A-level PHYSICS 7408/1

Paper 1

Mark scheme

June 2025

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256A7408/1/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

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	Diagram with: Up becoming down $_1$✓ Electron becoming (electron) neutrino $_2$✓ W connecting the two, with a boson charge consistent with their diagram $_3$✓	Accept uud changes to udd. Do not accept capital D for d. Accept e or e^- for electron but reject β^-. Condone ve for ν_e (ie same size e on same line) Accept v (roman) for ν (greek). Boson charge must be consistent bottom left to top right AND bottom right to top left. Do not accept a change in boson arrow direction in $_3$✓.	3	AO2

Question	Answers	Additional comments/Guidance	Mark	AO
01.2	In order for the nucleus to decay it needs (orbiting) electrons because it (only) decays by electron capture ✓	Treat irrelevant right or wrong comments as neutral. Accept reverse argument. Condone suggestion that probability of electron capture is decreased. Mention of 'ionisation' is neutral.	1	AO3

Question	Answers	Additional comments/Guidance	Mark	AO
01.3	Evidence of $22 \times 1.6 \times 10^{-19}$ or 3.52×10^{-18} (to determine charge) OR $\frac{\text{their charge}}{4.8\times10^{7}}$ (to determine mass) $_1$✓ Evidence of calculation leading to 22 neutrons, e.g.number of neutrons = their nucleon number $(44) - 22 = 22$ (neutrons) $_2$✓	Expect to see mass = $\frac{22\times1.6\times10^{-19}}{4.8\times10^{7}} = 7.3\times10^{-26}$ (kg) number of nucleons = $\frac{7.3\times10^{-26}}{1.67\times10^{-27}} = 44$ Accept alternatives for the nucleon mass Accept for $_1$✓ the idea that specific charge is $0.5 \times$ specific charge of proton Do not accept '22' without some evidence. Evidence to support $_2$✓ can be seen earlier in the calculation e.g. subtraction of masses.	2	1 × AO2 1 × AO3
Total			**6**	

Question	Answers	Additional comments/Guidance	Mark	AO
02.1	Idea that the oscillations (of particles in the wave) are at right angles $_1$✓ to the direction of energy transfer $_2$✓	Allow 'oscillates' for 'oscillations'. Do not accept 'vibrations'. Allow 'displacement' for 'oscillations' Credit a correctly labelled diagram Do not allow a contradiction in $_1$✓ $_2$✓ is contingent on $_1$✓. Do not allow direction of (wave) motion/travel Treat any reference to polarisation as neutral. If no other mark given: award **max 1** when answer suggests that <u>amplitude</u> is perpendicular to the direction of energy transfer.	2	AO1

Question	Answers	Additional comments/Guidance	Mark	AO
02.2	Idea that waves (from vibration generator and reflected wave) travel in opposite directions (along the wire) and superpose ✓	If a reflected wave is referred to, the presence of an incident wave can be assumed. Do not accept 'interfere' for 'superpose' Do not accept reference to 'phase (difference)'unless correct, ie a valid comment would be 'phase difference is time dependent'.	1	AO1

Question	Answers	Additional comments/Guidance	Mark	AO
02.3	Idea that particles in wave between $\mathbf{P_1}$ and $\mathbf{P_3}$ are in phase OR between $\mathbf{P_3}$ and $\mathbf{P_5}$ are in phase $_1$✓ Idea that particles between $\mathbf{P_1}$ and $\mathbf{P_3}$ are in antiphase with particles between $\mathbf{P_3}$ and $\mathbf{P_5}$ OR idea that $\mathbf{P_2}$ and $\mathbf{P_4}$ are in antiphase $_2$✓	If no other mark given: award **max 1** for 'P1 and P3 and P5 are nodes' **and** 'P2 and P4 are antinodes' provided that there is no reference to a phase relationship between the nodes. Reject: 'completely out of phase' or 'out of phase' for antiphase; allow 'π out of phase' or '180 degrees out of phase'.	2	AO2

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidance</th><th>Mark</th><th>AO</th></tr>
<tr>
<td>02.4</td>
<td>Determines mass per unit length for either wire and answer seen on answer line $_1$✓

