AS
PHYSICS
7407/2

Paper 2

Mark scheme

June 2022

Version: 1.0 Final

226A7407/2/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.

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

Copyright information

AQA retains the copyright on all its publications. However, registered schools/colleges for AQA are permitted to copy material from this booklet for their own internal use, with the following important exception: AQA cannot give permission to schools/colleges to photocopy any material that is acknowledged to a third party even for internal use within the centre.

Copyright © 2022 AQA and its licensors. All rights reserved.

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.

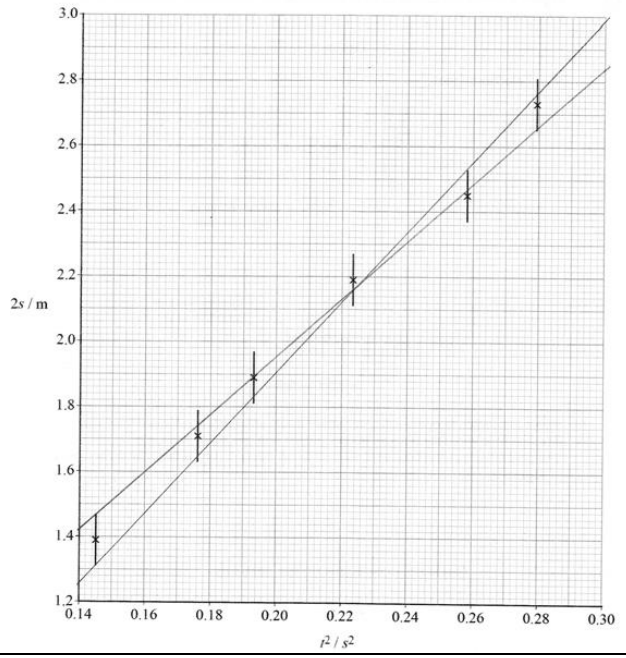
The exemplar materials used during standardisation will help you to determine the appropriate level. There will be an answer in the standardising materials which will correspond with each level of the mark scheme. This answer will have been awarded a mark by the Lead Examiner. You can compare the student's 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	(±) 0.04 (m) ✓	Correct answer only	1	AO3

Question	Answers	Additional Comments/Guidance	Mark	AO
01.2	G_{max} line ruled through bottom of first error bar and through top of fifth error bar **OR** G_{min} line ruled through top of first error bar and through bottom of sixth error bar $_1$✓ G_{max} between 10.7 and 10.9 $_2$✓ G_{min} between 8.7 and 8.9 $_3$✓	$_1$✓ requires at least one line to be well-drawn i.e. thin, single, continuous For $_2$✓ expect a 3 sf value. Accept 2 sf value only if it comes from expected range. Condone 4 sf value. For $_3$✓ accept 2 or 3 sf values only For $_{23}$✓ <u>at least one</u> Δt^2 step ≥ 0.08 (s^2) (i.e. half width of grid) Ignore any unit given with G_{max} or G_{min}  	3	3 × AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
01.3	uses $g = \frac{G_{max} + G_{min}}{2}$ with their values from **01.2** $_1\checkmark$ evaluates mean of their G_{max} and G_{min} to 2 sf $_2\checkmark$	If no other mark given, allow 1 mark for a value of $9.7\ (\text{m s}^{-2})$ from a well-drawn best-fit line. Give no credit for an unsupported answer. Treat "10" as a 2 sf answer.	2	2 × AO3

Question	Answers	Additional Comments/Guidance	Mark	AO
01.4	absolute uncertainty in g $_1$✓ percentage uncertainty in $g = \frac{\text{their } \Delta g}{\text{their } g} \times 100$ $_2$✓	Mark each point independently. If no other mark given, allow 1 mark for a percentage uncertainty (1 or 2 sf) based on the full range (rather than half the range). For $_1$✓ must use their G_{max} **AND/OR** their G_{min} e.g. $\Delta g = \frac{G_{max} - G_{min}}{2}$ **OR** $G_{max} -$ their g **OR** their $g - G_{min}$ May be seen in working for percentage uncertainty e.g. $\left(\frac{G_{max} - g}{g}\right) \times 100$ **OR** $\left(\frac{g - G_{min}}{g}\right) \times 100$ **OR** $\left(\frac{G_{max} - G_{min}}{G_{max} + G_{min}}\right) \times 100$ For $_2$✓ allow 1 or 2 sf	2	1 x AO3 1 x AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
01.5	systematic (error) ✓	'zero error' is neutral	1	AO1

Question	Answers	Additional Comments/Guidance	Mark	AO
01.6	points/line displaced to right owtte **OR** line moves down **OR** (vertical) intercept is decreased / now has negative intercept ✓	Must refer to a property of the graph; comments about error bars are neutral; ignore (new) calculated values of t^2. Accept 'gradient is decreased' / 'graph (or line) becomes a curve of decreasing gradient' owtte. No credit for 'points move down' / 't^2 values are increased'. Allow answers in form of their own diagram or on **Figure 2**.	1	AO3
Total			**10**	

