AQA

AS
PHYSICS
7407/2

Paper 2

Mark scheme

June 2024

Version: 1.0 Final

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	calculates, using all 4 values, a mean of 0.418 (s) ✓	Expect to see 25.08 (mean average) divided by 60, or 100.32 (sum) divided by 240 in working	1	AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
01.2	2.75 cycles (between **P** and **Q**) $_1$✓ $T_{PQ} = 0.42 \times$ their number of cycles $_2$✓	Expect $T_{PQ} = 1.15$, 1.16 or 1.2 (s) $_2$✓ Allow use of >2 sf T_{PQ} that rounds to 0.42 (s) $_2$✓ Their number of cycles must be between 2.5 and 3	2	2 × AO3

Question	Answers	Additional Comments/Guidance	Mark	AO
01.3	0.170 (m) ✓	Condone 2 sf value on answer line if working shows a 3 sf value or "170 mm" seen or "20 mm" used e.g. '8.5×20 mm'.	1	AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
01.4	correct use of an appropriate equation of motion $_1$✓ correct evaluation of their a $_2$✓	Expect to see a = 0.24, 0.25 or 0.26 (m s^{-2}) $_1$✓ Expect $a = \dfrac{2 \times \text{their } s}{\text{their } (T_{PQ})^2}$ **OR** $\text{mean } v = \dfrac{\text{their } s}{\text{their } T_{PQ}}$ **AND** $a = \dfrac{2 \times \text{their mean } v}{\text{their } T_{PQ}}$ Expect mean $v = 0.14$ or 0.15 (m s^{-1}) $_1$✓ Allow s in mm	2	2 × AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
01.5	links (absolute) uncertainty of 1 mm for one reading to the resolution of 2 mm of the graph paper $_1$✓ idea that s is based on two readings so (absolute) uncertainties in each reading are added $_2$✓	$_1$✓ Condone 'uncertainty in a single reading is half a grid division' $_2$✓ Allow 's is based on two readings so uncertainty in s is double the uncertainty of each reading'	2	2 × AO1

Question	Answers	Additional Comments/Guidance	Mark	AO
01.6	$\frac{0.002}{their\ s} \times 100$ **OR** 2×0.46 or 0.92 seen $_1$✓ % uncertainty in a = (their % uncertainty in s) + 0.92 $_2$✓	Expect to see % uncertainty in $a = 2.1$ $_1$✓ Expect % uncertainty in $s = 1.2$. Calculator value is 1.17647. $_1$✓Allow values in mm $_2$✓ Allow 1 or 2 sf values only	2	2 × AO3

Question	Answers	Additional Comments/Guidance	Mark	AO
01.7	resultant force should be lower $_1$✓ (student's value of) g is less (than $9.81\ \text{m s}^{-2}$) $_2$✓	$_1$✓ Default interpretation of "a" is the experimental value (from **01.4**) unless otherwise defined. $_1$✓ Allow idea that experimental value of a would be larger in absence of friction. $_1$✓ Credit algebraic expression that includes friction (F): $ma = mg\sin\theta - F$. Condone missing "m". $_2$✓ is contingent on $_1$✓	2	2 × AO3

Total			12

Question	Answers	Additional Comments/Guidance	Mark	AO
02.1	value in range 2.9×10^4 to 3.0×10^4 (N) ✓	Use of data from any point (plotted or using their line or using their B for brass) is acceptable	1	AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
02.2	smooth curve through at least 4 saltires 1a✓	1a✓ Reject thick or discontinuous lines 1a✓ can be awarded if no credit gained in 1b✓ or 2b✓	2	1 × AO1 1 × AO2
	correct read off at 1.60 mm, leading to answer in range 58 to 64 (kg mm^{-2}) 2a✓	2a✓ 2 or 3 sf values only		
	OR use of $B = \frac{their\ F}{\pi \times g \times 10 \times 1.6}$ 1b✓	1b✓ Condone use of D and h in metres if also seen (and penalised) in **02.1**		
	consistent calculation of B 2b✓	2b✓ 2 or 3 sf values only 2b✓ Their B should be $\frac{their\ F}{493}$		

Question	Answers	Additional Comments/Guidance	Mark	AO
02.3	uses $B = \frac{F}{\pi g D h}$ to: evaluate h, and compare to radius/diameter of steel sphere **OR** evaluate (minimum value of) B based on radius/diameter of steel sphere, and compare to $5\ (\text{kg mm}^{-2})$ 1✓ reduce F **OR** increase D 2✓	1✓ Expect h = $19\ \text{mm}$ 1✓Condone 'steel ball will be completely pushed into the lead' for comparison 1✓ Reject references to graph scale e.g. 'h scale only goes up to $3.5\ \text{mm}$ on graph' 2✓ Condone 'use a steel sphere with D > $19\ \text{mm}$' or 'use a bigger sphere'.	2	2 × AO3