Determines frequency of first harmonic f_1 for one wire and value of W $_2$✓

Evidence of use of $5f_1$ to determine the frequency range
OR
evidence of required frequency ≤ 10 Hz $_3$✓

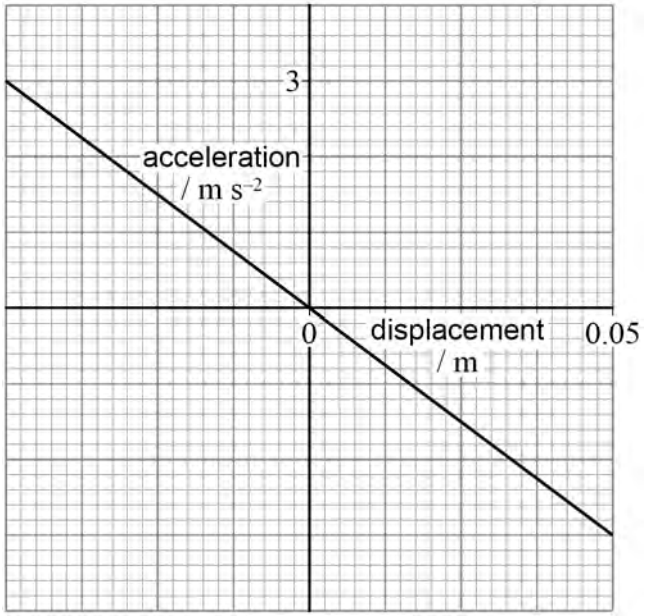
Comparison between the fifth-harmonic (frequency) and 50 Hz. $_4$✓

Wire B and $W = 1.0$ N $_5$✓</td>
<td>A $\mu = 6.60 \times 10^{-4}$ kg m^{-1}
B $\mu = 1.47 \times 10^{-3}$ kg m^{-1}
Allow incorrect values of mass per unit length to be carried forward from $_1$✓ to the rest of the answer except $_5$✓.
Expect to see values from:
<table>
<tr><th>W / N</th><th>A f_1 / Hz</th><th>A $5f_1$/Hz</th><th>B f_1 / Hz</th><th>B $5f_1$ / Hz</th></tr>
<tr><td>1.0</td><td>13.0</td><td>65.0</td><td>8.7</td><td>43.5</td></tr>
<tr><td>5.0</td><td>29.0</td><td>145</td><td>19.4</td><td>97.0</td></tr>
</table>
For $_4$✓, look for some idea that their selected fifth-harmonic frequency is the greatest that does not exceed 50 Hz or that first-harmonic is greatest that does not exceed 10 Hz.
Allow reference to ‘range’ for values of frequency.
$_4$✓ does not require a value for the fifth harmonic.

B can be identified by its mass or mass per unit length.
MP5 is a standalone mark and can be awarded without further evidence.</td>
<td>5</td>
<td>1 × AO1
4 × AO3</td>
</tr>
</table>

	Alternative $_2$✓ , $_3$✓ and $_4$✓ $_2$✓ Calculates a wavelength (or half wavelength) for 50 Hz and any one combination of wire and weight. $_3$✓ Evidence of maximum wavelength (or half wavelength) of fifth harmonic is 1.5/(5/2) or 0.6m (or 1.5/2 or 0.3 m). $_4$✓ compares between their combination wavelength and their fifth harmonic maximum wavelength.	For alternative $_2$✓ expect to see one from: **W / N** | **A** wavelength / **m** | **B** ***wavelength / m*** **1.0** | 0.78 | 0.52 **5.0** | 1.74 | 1.17 If alternative methods are used: $_2$✓ is for using the frequency formula, $_3$✓ is for a calculation that allows the comparison; $_4$✓ is for the comparison.		

