all three covered partially. There are likely to be several errors and omissions in the discussion.</td></tr>
<tr><td>2</td><td>Only one area discussed or makes a partial attempt at two areas.</td></tr>
<tr><td>1</td><td>One of the three areas covered without significant error.</td></tr>
<tr><td>0</td><td>No relevant analysis.</td></tr>
</table></td><td>The following statements are likely to be present.

Forces of repulsion and attraction that act between nucleons:
• (Repulsion =) Electromagnetic (between protons)
• (Attraction=) Gravitational force (between nucleons) or idea that gravitational is negligible
• (Both repulsive and attractive =) Strong interaction

Exchange particles associated with these forces:
• The pion is the strong interaction's exchange particle.
• Virtual photons for electromagnetic
• Treat mention of graviton for gravity as neutral

Role of these forces in keeping nucleus stable:
• Idea that strong interaction is greater in magnitude than any of the other interactions/ idea SI dominates.
• Strong interaction has short-range attraction acting on neighbouring nucleons (up to 3 to 4 fm).
• Strong interaction has very short-range repulsion at distances less than approximately 0.5 fm.
• Strong interaction acts between nucleons.

Further guidance:
Condone gluons as an alternative to pions.
Condone electrostatic force as an alternative to electromagnetic.</td><td>6</td><td>AO1</td></tr>
<tr><td>Total</td><td></td><td></td><td>14</td><td></td></tr>
</table>

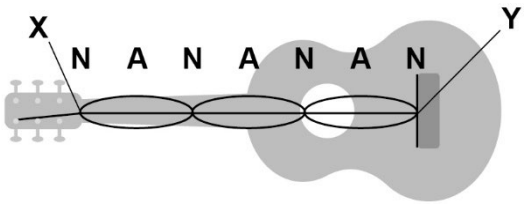
Question	Answers	Additional Comments/Guidance	Mark	AO
02.1	$(V =)$ 6.7 (V) ✓		1	AO1

Question	Answers	Additional Comments/Guidance	Mark	AO
02.2	Max 2 from ✓✓ • Converts 6.7 eV to $1.07(2) \times 10^{-18}$ (J) OR $(E =)$ 6.7 × 1.6 × 10^{-19} seen • Use of $E = \frac{hc}{\lambda}$ OR Use of $E = hf$ **and** $c = f\lambda$ • $\lambda = \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{their\ E}$ OR $\lambda = \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{6.7}$ $(\lambda =)$ 1.9×10^{-7} (m) ✓	**2nd bullet point, Use of:** by correct rearrangement to make λ Or substitution of all terms with maximum of one POT error. **3rd bullet point:** Allow their $E = 4.1875 \times 10^{19}$ without supporting working seen Using 6.7 as their E yields an answer = 2.97×10^{-26} (m) Calculator displays: $1.8554104480 \times 10^{-7}$ (m)	3	2 × AO1 1 × AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
02.3	Idea that a transfer of energy to atomic electron causes transition from ground state to **B**✓ Idea of atomic electron moves from **B** to **A** and (visible) photon is emitted✓ Reason for ground state to **B**, 1 from✓ • $18.4\ \text{eV}$ is equal to energy difference between the levels. • $-21.56 + 18.4(0) = -3.16$ seen • $21.56 - 3.16 = 18.4(0)$ seen. • $-3.16 - -21.56 = 18.4(0)$ seen • $21.56 - 18.4(0) = 3.16$ seen Reason for **B** to **A,** 1 from✓ • energy difference (between **B** and **A**) is $1.8\ \text{eV}$ and this is less than $6.7\ \text{eV}$ (and therefore will emit a longer wavelength photon) • other transitions (**B** to ground or **A** to ground) are too big, and wavelength is too small for visible light. • *calculates wavelength for 1.8 eV* $\lambda = (\frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{2.88 \times 10^{-19}}) = 6.9(1) \times 10^{-7}(m)$ and states this is in visible range✓	Accept an arrow drawn from ground state to **B**. Accept an arrow drawn from **B** to **A** and statement that this is the transition where visible photon is emitted or only arrow drawn for relaxation. Reason for **B** to ground: Do not credit use of 18.4 eV: • leads to 67.5 nm (not visible) • more energy than 6.7 eV (uv) *Where no other mark is scored* *Max 1 compensation mark for:* Atom in its ground state absorbs energy and electron moves up energy level. OR Atom de-excites and electron moves down energy level an emits a photon✓	4	2 × AO2 2 × AO3
Total			**8**	