Question	Answers	Additional Comments/Guidance	Mark	AO
02.4	travelling microscope **OR** micrometer / screw gauge **OR** digital vernier calliper ✓		1	AO1

Question	Answers	Additional Comments/Guidance	Mark	AO
02.5	d is (always) larger (than h) 1a✓ so <u>percentage</u> / <u>%</u> uncertainty is smaller 1b✓ **OR** d can be measured in different directions 2a✓ so can obtain an average 2b✓ **OR** idea that readings for d are clearer to judge (than for h) 3a✓ so measurement is closer to true value / more accurate 3b✓	1 mark for an advantage AND 1 mark for a relevant explanation. No credit for an explanation without the relevant advantage. Allow reverse arguments throughout e.g. 'h is (always) smaller than d ' 2a✓Allow 'can take multiple readings of d' or 'h can only be measured once' 2b✓Allow 'can identify anomalous readings' or 'can reduce the effect of <u>random</u> error' 3a✓Allow 'difficult to see where the centre of indentation is for *h*' or wtte. 3a✓ Allow 'easier to define d'. Reject 'easier to measure d '. 3b✓ Allow idea that parallax error can be reduced.	2	2 × AO3
Total			**8**	

Question	Answers	Additional Comments/Guidance	Mark	AO
03.1	use of $\rho = \frac{m}{V}$ **AND** $V = Al$ 1✓ 260 (m) 2✓	1✓ Expect to see $V = 2.5\ \text{m}^3$ or total $V = 5.0\ \text{m}^3$	2	2 × AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
03.2	calculates total tension of $3.2 \times 10^6\ \text{N}$ 1✓ $F = T - W$ seen **OR** subtracts a weight from tension 2✓ uses $F = ma$ 3✓ 0.28 or 0.29 (m s^{-2}) 4✓	Expected values seen: Total mass = $3.17 \times 10^5\ \text{kg}$ Load weight = $2.75 \times 10^6\ \text{N}$ Cable weight = $3.63 \times 10^5\ \text{N}$ Total weight = $3.11 \times 10^6\ \text{N}$ Resultant force = $9.02 \times 10^4\ \text{N}$ 4✓ Calculator values are: 0.28464 (using $g = 9.81$) and 0.29464 (using $g = 9.8$)	4	4 × AO2

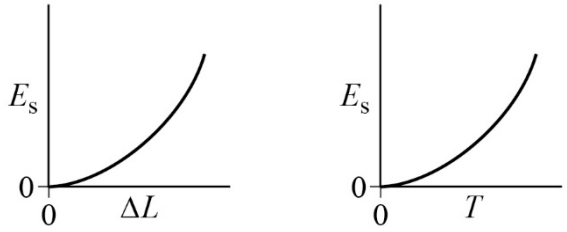
Question	Answers	Additional Comments/Guidance	Mark	AO
03.3	calculates stress per cable (167 MPa) **OR** breaking force for one cable (8.5×10^6 N) $_1$✓ concludes that system operates safely because: $_2$✓ 8.5×10^6 N **<** $(3 \times 1.6 \times 10^6)$ N **OR** (3×167) MPa **<** 890 MPa, or 167 MPa **<** $\frac{890}{3}$ MPa **OR** $3 < \frac{890}{167}$ or $3 < \frac{8.5}{1.6}$	Calculations for $_1$✓ may be seen in response to $_2$✓ N.B. $\frac{890}{3} = 297$ N.B. $\frac{890}{167} = 5.3$ and $\frac{8.5}{1.6} = 5.3$	2	2 × AO3

Question	Answers	Additional Comments/Guidance	Mark	AO
03.4	Max 3 from: $_1$✓$_2$✓$_3$✓ correctly takes into account energy transfer efficiency $_a$✓ determines a relevant area of graph between 10:00 and 14:00 $_b$✓ conversion of energy unit (kW h to J or vice versa) $_c$✓ quantitative comparison of their energy supply (turbine + storage capacity) to their energy demand or their energy deficit versus their storage capacity $_d$✓ concludes that demand cannot be met, based on comparison of: 4.14 GJ with 3.89 GJ **OR** 900 MJ with 646 MJ $_4$✓	$_a$✓ 760 MJ × 0.85 gives 646 MJ of useful energy from storage system. Condone POT error. $_a$✓ can be given for stating that at 100% efficiency the storage system would provide 760 MJ. $_b$✓ for dashed/demand line: 11.5 'squares' = 1150 kW h; for solid/output line: 9 'large squares' = 900 kW h; between dashed and solid: 2.5 'large squares' = 250 kW h $_c$✓ Expect: 1 'small square' = 14.4 MJ; 1 'large square' = 360 MJ; 1150 kW h = 4.14 GJ; 900 kW h = 3.24 GJ; 250 kW h = 900 MJ Award $_b$✓ and $_c$✓for any area given in J. $_d$✓ Allow 760 MJ for their storage capacity. demand = 4.14 GJ; supply (turbine+storage) = 3.24 + 0.646 GJ = 3.89 GJ deficit (demand – turbine supply) = 4.14 GJ – 3.24 GJ = 900 MJ; storage system supply = 646 MJ	4	1 × AO1 1 × AO2 2 × AO3
Total			**12**	