Total			**10**

Question	Answers	Additional comments/Guidance	Mark	AO
03.1	Evidence of $\omega = \frac{2\pi}{T}$ OR $0.05\ \text{m}$ seen OR $A = \frac{V}{\text{their } \omega}$ $_1$✓ Use of $a = -\omega^2 x$ OR $3.0\ \text{m s}^{-2}$ seen $_2$✓ Straight line through origin with negative gradient featuring all four quadrants $_3$✓ Single straight line ends at (0.05,-3.0) OR Single straight line ends at (0.05, 3.0) $_4$✓	Expect to see:  Condone axes either way round Award **4** for correct graph with correct values Evidence for $_1$✓ and $_2$✓ can be seen on the graph. In $_3$✓ (0,0) must be in centre of line. $_4$✓there is no ecf from $_1$✓ or $_2$✓.	4	2 × AO1 2 × AO2

Question	Answers	Additional comments/Guidance	Mark	AO
03.2	**P** at $\frac{\text{their max displacement}}{\sqrt{2}}$ (judge by eye)	Accept on either quadrant Expect to see 3.54 x 10^{-2} m **AND** 2.1 m s^{-2}	1	AO1
Total			**5**	

Question	Answers	Additional comments/Guidance	Mark	AO
04.1	Idea that YM = $\frac{\text{(tensile) stress}}{\text{(tensile) strain}}$ and (tensile) strain has no units ✓		1	AO1

Question	Answers	Additional comments/Guidance	Mark	AO
04.2	Evidence of determination of volume of one wire $_1$✓ Uses relationship between density of **X** OR the density of the wire used in MP1 and their volume to determine their mass $_2$✓ Answer between £4800 and £4900 $_3$✓	When X is used in MP1, condone the use of diameter for radius of X. Expect $V = 3.3 \times 10^{-6}\ \text{m}^3$ Condone PoT error Expect $M = 64\ \text{g}$ or $65\ \text{g}$ Condone PoT error 75×64 or 75×65	3	AO3

Question	Answers	Additional comments/Guidance	Mark	AO
04.3	**W** and **Z**, as their densities are the same (and density is the only one that is a property of the material) ✓	Allow suggestion that the Young modulus is the same provided there is evidence of its determination for both.	1	AO1

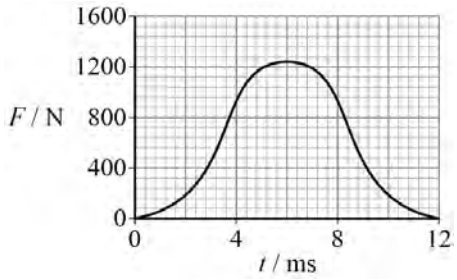
Question	Answers	Additional comments/Guidance	Mark	AO
04.4	Draws best-fit line $_1$✓ Uses pair of values of stress and strain from point on line more than halfway along the line OR uses a difference in two pairs that is more than half the line $_2$✓ Evidence of attempt to use equation(s) to determine E, k, l, A or d from graph OR for **W** (for use in a comparison)**.** $_3$✓ Compares E for **W** with value from **Figure 5** OR compares k, l, A or d for **Figure 5** with value for **W** With answer yes $_4$✓	For $_1$✓ look for an equal scatter of points either side of the line. Allow half square tolerance on graph read-offs. Condone PoT error Copy of W data from table 1 Wire: W; Length / m: 3.10; Diameter / mm: 1.7; Stiffness / N m^{-1}: 4.90×10^4; Density / kg m^{-3}: 2.71×10^3 eg cross-sectional area of **W** = 2.27×10^{-6} m^2 Condone PoT error $E = 6.8 \times 10^{10}$ (N m^{-2}) Accept answers that round in the range 6.7×10^{10} to 6.9×10^{10} for E from graph.	4	AO3
Total			**9**	

Question	Answers	Additional comments/Guidance	Mark	AO
05.1	$V_T = 3.46$ (V) ✓	$E = V + Ir$ $3.66 - (6.77 \times 0.0300) = 3.46$ Do not accept rounding errors. Calculator value = 3.4569 Accept 3.5	1	AO1

Question	Answers	Additional comments/Guidance	Mark	AO
05.2	Resistance of cells in series $= 5 \times 0.0300\ \Omega = 0.150\ \Omega$ OR In parallel: *their series resistance* $\div 4$ ($= 0.0375\ \Omega$) $_1$✓ $r = 0.0375\ (\Omega)$ $_2$✓	Condone method that uses 5 sets of 4 parallel cells in series. Condone POT error in MP1 Accept 0.038	2	1 × AO1 1 × AO2

