AQA

AS
Physics
7407/2

PAPER 2

Mark scheme

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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 Assessment Writer.

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.

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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 not 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 weber/metre^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. i.e. 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	Answer	Additional Comments/Guidance	Mark
01.1	15(.0) (Ω) ✓	Only acceptable answer Must be on answer line or clearly identified as (largest)R by $R = 15\ (.0)\ (\Omega)$ seen. Allow an answer just above (or below) the answer line in cases where a previous answer has been crossed out. If not on the answer line, units must be stated.	1

01.2	$1.4(1)\ (\Omega)$ ✓✓ Only selects 2.2 Ω and 3.9 Ω in parallel ✓	Accept evidence from working or a clear labelled sketch of $2.2\ \Omega$ and $3.9\ \Omega$ in parallel Possible allowed combinations include: $\left(\frac{1}{R} =\right) \frac{1}{2.2} + \frac{1}{3.9}$ Condone $R = \frac{1}{2.2} + \frac{1}{3.9}$ $(R =) \frac{1}{\frac{1}{2.2} + \frac{1}{3.9}}$ $(R =) \left(\frac{1}{2.2} + \frac{1}{3.9}\right)^{-1}$ $\left(\frac{1}{R} =\right) \frac{5}{11} + \frac{10}{39}$ $(R =) \frac{2.2 \times 3.9}{2.2 + 3.9}$ Accept $1.407\ \Omega$ but not >4 sf Must be on answer line or clearly identified as (smallest)R by $R = 1.4\ (1)\ (\Omega)$ seen. Allow an answer just above (or below) the answer line in cases where a previous answer has been crossed out. Common wrong answer = 0.71 (Ω) is worth one mark with correct supporting working	2

01.3	Any of the following statements: Power supply is on open circuit (so current is zero) OR Voltmeter has a (very) large resistance (so current is zero) OR No current (load) (so no lost volts) OR (Current is zero) so no lost volts	Accept 'negligible' current for zero current Accept 'very large' resistance; don't penalise 'voltmeter has very large internal resistance' **Do not allow**: Resistance is zero Only resistance is the internal resistance No other component (this implies that the internal resistance is zero)	1

01.4	(Current through power supply leads to) lost volts (across the internal resistance) OR (Current through power supply leads to) voltage drop across the <u>internal resistance</u> OR (Current through power supply leads to) Some of the emf is used in the <u>internal resistance</u> OR Voltage is shared between the internal and external resistances	Allow correct 'energy transfer in the internal resistance' arguments Must refer to a voltage across the internal resistance or *r* except when the term "lost volts" is used. **Do not allow**: The current decreases	1

01.5	$\varepsilon - V = (1.62 - 1.14 =)\ 0.48(0)$ (V) and $\frac{V}{R} = \left(\frac{1.14}{9.0} =\right) = 0.13(\text{V}\ \Omega^{-1})$ ✓	Both results required for ✓; accept 0.127 or 0.1267 for $\frac{V}{R}$ Do not allow answers expressed in terms of unknown variables Answers must be on answer line or clearly identified as answer by using correct subject and equals sign Allow an answer just above (or below) the answer line in cases where a previous answer has been crossed out.	1

Question	Answer	Additional Comments/Guidance	Mark
01.6	Point correctly plotted to nearest 1 mm (half a grid square) and continuous ruled best fit line for the 5 (originally printed) points ✓	Withhold mark if point is hidden or if best fit line is of variable thickness or has discontinuities. Data point should be marked with a cross. Both X and + marks are acceptable. **Do not allow** points plotted as dots / dots in circles If point is wrongly calculated in Part 1.5 allow CE for an accurate plot of this but this should then be treated as anomalous when judging the best fit line. The best fit line must intersect each of the 5 originally printed X symbols. Allow no plot where ECF (even as algebraic equation) point won't fit on the grid and student has stated that it can't be plotted. If no answer / no plottable answer in 1.5 but student chooses to plot a point then it must be the correct point only (0.13,0.48)	1

01.7	Gradient triangle for **Figure 3**; correct read-offs for points ($\pm$ 1 mm) from triangle with the $\varepsilon - V$ step at least 0.5 V *r* in range 3.49 to 3.95 (Ω)	Allow $\frac{y2-y1}{x2-x1}$ seen or gradient triangle drawn with $\frac{\Delta y}{\Delta x}$ seen, read-offs must be substituted into $\frac{y2-y1}{x2-x1}$ or $\frac{\Delta y}{\Delta x}$ Condone one read-off error in four read-offs for gradient method (common error: candidates miss non-origin on ordinate axis) (common error: makes a power of 10 error on abscissa) Any correct method other than gradient method (no read-off errors here) allow 1 mark i.e. allow 1 mark for the accurate use of 1 point from their line *r* must be quoted to a minimum of 2 significant figures **ecf** for *r (their gradient from their best fit line)* *r must be supported by correct working*	2