Question	Answers	Additional Comments/Guidance	Mark	AO
02.1	0.879 (m) ✓		1	AO3

Question	Answers	Additional Comments/Guidance	Mark	AO
02.2	correctly determines R_4 **OR** divides their incorrect R_4 by their **02.1** $_1$✓ evaluates $\frac{\text{correct } R_4}{\text{their } 02.1}$ $_2$✓	Correct answer gives $0.15(1)$ (Ω m^{-1}). $_1$✓ Correct $R_4 = 0.13(3)$ Ω $_{12}$✓Allow a correction to m if their **02.1** is in mm $_2$✓ Condone 3 sf answer	2	2 × AO3

Question	Answers	Additional Comments/Guidance	Mark	AO
02.3	micrometer screw gauge **OR** digital (vernier) callipers $_1$✓ repeat measurements at different points (along the wire) **OR** repeat measurements in different directions / orientations **OR** repeat measurements AND reject / discard anomalies $_2$✓ calculate average / mean (from repeated measurements) $_3$✓	Treat references to zero error as neutral unless explicitly linked to reducing random error. For $_1$✓ allow 'micrometer' or 'screw gauge' or travelling microscope. Reject '(vernier) callipers'. Accept "readings" for "measurements". Repeat "experiment" is insufficient. For $_3$✓ some mention of repeat (measurements) owtte must be seen in body of answer	3	3 × AO1

Question	Answers	Additional Comments/Guidance	Mark	AO
02.4	use of $A = \frac{\pi d^2}{4}$ ₁✓ ρ = their **02.2** × $1.1(3) \times 10^{-7}$ (Ω m) ₂✓	For ₁✓ allow POT in d: either $A = \frac{\pi \times 0.38^2}{4}$ **OR** $A = \pi \times 0.19^2$ **OR** $A = 1.1(3)$ ($\times 10^{-7}$) seen For ₂✓ expected answer is 1.7×10^{-8} (Ω m) If no other mark given, allow 1 mark for 6.8×10^{-8} (Ω m)	2	2 × AO3

Question	Answers	Additional Comments/Guidance	Mark	AO
02.5	decrease R_1 / 2.2 MΩ by a factor of 30 **OR** increase R_2 / 3.9 kΩ by a factor of 30 **OR** increase R_3 / 75 Ω by a factor of 30 ✓	Unless quantitative change identified, must give new resistance, e.g. (new) R_1 is 73 kΩ (new) R_2 is 120 kΩ (new) R_3 is 2.3 kΩ	1	AO3

Question	Answers	Additional Comments/Guidance	Mark	AO
02.6	2.1 (mm) ✓	allow > 2 sf answer rounding to 2.1 (mm)	1	AO2

Total			10

Question	Answers	Additional Comments/Guidance	Mark	AO
03.1	attempts to calculate energy stored during 2.6 hr period **OR** attempts to calculate average output power during 12 hr period using their energy stored $_1$✓ 2.2 (W) $_2$✓	Correctly rounded answer gains both marks. (Calculator value is = 2.16666667) For $_1$✓ stored energy = 93.6 kJ For $_1$✓ condone use of t in hours. (2.6 hr = 9360 s; 12 hr = 43200 s) If no other mark given, award 1 mark for calculating charge transfer during 2.6 hr period as 18.7 kC	2	2 × AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
03.2	Max 2 from: ✓ ✓ microwaves are transverse; sound are longitudinal; microwaves have higher frequency (than sound); microwaves can be polarised but sound can't; microwaves can travel through a vacuum but sound can't/requires a medium **OR** sound are mechanical waves but microwaves are EM waves	Apply list principle. Do not allow reference to applications e.g. cooking food. For first point, allow weak descriptions in terms of parallel and perpendicular oscillations/vibrations with direction of energy transfer.	2	2 × AO1

Question	Answers	Additional Comments/Guidance	Mark	AO
03.3	fixed/constant phase difference $_1$✓ same frequency $_2$✓	For $_1$✓ do not accept "in phase" or fixed path difference. For $_2$✓ condone "same wavelength". Ignore reference to other features e.g. amplitude or type of wave.	2	2 × AO1

Question	Answers	Additional Comments/Guidance	Mark	AO
03.4	evaluates **AM** from **AM**$^2 = 8.00^2 + 0.34^2$ **OR** evaluates **BM** from **BM**$^2 = 8.00^2 + 2.14^2$ ✓ $8.28 - 8.01 = 0.27$ (m) ✓	No credit for using double-slit equation. Expect 8.01 (m) for **AM** and 8.28 (m) for **BM**	2	2 × AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
03.5	statement that path difference = $\lambda/2$ **OR** uses wavelength = 2 × their **03.4** answer $_1$✓ evaluates $\frac{340}{\text{correct } \lambda}$ (Hz) $_2$✓	No credit for using double-slit equation. For $_1$✓ expect to see 0.54 or 0.60 m for wavelength For $_2$✓ expect 570 Hz (from 0.3 m) **OR** 630 Hz (from 0.27 m) **OR** 620 Hz (from 0.274 m). If no other mark given, allow 1130 Hz or 1260 Hz. for 1 mark.	2	2 × AO2

