A-level
PHYSICS
7408/1

Paper 1

Mark scheme

June 2024

Version: 1.0 Final

246A7408/1/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/Guidelines	Mark	AO
01.1	gravity, weak (nuclear), strong (nuclear), electromagnetic ✓	Any order, all four must be correct. Condone any reference to “interaction” or “force” Condone “gravitational” Do not accept ‘electrostatic’, ‘gravitational potential’, ‘em’, ‘EM’	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
01.2	proton, beta minus, (electron) antineutrino all correct ✓	Allow alternative ways of writing beta minus: electron/ e / e^- / β^- Accept p and P for proton and $\overline{\upsilon_e}$ or $\overline{\upsilon}$ for antineutrino Condone ‘anti electron neutrino’	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
01.3	weak (nuclear) ✓ it involves leptons (which do not experience strong interaction/force) **OR** there is a change in quark (flavour) ✓	Accept reference to W^- or W together with transfer of charge (from neutron) Accept d (quark) converted to u (quark) MP2 is conditional on award of MP1	2	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
01.4	idea that the exchange particle is a (virtual) photon ✓ (virtual) photons/the exchange particles have momentum ✓ conservation of momentum (means that photon interchange) enables the electron momentum/path to change ✓	Accept γ for photon.	3	AO1
Total			**7**	

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	All four rows correct $_1$✓$_2$✓ Any two rows correct $_1$✓	<table><tr><th>Particle</th><th>Baryon</th><th>Hadron</th><th>Lepton</th><th>Meson</th></tr><tr><td>π^+</td><td></td><td>✓</td><td></td><td>✓</td></tr><tr><td>n</td><td>✓</td><td>✓</td><td></td><td></td></tr><tr><td>K^+</td><td></td><td>✓</td><td></td><td>✓</td></tr><tr><td>Σ^0</td><td>✓</td><td>✓</td><td></td><td></td></tr></table> Accept any reasonable notation for ✓	2	1 × AO1 1 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	Identifies strangeness as the consideration as interaction would be strong/not weak ✓ K^- and Σ^0 have same strangeness of -1✓ Demonstration that LHS and RHS strangeness not equal AND that the LHS is zero ✓	Do not award MP1 for suggestion that any other quantum number is not conserved. Evidence for MP2 and MP3 can be seen in a correct use of strangeness values e.g. 0 + 0 → -1 -1	3	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
02.3	clear assignment of each particle to its correct rest mass including the photon ✓ idea that LHS mass > RHS mass✓	Electron AND positron rest energy = 0.510999 MeV π^0 rest energy = 134.972 MeV Gamma/photon rest mass = 0 Allow rounded values for rest mass.	2	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
02.4	annihilation of the positron with an electron ✓	Do not allow answers such as ‘elimination’	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
02.5	Idea that international collaboration/co-operation/verification is required OR (investment in) expensive equipment/hardware/ infrastructure is required ✓	Accept idea that (people with) particular/specialist talents/technology/infrastructure must be in place. Ignore references to peer review or vague statements such as 'it takes a long time' or 'it/the research is expensive'.	1	AO1
Total			**9**	

Question	Answers	Additional comments/Guidelines	Mark	AO
03.1	ray through A links to ray in B AND ray in B horizontal by eye ✓	Ignore any arrow directions.	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.2	Conclusion consistent with their **Figure 1** ✓ Supported by consideration of their angles of incidence and refraction at AB boundary ✓	Answer must be consistent with their **Figure 1.** For a correct diagram expect to see B has greater refractive index / A has lower refractive index' For a correct diagram expect to see 'at AB boundary angle of incidence > angle of refraction' OR 'at AB boundary the ray bends towards the normal'.	2	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
03.3	appropriate application described ✓	how the grating is used must be described e.g 'used to determine λ of named light source' or 'used to identify elements in a sample' Examples: To analyse chemical composition (of a sample) To stabilise/filter laser light To provide a monochromatic source/select a particular wavelength of light In optical encoders for high-precision motor control Spread evenly the light from e-readers Condone: to identify (some) authentic bank notes applications asociated with entertainment eg light shows/diffraction glasses. application associated with analysis of the light from the Sun	1	AO1