Question	Answers	Additional Comments/Guidance	Mark	AO
04.1	Max 2 from: $_1$✓$_2$✓ links constructive interference as cause of bright fringe $_a$✓ correct reference to zero phase difference or 'in phase' $_b$✓ path difference = $2d$ **OR** $(n + 0.5)\lambda$ seen $_c$✓ $2d = (n \pm 0.5)\lambda$ $_3$✓		3	2 × AO2 1 × AO3

Question	Answers	Additional Comments/Guidance	Mark	AO
04.2	determines s from $\frac{5}{11}$ **OR** substitutes their s into $\frac{t}{l} = \frac{\lambda}{2s}$ with values for l and λ $_1$✓ 3.9×10^{-5} (m) $_2$✓	$_1$✓ Expect $s = 0.45$ mm. Condone POT errors. $_1$✓ All substitutions must be in consistent units of length. $_1$✓ Must be some attempt to determine s. Reject use of 5.0 mm.	2	1 × AO2 1 × AO3

Question	Answers	Additional Comments/Guidance	Mark	AO
04.3	Allow either $_1$✓ or $_2$✓ if there is no reference to frequency, but not both: wave speed decreases (and frequency is constant) $_1$✓ (frequency is constant so) wavelength decreases $_2$✓ s will decrease, with reference to $\frac{t}{l} = \frac{\lambda}{2s}$ $_3$✓	If no other mark, credit use of 1.3 e.g. c_{water} = 2.3 × 10^8 m/s. $_2$✓ May see calculated λ_{water} = 454 nm $_3$✓ Only awarded if values of both t and l are stated, or a clear reference to both of them being constant. $_3$✓ Allow ecf from an incorrect $_2$✓ $_3$✓ Reject references to e.g. double-slit equation.	3	1 × AO1 1 × AO2 1 × AO3
Total			**8**	

<table>
<tr><th>Question</th><th>Key</th><th>Answer</th></tr>
<tr><td>05</td><td>B</td><td>one alpha decay followed by two β^- decays</td></tr>
<tr><td>06</td><td>C</td><td>8.7×10^{20}</td></tr>
<tr><td>07</td><td>B</td><td>390 nm</td></tr>
<tr><td>08</td><td>A</td><td><table><tr><td>positron</td><td>alpha particle</td></tr></table></td></tr>
<tr><td>09</td><td>A</td><td>48 Ω</td></tr>
<tr><td>10</td><td>D</td><td> 
</td></tr>
<tr><td>11</td><td>D</td><td><table><tr><td>speed</td><td>not negligible</td></tr></table></td></tr>
<tr><td>12</td><td>C</td><td>16 W</td></tr>
<tr><td>13</td><td>B</td><td>4.0 V</td></tr>
</table>

14	A	frequency
15	D	32 cm
16	C	$\bar{u}s$
17	D	4.9×10^{-11} m
18	D	4
19	D	24 m s^{-1}
20	C	proportional to t.
21	C	reduces signal loss.
22	D	200 N
23	A	19 m
24	B	A brittle fracture occurs after little or no plastic deformation.
25	D	460 N
26	C	3.6 V
27	B	63%
28	A	1.1×10^{-6} Ω
29	B	0.6 m s^{-1} to the right
30	D	They must be polarised in the same plane.

<table>
<tr><td>31</td><td>C</td><td colspan="4">The lines of action of the forces must pass through the centre of mass of the body.</td></tr>
<tr><td>32</td><td>C</td><td colspan="4"><table><tr><td>All the particles vibrate.</td><td>Some of the particles do not vibrate.</td></tr></table></td></tr>
<tr><td>33</td><td>D</td><td colspan="4">the intercept on the y-axis</td></tr>
<tr><td>34</td><td>A</td><td colspan="4"><table><tr><td>f</td><td>p</td><td>μ</td><td>c</td></tr></table></td></tr>
</table>

Total = 30 marks