Total			10

Question	Answers	Additional Comments/Guidance	Mark	AO
04.1	(a =) 9.81 sin30 = 4.9 (m s^{-2}) seen ✓	Allow g sin30 or 9.8sin30 Accept cos60	1	AO2

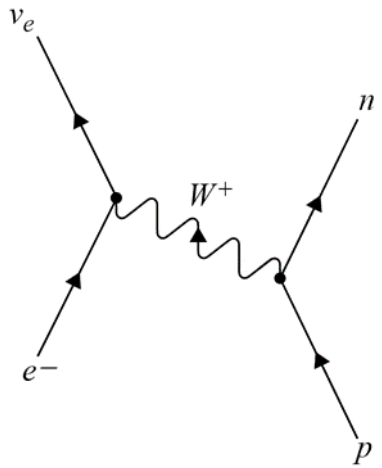
Question	Answers	Additional Comments/Guidance	Mark	AO
04.2	substitutes into $v^2 = u^2 + 2as$ e.g. $v^2 = 2 \times 5 \times 0.3$ **OR** uses $\frac{v^2}{2} = g\ 0.3 \cos 60$ ✓ 1.7 (m s^{-1}) ✓	Do not allow 9.81 for a in suvat equation.	2	2 × AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
04.3	attempt to find area between 0.35 s (**B**) and 0.80 s (**C**) $_1$✓ answer in range 390 to 400 (N s) $_2$✓	Max 1 for counting (small) squares **AND** a conversion factor of 2 N s stated Do not allow use of approximated shapes. For $_1$✓ need to see working for at least one part of the area under the graph. May see: Triangle: $0.5\times0.05\times1100 = 27.5$ Trapezium: $0.5\times(1100+1300)\times0.10 = 120$ Trapezium: $0.5\times(1000+1300)\times0.15 = 172.5$ Triangle: $0.5\times0.15\times1000 = 75$ Treat "400" as a 2 sf answer.	2	1 x AO3 1 x AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
04.4	uses a relevant time in suvat equation(s) to get s $_1$✓ doubles their s **OR** halves their **C** to **D** duration $_2$✓ answer that rounds to 0.5 (m) $_3$✓	For $_1$✓ condone 9.81 for a. Do not allow $_1$✓ or $_3$✓ for solutions that use u=1.7 m s^{-1} For $_1$✓ allow 0.60 to 0.63 s for duration **C** to **D.** 1. Direct method: $s = \frac{1}{2}at^2$ 2. a) Obtains u first using $v = u + at$ **OR** $s = ut + \frac{1}{2}at^2$ 2. b) Then s using $s = \frac{1}{2}(u + v)t$ **OR** $v^2 = u^2 + 2as$ Expect to see u = 1.5 (m s^{-1}) For $_3$✓ accept 0.44 (m).	3	2 × AO3 1 x AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
04.5	reads resting force from graph = 360 N **OR** divides an incorrect reading by 5 (4.91 N/kg) $_1$✓ 72 or 73 (kg) $_2$✓	for $_1$✓ allow use of their **04.3** with Δv = 3.2 m s^{-1}	2	1 x AO3 1 x AO2

Total			10

Question	Key	Answer
05	A (AO1)	electron alpha particle
06	C (AO3)	$100–1000\ \text{N m}^{-1}$
07	B (AO1)	A, K, mol, s
08	A (AO1)	
09	C (AO1)	antiproton baryon $\bar{u}\bar{u}\bar{d}$
10	B (AO1)	$^{13}_{6}\text{C}$
11	C (AO1)	polarised absorbs the incident beam
12	D (AO1)	$1.1 \times 10^{-19}\ \text{J}$
13	C (AO1)	line spectra
14	B (AO1)	10 2.0

15	C (AO2)	$\frac{2\pi d}{\theta}$
16	A (AO2)	0.8 m
17	B (AO1)	420 Hz
18	C (AO1)	The oscillations at two adjacent antinodes are in antiphase.
19	D (AO2)	7
20	A (AO2)	1.5 1.4
21	B (AO1)	kinetic energy
22	A (AO2)	14 N
23	C (AO1)	consists of two equal and opposite forces N m
24	D (AO1)	$t_P < t_Q$ $d_P > d_Q$
25	A (AO2)	increasing upwards constant downwards
26	C (AO2)	980 kJ
27	D (AO2)	290 W
28	B (AO2)	50 g
29	A (AO2)	$\frac{AEe^2}{2L}$
30	B (AO1)	increases.

31	D (AO2)	1.50 V
32	D (AO1)	270 V
33	A (AO1)	charge.
34	C (AO2)	the energy dissipated in the whole circuit, divided by the product It.