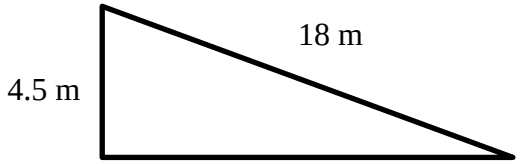
Question	Answers	Additional comments/Guidelines	Mark	AO
03.4	MAX 2 from ✓✓ • λ read from spectrum = 380 nm • use of $d \sin\theta = n \times$ (their λ) • use of $G = \frac{1}{d}$ to give 1.2×10^{6} (m^{-1}) ✓	Ignore POT error in MP1 & MP2. Accept answer in range 377.5 – 382.5 nm. 'Use of' means clear substitution of *n*, θ and their λ or rearrangement of equation to give $d = \frac{n\lambda}{\sin\theta}$. If *n* not seen, assume that *n* = 1. Expect to see 8.04×10^{-7} m for d MP2 and MP3 may be seen together Calculator value range: 1.251790×10^{6} m^{-1} to 1.2435547×10^{6} m^{-1} to 1.235427×10^{6} m^{-1}	3	2 × AO2 1 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
03.5	Argument involving $\sin\theta = nG\lambda$ or equivalent comparing effect of $n = 2$ and $G' = 2G$ ✓ Appreciation that angular separations would be the same for both options ✓ Discussion suggesting option 2 / $2G$ should be used, as $n = 2$ spectrum could overlap with other orders obscuring absorption lines ✓	For MP3, allow maxima are better defined in option 2 Alternative for MP3: idea that $2G$ should be used as the second-order spectrum would be dimmer – allow reverse argument that 2*G* first order would be brighter.	3	3 × AO3
Total			**10**	

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	Either appreciation of mass of He = 4 × mass of neutron OR idea that n and He have equal (and opposite) momenta ✓ Combination of momentum and KE equations (to give idea that KE is inversely proportional to *m* with same *p*) and therefore KE of neutron = 4 × KE of He ✓	Expect to see KE = $\frac{p^2}{2m}$	2	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	calculates KE of neutron OR uses mass of neutron from data booklet with *their calculated KE* in a KE equation✓ $v = 5.2 \times 10^7$ m s^{-1} ✓	$80\% \times 2.82 \times 10^{-12} = 2.26 \times 10^{-12}$ (J) Do not allow use of 2.82×10^{-12} as *their calculated KE.* $m_n = 1.67(5) \times 10^{-27}$ kg Accept answers of 5.18×10^7 or 5.19×10^7 m s^{-1} Calculator values: 5.1823878×10^7; (using 1.68) 5.1901169×10^7; (using 1.675) 5.1978807×10^7 (using 1.67)	2	AO2
Total			**4**	

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	Formation of a parallelogram OR triangle to draw W 1✓ Use of their W to obtain the scale at which force diagram is drawn 2✓ Use of their scale to obtain T_1 and T_2 3✓ T_1 = 480 N AND T_2 = 400 N 4✓	Correct by eye. If a hybrid approach is used, note that MP2 is given for a measurement of their W used to determine a scale OR for the measurement of the two angles within range. If correct values in range seen for MP4, then it can be assumed that a scale was used to obtain T_1 and T_2, MP3 can be awarded Expect to see: $\frac{350}{35}$ mm = 10 N mm^{-1} T_1 = 48 mm × 10 T_2 = 40 mm × 10 Range: allow T_1 470 – 490 N and T_2 390 – 410 N	4	AO3
	Alternative Approach 1 Formation of a parallelogram OR triangle to draw W 1✓ Both angles measured correctly/evaluated to be (34 — 35)° and (11 — 12)° 2✓ T_1sin 34 + T_2 sin 11 = 350 AND T_1cos 34 = T_2 cos 11 3✓ T_1 = 480 N AND T_2 = 400 N 4✓	Allow complementary angles where quoted. In MP3 allow their angle values OR angle symbols consistent with labels on their diagram. Allow correct application of sine or cosine rules. Range: allow T_1 470 – 490 N and T_2 390 – 410 N		

Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	Max 4 from: • $m = \frac{350}{g}$ ✓ • their m to give KE with v = 6.5 m s^{-1} at B ✓ • 350 N and 4.5 m in GPE equation✓ • evidence of *their* Δ*GPE* – *their* Δ*KE* to give work done against friction ✓ • evidence of friction force $= \frac{\text{their work done}}{18}$ ✓ Calculates average force = 46 N ✓	Expect to see 36 kg Expect to see 754 J Expect to see 1575 J Expect to see 821 J Alternative for first **four** marks. Must see a labelled diagram indicating use of this approach:  If the diagram is not seen, mark according to the main scheme (in the 'Answers' column). Max 4 from: • $m = \frac{350}{g}$ ✓ • Use of suvat to obtain a = 1.17 m s^{-2}✓ • Uses $F = ma$ to obtain their effective resultant force✓ • Uses 350 × (4.5÷18) or equivalent to obtain their effective component of weight✓ • Subtracts their resultant force from their component of weight✓ Accept answers that round to 46 N.	5	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
05.3	Idea that contact time or distance travelled during contact is increased ✓ Generic mark scheme for MP2 and MP3 • reference to physical principle ✓ • application of principle to explain why force is reduced ✓	**Momentum approach (time increased)** • reference to Force is rate of change of momentum • change in momentum/impulse/ $F \times \Delta t$ constant therefore force decreased **Energy approach (distance increased)** • reference to force × distance = change in KE/work done • change in KE/work done/$F \times s$ constant so force reduced **Newton 2 approach (time/distance increased)** • reference to Force = mass × acceleration • change in velocity constant, so acceleration reduced so force reduced	3	AO3
Total			**12**	

Question	Answers	Additional comments/Guidelines	Mark	AO
06.1	Appropriate use of $V = IR$ ✓ Variable resistor resistance = $190\ (\Omega)$ ✓	e.g. for MP1: • determines total circuit resistance • determines pd across thermistor • use of $= I(R_{XY}+R_{YZ})$✓ Condone POT error in MP1 Expect to see total circuit resistance of $542\ (\Omega)$ Expect to see pd across resistor of $2.3\ \text{V}$. Condone POT error in MP1 Calculator value: 191.67 Ω	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.2	Evidence of $22\ ^{o}\text{C}$ converted to K ✓ Determines R OR $\frac{3.2}{12}$ OR $\frac{3.2}{12\times10^{-3}}$ ✓ Evidence of use of $\ln(\frac{R}{R_0})$ with their values✓ $B = 1110$ ✓ K ✓	Allow ecf from MP1. Expect $295\ \text{K}$ Expect to see $267\ \Omega$ Condone use of $R_0 = 190\ \Omega$ in MP3 Accept 1100 Accept answers that round to 1110 or 1120 Allow ecf only from temperature conversion. Do not accept k for K	5	AO2

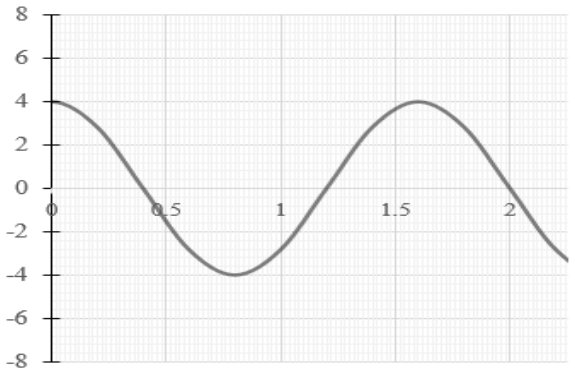
Question	Answers	Additional comments/Guidelines	Mark	AO
06.3	Current causes thermistor temperature to change ✓ Thermistor resistance decreases as temperature increases✓	Allow a clear description of thermal runaway for both marks.	2	AO3