01.8	The Figure 1 method is better **because** more R values are available ✓ 6 values of R (possible) for method (seen) in Fig 4 ✓	Do not allow: The 2nd method has a wider range The 2nd method has a larger maximum resistance The 2nd method has a smaller minimum resistance The 2nd method only goes up to 8.2 Ω (resistances available in Fig 4: 2.0 Ω, 3.2 Ω, 4.3 Ω, 4.6 Ω, 5.0 Ω, 5.3 Ω)	2

Question	Answer	Additional Comments/Guidance	Mark
02.1	To detect anomalies so these can be rejected OR Determine a mean thus producing a more accurate / repeatable / reproducible value OR To reduce the effect of random error / variations in width of pencil OR Readings from micrometer are more accurate / have a smaller (percentage) uncertainty (than using a ruler) because the micrometer has a greater resolution	Reason for calculating a mean must be qualified. **Ignore**: To decrease the percentage uncertainty To make it more accurate (without reason why) To make the reading more reliable To make it more precise Condone 'sensitivity' for resolution	1

02.2	% uncertainty (= $\frac{\frac{1}{2}\text{range}}{\text{mean}} \times 100) = 1.19\%$ ✓✓ 1 mark can be awarded for: (Evidence for a calculated mean =) 7.15 (mm) OR ($\frac{1}{2}$ range =) 0.085 (mm) OR Use of % uncertainty = $\frac{uncertainty}{mean}$ x 100 OR Use of % uncertainty = $\frac{\frac{1}{2}\text{range}}{\text{mean}} \times 100$	1.19 % awarded 2 marks without supporting working 1 % or 1.2 % are permissible answers but must be supported by convincing working Maximum of 3 sf permissible for answer Reject 7.2 for calculated mean Reject $\frac{1}{2}$ range = 0.09 (mm) Allow their "½ range", their "uncertainty "and their "calculated mean" in use of... But will need to see formula quoted on page and numbers or correct subject and equals sign and numbers for awarding use of…	2

02.3	d = 2.2(1) mm ✓✓ 1 mark can be awarded for: (Area of core = 0.09 x 42.43 or =) 3.8(2) seen *Penalise Talk Out on same line by use of a subject that is not an area* OR $d = \sqrt{\frac{4 \times 0.09 \times 0.83\, w^2}{\pi}}$ Accept their area (as a numerical value) for (0.09 x 0.83 w^2) OR $r = \sqrt{\frac{0.09 \times 0.83\, w^2}{\pi}}$ Accept their area (as a numerical value) for (0.09 x 0.83 w^2)	Correct answer worth 2 marks Condone 3rd sf rounding error if process correct ECF from 02.2 Allow $\frac{\pi d^2}{4}$ as area of core or πr^2 Allow any value of w from this list (7.06, 7.10, 7.15, 7.16, 7.20, 7.23, 7.1, 7.2, 7) or ECF from 02.2 Allow any value of 0.83 w^2 from this list (41.37, 41.84, 42.43, 42.55, 43.02, 43.39, 40.67) or ECF from 02.2 Allow any value of core from this list (3.72, 3.77, 3.82, 3.83, 3.87, 3.90, 3.66) or ECF from 02.2 Condone power 10 error for 1 mark **Do not allow** area of core = 0.83 d^2 Answers must be on answer line or clearly identified as answer by using correct subject and equals sign	2

02.4	85.3 ***or*** 85.4 (mm) ✓	**General Marker** Must be 3 sf	1

02.5	83.8 **or** 83.9 (mm) ✓	**General Marker** **Mark together with 02.4** Where <u>both</u> 02.4 and 02.5 are incorrectly quoted as the **cm** value then award a compensatory 1 mark. Otherwise mark independently e.g: (8.53 <u>and</u> 8.39) or (8.53 <u>and</u> 8.38) or (8.54 <u>and</u> 8.39) or (8.54 <u>and</u> 8.38): award 1 mark Must be 3 sf	1

02.6	Answers 133.43, 142.33, 152.32, 142.16 ✓✓ (Allow 2 sf or more) Allow **ECF** 1 mark can be awarded for: (Decrease in length per cm drawn found =) $\frac{\text{change in length (ans to 02.5} - \text{ans to 02.4)}}{20 \times 25}$ = 2.8 x 10^{-3} Or $\frac{\text{half pencil length (ans to 02.4} \div 2)}{\text{change in length (ans to 0.25 - ans to 0.24)}}$	One of these correct answers without working obtains two marks. ECF must be supported by appropriate working Allow ecf from answers to 02.4 and 02.5, condone any power of 10 errors on intermediate working seen	2

Question	Answer	Additional Comments/ Guidance	Mark
03.1	Period = 0.2×10^{-14} (s) read off OR Recognisable T substituted into $T = 1/f$ $_1$✓ Use of $T = 1/f$ and $c = f\lambda$ $_2$✓ OR Use of $\lambda = cT$ $6(.0) \times 10^{-7}$ (m) $_3$✓	An acceptable subject (period, time for one cycle, one cycle, T, etc.) Allow non-standard symbol with unit seen on time. Allow this subtraction of two times seen in $f = 1/T$ Use of here is: Subject must be seen with substitutions or rearranged equations with $f = 1/T$ and $\lambda = c/f$ Condone power 10 error here Condone lack of subject in vertical working where rearranged equation with appropriate subject seen at heading of column Number must be expressed as 6×10^{-7} or 600×10^{-9} or equivalent not enough to see only nano prefix. .	3