Question	Answers	Additional Comments/Guidance	Mark	AO
03.1	$\lambda = 2 \times 0.648$ **OR** Use of $v = f\lambda$ ✓ $(v =)$ 191 (m s^{-1}) ✓	Allow 1296 (mm) or 1.296 (m) or 129.6 (cm) seen. Condone **one error** in their substitution where λ and f have been substituted and v would be the subject: Allow $(v=)$ 0.648 x 147 (forgets to double L) OR $(v=)$ $\frac{0.648}{2}$ x 147 (halves L) Do not allow: $(v=)$ 648 x 147 (POT error **and** forgets to double L) NOR $(v=)$ $\frac{648}{2}$ x 147 (POT error **and** halves L) Calculator display= 190.512 190 (ms^{-1}) correct to 2 sf	2	1 × AO1 1 × AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
03.2	Use of $f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$ OR Use of v = $\sqrt{\frac{T}{\mu}}$ OR (μ =) 1.956×10^{-3} (kg m^{-1})✓ Use of m = their μ × *their* l✓ (m =) 1.3×10^{-3} (kg) ✓	Condone **one error** where f, l and T have been substituted. OR μ would be subject of a correctly rearranged expression (μ=) $\frac{T}{4l^2f^2}$ Their l: must be seen in **MP1**: **or** condone a POT error (if already penalised in **MP1** or 03.1) allow ecf from **03.1** where v = $\sqrt{\frac{T}{\mu}}$ seen **MP1** μ= $\frac{T}{v^2}$ or μ= $\frac{71}{(answer\ to\ 03.1)^2}$ **MP2** *(m=) their ecf* $\mu \times 0.648$ **MP3 ecf answer** Calculator display= $1.267618831 \times 10^{-3}$ (kg)	3	1 × AO1 2 × AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
03.3	At least one NAN envelope with its nodes N and antinodes A labelled. **OR** The positions of all nodes N and all antinodes A labelled✓ 3 (NAN) envelopes drawn✓ All 3 envelopes drawn same dimensions and all nodes N and antinodes A labelled correctly ✓	 Must not have any obvious differences in height and width by eye. **MP3:** Do not allow unequal width **and** unequal height. Penalise **A** labelled twice at one antinode in **MP3.**	3	1 × AO1 1 × AO2 1 × AO3

Question	Answers	Additional Comments/Guidance	Mark	AO
03.4	**MP1** Node at the midpoint **MP2** Idea that stationary wave can only exist if one of its nodes coincides with midpoint. **OR** Idea odd harmonic(s) require(s) an antinode to exist at this point and therefore cannot exist. **OR** Idea that the frequency f_2 ~~/~~ $(\sim)300$ Hz can exist (when string is touched lightly at midpoint) **OR** Idea that the frequency f_4 ~~/~~ $(\sim)600$ Hz can exist (when string is touched lightly at midpoint) (about 600 Hz)✓	**ECF** from **03.3** where third harmonic drawn with node at midpoint. **MP1** node at midpoint (ecf) **MP2** idea that one of the even harmonics, would have an antinode here and can't exist (ecf) **OR** idea that one of the odd harmonics can exist, would have a node here (ecf) **MP3** f_1, f_3 and f_5 all exist. (ecf) Alternative **MP2** Determines longest wavelength that can form stationary wave between **X** and **Z** (or equivalent) to arrive at 294 Hz (allow ecf from speed **03.1**) OR Determines next longest that can form stationary wave between **X** and **Z** (or equivalent) to arrive at 588 Hz (allow ecf from speed **03.1**)✓	3	AO3

	MP3 f_2 and f_4 are both present. **OR** 2nd and 4th (harmonics) are both present. **OR** The harmonics in **Fig 4** have double the frequency✓	Alternative **MP3** both frequencies calculated. (allow ecf from speed 03.1) ✓ Treat any reference to change in amplitude as neutral. Compensatory mark max one: Condone a discussion in terms of two strings (or one-half vibrating) e.g. even harmonics are present.		
Total			**11**	