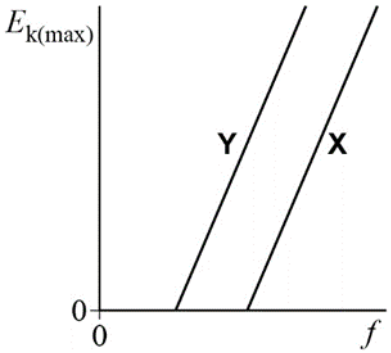
Question	Answers	Additional comments/Guidelines	Mark	AO
06.4	Uses ammeter(s) (in series) to show current at X = current at Y = current at Z OR Uses voltmeter(s) to show that emf/terminal pd / $6.5\ \mathrm{V}$ = pd across XY + pd across YZ✓ Links current readings to (conservation of) charge AND Links pd readings to (conservation of) energy✓	Do not allow ‘currents across’. Do not accept ‘battery pd’ unless it is clearly being measured. If points XYZ are not referred it must be clear where the meters are attached.	2	AO1
Total			**11**	

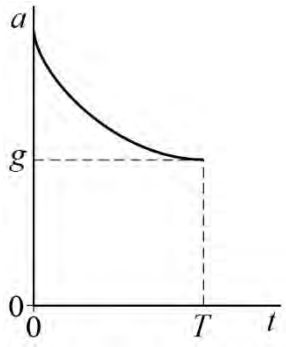
Question	Answers	Additional comments/Guidelines	Mark	AO
07.1	3.5 mm ✓	Accept 3.4 to 3.6	1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
07.2	Evidence of use of $v = f\lambda$ including 625 (Hz) ✓ Uses wavelength = 0.7 m to get 440 (m s^{-1}) ✓	Allow range of 0.68 – 0.72 m in λ or 425-450 m s^{-1}	2	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
07.3	In phase OR 0 ✓	Accept 2π, 360^{o} and multiples	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
07.4	Sinusoidal wave starting at displacement = 4 mm ✓ Amplitude = 4 mm ✓ Period (= 625^{-1}) = 1.6 ms ✓	Tolerance on drawing: half a square  Judge shape of wave on their first complete cycle. If there is no complete cycle, the line they have drawn must cover the width of the grid.	3	AO3
Total			**7**	

Question	Key	Answer	AO
08	C	the beta-plus decay of a $^{39}_{20}\mathrm{Ca}$ nucleus	AO2
09	A		AO1
10	A	increases decreases	AO2
11	C	3	AO1
12	D	1800	AO2
13	D	5×10^6	AO2
14	A	unpolarised polarised	AO1
15	D	$2(L_2 - L_1)$	AO1
16	A	$(S_1Y - S_2Y) - (S_1W - S_2W)$	AO1
17	A	using monochromatic light of lower frequency.	AO1
18	B	$\frac{F}{m}\cos\beta - g\sin\alpha$	AO1

19	A	41°	AO2
20	D	$4d$	AO2
21	A	0.2 m	AO2
22	B		AO2
23	D	931 N	AO2
24	D	4700 kg	AO2
25	C	$3E$	AO2
26	C	$\frac{k(\Delta L)^2}{2t}$	AO2
27	D	1.50 V	AO2
28	A	from **P** to **O**	AO1
29	B	$2\pi^2 mf^2 r^2$	AO1

30	B	$0.57\ \text{m s}^{-1}$	AO1
31	B	$\frac{T}{\sqrt{2}}$	AO2
32	C	$T \qquad T\sqrt{2}$	AO2