Question	Answers	Additional comments/Guidance	Mark	AO
05.3	emf per module = $352 \div 16 = 22.0$ V $_1$✓ Number of cells in one row = their emf per module $\div 3.66$ OR Number of rows in parallel = $500 \div 6.77$ (= 73.9) = 74 $_2$✓ Number of cells = 444 ✓	Expect to see: Number of cells in one row = 6 **MAX 2** if answer not a whole number If no other mark given: award **max 1** for 96 cells (divided by 16) to give 6 per module	3	AO3
Total			**6**	

Question	Answers	Additional comments/Guidance	Mark	AO
06.1	Max 1 from: Calculation of Δv Calculation of E_k using their Δv 1✓ 52(.3) J 2✓	For 1✓ expect to see $Ft = m\Delta v$ and $u = 0$ $v = \frac{6.55}{0.410} = 15.9756 \text{ m s}^{-1}$ Condone POT error in 1✓ $E_k = \frac{1}{2}pv = \frac{1}{2} \times 6.55 \times 15.9756$ $= 52.320$ (J) Do not allow rounding error. If no other mark given, award **max 1** for a combination of ke and momentum equations seen in numbers or symbols $Ek = \frac{1}{2}\frac{(mv)^2}{m}$	2	1 × AO1 1 × AO2

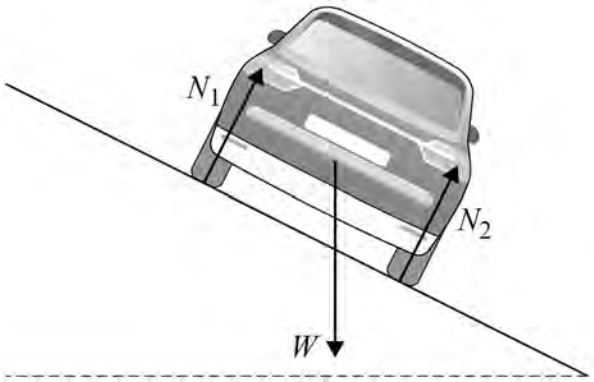
Question	Answers	Additional comments/Guidance	Mark	AO
06.2	Area under graph = 8.5 large squares OR 212 small squares $_1$✓ uses area of graph = impulse $_2$✓ judges that the interval is 400 N AND annotates *y*-axis with 400 N intervals $_3$✓	Allow 8 to 9 or (small □) 200 to 225 Accept attempt to calculate area using y-axis interval as unknown quantity Area = 6.55 N s on its own is insufficent for $_2$✓ Allow evaluation of impulse ÷ their number of squares One square = $F \times 2 \times 10^{-3}$ = $\frac{6.55}{\text{their number of squares}}$ And F = their area of one square ÷ 2×10^{-3} s  $_3$✓: minimum 3, non-zero, major grid lines labelled	3	1 × AO2 2 × AO3

Question	Answers	Additional comments/Guidance	Mark	AO
06.3	Any **two** from: $_1$✓$_2$✓ • resolve $18\ \text{m s}^{-1}$ vertically (to obtain u) • use of SUVAT with their u eg s = (their u)$\times t + \frac{1}{2}at^2$ • evidence of consistent sign for s, u and a $t = 2.87$ (s) $_3$✓	$18\sin 48$ seen or inferred from use of $(-)13.37(7)$ use of $v = u + at$ with $v = 0$ and $s = ut + \frac{1}{2}at^2$ with $u = 0$ $-2.0 = (18\sin 48)t + \frac{1}{2}(-9.8)t^2$ OR $2.0 = (-18\sin 48)t + \frac{1}{2}(9.8)t^2$ Do not award MP3 if negative solution quoted. Allow 2.86 or 2.9 Allow any correct alternative route	3	1 × AO1 2 × AO2
Total			**8**	

Question	Answers	Additional comments/Guidance	Mark	AO
07.1	$E_k = \frac{1}{2}mv^2$ AND $F = \frac{mv^2}{R}$ ✓ Combines two equations correctly ✓ (To give $R = \frac{2E_k}{F}$)	In MP1 do not condone use of *r* for R unless explicitly equated. E.g.r =R Do not allow use of *r* for R in MP2. In MP2 allow r becoming R without explanation. Eg for MP2: $F = \frac{m2E_k}{mR}$ (need to see m or ~~m~~) OR $mv^2 = FR = 2E_k$	2	AO2