Question	Answers	Additional Comments/Guidance	Mark	AO
04.1	Use of appropriate equation(s) of motion ✓ (s =) 112 m ✓	For example: expect to see use of: • $v^2 = u^2 + 2as$ use of is: rearrangement to make s subject. $s = \frac{u^2}{2a}$ *or* $s = \frac{v^2 - u^2}{2a}$ OR substitution condone **one error** in substitution. • $v = u + at$ **and** s = $\frac{u+v}{2}\ t$ condone one error in substitution. Calculator display = $111.60714285\dot{}$ 110 (m) correct to 2 sf	2	1 × AO1 1 × AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
04.2	Use of $W = mg$ to determine mass **OR** Use of $F = ma$ ✓ $(P_H =)$ 380 (N) ✓	$m = 254.8$ (kg) with their mass: allow use of m=2500 in F=ma allow use of $g = 9.8$ N kg^{-1} (2 sf) $g = 9.8$ calculator display: 382.653061224489 $g = 9.81$ calculator display: 382.2629969	2	1 × AO1 1 × AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
04.3	Attempts to use Pythagoras's theorem. **OR** Attempts to use $\sin\theta = \frac{P_V}{P_{Res}}$ **and** $P_H = P_{Res}\cos\theta$✓ $P_H = 500$ N **OR** A correct read-off of their v from **Figure 9** for their P_H ✓ $(v_1 =)$ 10 (m s^{-1}) ✓	Condone **one error** in attempt to use either Pythagoras's theorem or trigonometric ratios: Substitution or rearrangement P_H would be subject. Allow $P_H = 90\sqrt{31}$ Read-off within $\pm\frac{1}{2}$ *smallest division* of their accurate read-off. Must see working to support answer from **MP1** or **MP2** to score **all 3 marks**. Answer in range without **MP1** or **MP2** obtains **MP3** only. Answer in range 9.75 to 10.25 (ms^{-1}) Condone 10.3 (ms^{-1}) to 3 sf	3	2 × AO2 1 × AO3

Question	Answers	Additional Comments/Guidance	Mark	AO
04.4	P_H's line of action passes through the centre of the wheel. **OR** the perpendicular distance between P_H's line of action and the centre of the wheel is zero. **OR** $m = Fd$ and d is zero✓	Condone: Idea that P_H acts through the centre of the trailer's wheel. **Or** The perpendicular distance is zero. Do not accept: The distance between the centre of the wheel and P_H is zero. P_H acts parallel to the centre of the wheel is insufficient.	1	AO1.1b

Question	Answers	Additional Comments/Guidance	Mark	AO
04.5	Max 2 from: ✓✓ • Attempts to use principle of moments about the centre of the trailer's wheel. • $D = 2100$ (N) • Read-off from graph of v_2 for their value of D. **MP3:** (Read-off from graph, $v_2 =$) 20.5 (m s^{-1}) ✓	Condone **one error** in attempt to use: $D \times 0.95 = 2500 \times 0.8$ Read-off within $\pm\frac{1}{2}$ *smallest division* of their accurate read-off. Allow a read-off for a force including P_H as D may equal P_H v_2 must be greater than zero. Must see working that includes a correct principle of moments equation to score MP3. Answer in range 20 to 21 m s^{-1}	3	1 × AO1 1 × AO2 1 × AO3