03.2	(Determines a fraction of cycle) $\frac{0.04}{0.2}$ or $\frac{2}{10}$ or $\frac{1}{5}$ or 0.2 or $\frac{1.2\,(\times10^{-7})}{6\,(\times10^{-7})}$ or 0.2 λ seen ✓ 2π/5 OR 0.4 π OR 1.26 or 1.3 ✓	Condone their fraction x 2π or their decimal x 2π For 1st mark Allow 8π/5 OR 1.6 π OR 5.03 or 5.0	2

03.3	(Distance =) $3 \times 10^{-7} \times 2.37 \times 10^{5}$ seen OR (Distance =) $0.07(11)$ (m) seen ✓ Subs into $s = \frac{1}{2} at^2$ ✓ $\underline{9.88}$ (3 sf only) ✓	Condone error in sub for s where formula has been otherwise correctly manipulated with a (or g) as subject Alternative: 1st mark average speed = $\frac{3 \times 10-7 \times 2.37 \times 105}{0.12}$ 2nd mark $a = \frac{2 \times \text{their average speed}}{0.12}$ 3rd mark 9.88	3

03.4	Draws a tangent to the curve at approximately t = 120 ms <u>and</u> attempts a gradient calculation ✓ (Gradient =) 1.2 (range 1.1 to 1.3) ✓	Tangent must be a straight line that touches curve and divergent from curve before 90 ms and after 150 ms Allow 1.2×10^{-3} (range 1.1×10^{-3} to 1.3×10^{-3}) ✓ Ignore units on answer line 2nd mark is dependent on 1st mark Max 1 mark for correct answer in range where tangent satisfies above conditions but doesn't quite touch curve (half-square tolerance) **first alternative**: 1st mark Use of v=u +at with sub for $a = 9.88$ or 9.875 **and** t=0.12 2nd mark 1.2 or 1.19 or 1.185 **only** **Second alternative:** 1st mark Use of $s = 1/2at^2$ and d*s*/d*t* = *at* with sub for $a = 9.88$ or 9.875 **and** t=0.12 2nd mark	2

		~~1.2 or 1.19 or 1.185~~ **only**	

03.5	(instantaneous) Velocity (of the mirror) or (instantaneous) speed (of the mirror) ✓	Ignore any units quoted **Do not allow**: Average speed / constant speed	1

Question	Answer	Additional Comments/Guidance	Mark
04.1	$7.3(4) \times 10^{5}$ ✓ C kg^{-1} ✓	Numerical answer (in terms of powers of 10) must match unit prefixes where used Penalise rounding errors (733944.9541) Do not allow use of solidus in unit: C / kg Condone a capital k or lower case c but not a capital g	2
04.2	(1300 (eV) =) 2.08×10^{-16}(J) OR 2.1×10^{-16}(J) ✓		1

04.3	Correct answer of 3.59 x 10^7 gains 3 marks (without working) (Number of Xe ions per second) = $\frac{2.1 \times 10^3}{\text{ans to 4.2}}$ OR $1(.01)$ x 10^{19} seen ✓ (Mass of Xe ions per second) = $2(.2)$ x 10^{-6} ✓ (time = $\frac{total\ mass}{mass\ per\ second} = \frac{79}{2(.2) \text{ x } 10^{-6}}$ =) 3.59 x10^7 (s) or 3.6 x10^7 (s)✓ OR (Total number of Xe ions) = $\frac{79}{2.18 \times 10^{-25}}$ OR 3.6 x 10^{26} seen ✓	Ecf form part 4.2 Ecf from part 4.2	3

	(total energy available) 3.6×10^{26} x (ans to 4.2) OR $7.5(4) \times 10^{10}$ ✓ (time $= \frac{E}{P} = \frac{7.5(4) \times 10^{10}}{2.1 \times 10^{8}}$ =) 3.59×10^{7} (s) ✓	~~Ecf from part 4.2~~ Ecf from part 4.2 If both 'methods' attempted, restrict marks awarded to optimum method.	

04.4	Speed of He ions will be greater ✓ (Momentum depends on mass and speed, although) He (has higher speed) has (considerably) less mass, therefore less momentum (gained by He ion during the acceleration) ✓ He ion exerts less thrust (on spacecraft therefore xenon is better) OR Xenon ion exerts more thrust (on spacecraft therefore xenon is better) ✓	**Must address these points** Other points (e.g. He smaller so more can be stored) are neutral: no credit awarded Must be clear about which ion candidate is discussing Condone use of terms such as 'heavier' / 'lighter'	3

Keys to Multiple Choice Questions
(each correct answer is worth 1 mark)

5	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
A	A	D	C	A	C	D	B	A	A
15	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
D	C	B	C	D	C	A	D	C	C
25	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**
B	C	D	A	A	B	B	B	C	D