Question	Answers	Additional comments/Guidance	Mark	AO
07.2	v = 58.7 (m s^{-1}) ✓	Calculator value: 58.73670062 Accept 59 Do not accept rounding error.	1	AO2

Question	Answers	Additional comments/Guidance	Mark	AO
07.3	Idea that the radius of the path of the car can be increased OR Idea that friction between tyres and track can be increased ✓	eg Start at the outside of the track and drive to the inside of the curve Condone 'reduce mass of car' Treat banking answer as neutral.	1	AO3

Question	Answers	Additional comments/Guidance	Mark	AO
07.4	 W ✓ N_1 and N_2 ✓	W must be straight and vertically downwards with a line of action that passess approximately through the centre of mass Normal reaction forces with lines of action through tyres at right angles to slope Condone any symbols for W, N_1 and N_2 Award **max 1** if centripetal force appears. Treat components as neutral	2	1 × AO1 1 × AO2

Question	Answers	Additional comments/Guidance	Mark	AO
07.5	(with the slope) there is a (horizontal) component of the normal reaction force that increases the (maximum) centripetal force ✓ Idea that v can be greater (for same R) when centripetal force greater ✓		2	AO3
Total			**8**	

Question	Answers	Additional comments/Guidance	Mark	AO
08.1	$QV = \frac{1}{2}mv^2$ OR $v = \sqrt{\frac{2QV}{m}}$ ✓ To get answer that rounds to 6.8×10^6 (m s^{-1}) ✓		2	AO2

Question	Answers	Additional comments/Guidance	Mark	AO
08.2	Idea that the (average) KE of (current) electrons is reduced through inelastic collisions (with mercury atoms) ✓	Condone 'electrons transfer (kinetic) energy to mercury/gas atoms' Allow particles for atoms	1	AO1

Question	Answers	Additional comments/Guidance	Mark	AO
08.3	Yes AND idea that the graph shows that substance **X** released (most) photons in the UV part of the spectrum ✓ Idea that UV radiation excites (atoms in) the coating to give longer wavelength radiation (when atoms de-excite)✓	Accept appropriate synonym for 'radiation' Accept for 'coating': phosphor/lining/fluorescent material	2	1 × AO3 1 × AO1

Question	Answers	Additional comments/Guidance	Mark	AO
08.4	Max 2 from✓✓ 2.55 $\times 10^{-7}$ m used their energy = $\frac{hc}{\text{their wavelength}}$ Converts their energy to eV 4.9 eV ✓	Do not condone POT error in MP1 bullet point 1 Acceptable range: 250 nm to 260 nm Energy: 4.77 eV to 4.97 eV Accept 5.0	3	1 × AO1 2 × AO2
Total			**8**	

Question	Key	Answer	AO
09	C	$\mathrm{d}\,\overline{\mathrm{u}}$	AO1
10	A	energy is conserved.	AO1
11	A	$1\ \mathrm{mN}$ | $1\ \mathrm{km}$	AO1
12	C	using a light source that emits light of a shorter wavelength	AO1
13	C	photoelectric effect | diffraction	AO1
14	A	$\frac{1}{\text{diameter of the wire}}$	AO1
15	C	light from adjacent slits arrives at the screen in phase.	AO1
16	A	The resistance of the diode decreases as V increases for $V > V_s$.	AO1
17	D	$\frac{Ys}{\lambda D}$	AO1
18	D	2.32	AO2

19	B	2.1×10^{8} m s^{-1}	AO2
20	D	17	AO2
21	B	The drag force when her velocity is v_2 is equal to the drag force when her velocity is v_1.	AO2
22	B	3.5×10^{-19} J	AO2
23	B	5.3°	AO2
24	D	4.7 N	AO2
25	B	maximum | minimum	AO1
26	A	$\rho_1 + \rho_2$	AO2
27	A	2.2×10^{-13} m	AO1
28	C	18 | 18	AO2
29	A	1.44 C	AO1

30	D	$\frac{q}{r}$	AO1
31	A	190 g	AO2
32	B	1.1 Hz	AO2
33	C	6	AO1