Question	Answers	Additional Comments/Guidance	Mark	AO
04.6	As v increases: more air particles are given momentum (each second). **OR** each air particle given more momentum. **OR** Idea that more air is displaced (each second) **OR** Idea that the displaced air has a greater velocity. **OR** More air particles change direction (per second) **OR** There are more collisions with the air (particles each second)✓ Idea of a **greater** rate of change of momentum of air requires a **greater** force on air (relates to Newton's 2nd law) ✓ (Greater) force on air by trailer means (greater) force on trailer by air (relates to Newton's 3rd law.) ✓	Compensatory mark, Max 1: there is a greater force on the air (as v increases) To achieve 3 marks, must link: **MP2** to Newton's 2nd law or its formula **OR** **MP3** to Newton's 3rd law	3	AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
04.7	Max 2 from✓✓ • Use of $P = Fv$ • Subtracts D from their thrust. • Subtracts their rate of work done by D on trailer from $95\ \text{kW}$. (Air resistance on car =) $700\ \text{N}$ ✓	Condone **one error** in use of $P=Fv$ Where: P and v or F and v have been substituted. Expect to see: • $95 \times 10^3 = F \times 25$ • $(F =) 3800\ (\text{N})$ • $(P =) 3100 \times 25$ • $(3100 \times 25 =) 77500$ $3800 - D$ **OR** $3800 - 3100$ $95 \times 10^3 - 77500$ **OR** 17500 **OR** 95×10^3 – their rate of work done by D	3	1 × AO1 2 × AO2
Total			**17**	

Question	Answers	Additional Comments/Guidance	Mark	AO
05.1	Straight-line graph through the origin and passing through (0.5 A, 0.375 V) ✓	Line must: • be drawn with a ruler. • be close to (0.5 A, 0.375). Do not allow vertical **and** horizontal inaccuracy. • pass within their line's width of origin.	1	AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
05.2	correct read-off of resistance for $I = 1.9$ A **OR** Use of $P = I^2R$ for their R **OR** Use of $V=IR$ **and** $P= VI$ for their R OR Use of $V=IR$ **and** $P=\frac{V^2}{R}$ for their R ✓ (power =) 13(.0) (W) ✓	Allow R in range 3.5 to 3.7 Ω Accept answers in range 12.6 to 13.4 Allow 1 mark for 13.7(18) (W) or 14 (W) on answer line without supporting work.	2	1 × AO1 1 × AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
05.3	Use of $V_T = V_1 + V_2$ **OR** Use of $V = IR$ for their V✓ $(R =)\ 3.8\ \Omega$ ✓ **Alternative method:** Use of $R = \frac{V}{I}$ **OR** Use of $R_T = R_1 + R_2$ for their R_{lamp} **or** their R_T ✓ $(R =)\ 3.8\ \Omega$ ✓ **Alternative method**: Reads off $R_{lamp} = 2.2\ \Omega$ **OR** Use of $R = \frac{V}{I}$ **OR** Use of $R_T = R_1 + R_2$ for their R_{lamp} **or** their R_T ✓ $(R =)\ 3.8\ \Omega$ ✓	$(V =)\ 9 - 3.3$ or $(V =)\ 5.7$ (V) Expect to see $(R_{lamp} =) \frac{3.3}{1.5}$ OR $(R_{lamp} =) 2.2\ (\Omega)$ And $(R_T =) \frac{9}{1.5}$ OR $(R_T =) 6\ (\Omega)$ Allow R in range 2.1 to 2.2 Ω Expect to see $R = \frac{9}{1.5}$ OR $R = 6\ (\Omega)$ Range of R where read-off used for R_{lamp} is 3.8 to 3.9 Ω.	2	1 × AO1 1 × AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
05.4	**R**'s value must decrease ✓ • More current (in bulbs parallel section) ✓ • Idea this requires a lower resistance for **R** to maintain same pd across **R** (therefore same pd across bulbs). ✓ **OR** • Total resistance (of $\mathbf{L_1}$ & $\mathbf{L_2}$) is lower ✓ • Idea that the ratio of pd division For example: $V_R : V_L$ is same for **R** and $\mathbf{L_1}$ & $\mathbf{L_2}$ combination as for **R** and $\mathbf{L_1}$. ✓	Allow any value quoted for decrease. Condone Max 2 for use of a calculation. Be wary of 'the resistance is decreasing', needs a definite statement that this relates to **R** to score **MP1**.	3	2 × AO2 1 × AO3
Total			**8**	

Question	Answers	Additional Comments/Guidance	Mark	AO
06.1	between $s = 7.5$ m and $s = 15$ m ✓	Tick in 2nd box only	1	AO3

Question	Answers	Additional Comments/Guidance	Mark	AO
06.2	Use of $\Delta E_P = mgh$ ✓ $(m =)65(.0)$ (kg) ✓	Use of: rearrangement where m would be subject or substitution. Condone **one error** in substitution. Calculator display = For g = 9.81 ms^{-2} = 64.96772001 For g = 9.8 ms^{-2} = 65.0340136054421 Alternative method for an ECF from **06.1** (tick in 3rd or 4th boxes). • Use of $E_k = \frac{1}{2}mv^2$ **OR** Read-off for $v = 15.4$ ms^{-1} (Acceptable range 15.2 ms^{-1} to 15.6 ms^{-1}) • $m = 80.6$ (kg) (Acceptable range 78.57 kg to 82.76 kg)	2	1 × AO1 1 × AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
06.3	Max 2 from: ✓✓ • Energy difference (E) = 9.56 – 7.71 = 1.85 (kJ) ✓ • Use of $E = \frac{1}{2}k\Delta L^2$ • $\Delta L = \sqrt{\frac{2 \times their\ energy\ difference}{k}}$ ΔL = 5.8(0) m ✓	Accept correct energy conservation statement for **MP1** For example: $\Delta E_P = E_K + energy\ stored\ (in\ rope)$ Use of: Rearrangement to make ΔL the subject or by substitution. Condone use of their E and **one other error** in substitution. (allow 9.56 (kJ) or 7.71(kJ) for E) Condone use of $E = \frac{1}{2}F\Delta L$ **and** $F = k\Delta L$ **OR** $E = \frac{1}{2}F\Delta L$ **and** $F=mg$ With their F and their E seen in $E = \frac{1}{2}F\Delta L$ Must be an energy difference. Condone POT Do not accept 9.56 (kJ) or 7.71(kJ) for their energy difference. Max 1 mark for: 637.65 = 110 × ΔL giving ΔL = 5.8 m must be done by considering energy transfers. **OR** answer without working.	3	1 × AO1 2 × AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
06.4	(Tension =) 640 (N) ✓ Reason: Idea that the resultant force / acceleration is upwards (in opposite direction to motion) for tension greater than this value. **OR** Idea that the resultant force / acceleration is downwards (in same direction as motion) for tension less than this value **OR** Resultant force / acceleration is zero (when kinetic energy is at its maximum.) **OR** Tension is directly proportional to the extension / (rope obeys) Hooke's law. ✓	Potential ECF from: • m in **06.2** where use $T=mg$ • ΔL in **06.3** (typical ecf answer =1300 (N) where use $T=k\Delta L$ For two marks: Reason must be consistent with any working seen. Insufficient to state that tension = weight at maximum kinetic energy. Apply list rules to the reason. If use $F=k\,\Delta L$ without further support in their reason can score max 1 mark. e.g. Each term to be defined	2	1 × AO2 1 × AO3

Question	Answers	Additional Comments/Guidance	Mark	AO
06.5	Use of $k = \frac{EA}{L}$ to show k is same for both ropes ✓	Accept 1.2 $E = \frac{k \times 1.2\,L}{A}$ $\Rightarrow$ ~~1.2~~ $E = \frac{k \times \text{~~1.2~~}\,L}{A} \Rightarrow E = \frac{k \times L}{A}$ Or equivalent Allow use of $k = 110\ \text{Nm}^{-1}$ in working.	1	AO1

Question	Answers	Additional Comments/Guidance	Mark	AO
06.6	Yes: MAX 2 from: ✓✓ • (Second) rope's (unstretched) length is greater. • Has a greater velocity before rope begins to stretch (for second rope). • Extension of each rope is same (when tension = weight.) • Work done in stretching rope is same (in travelling to max velocity) / energy stored in rope is same • Total distance fallen to reach max velocity is greater (for second rope) • Total distance fallen (to max velocity) = unstretched length + same extension • Idea of longer time in free-fall Correct use of principle of conservation of energy **or** correct use of Newton's 2nd law ✓	Must have correct deduction for 3 marks. **Conservation of energy:** Gains more kinetic energy before work done by tension becomes greater than work done by gravity. **Newton's 2nd law:** Gains more velocity before acceleration's direction becomes opposite to motion's direction.	3	3 × AO3
Total			**12**	