AQA

A-level
PHYSICS
7408/1

Paper 1

Mark scheme

June 2021

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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 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.

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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 <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. 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	Answers	Additional comments/Guidelines	Mark	AO
01.1	MP1 is for evidence of determining the charge on the nucleus. ✓ MP2 is for evidence of determining either the number of protons OR the number of nucleons. ✓ MP3 is for determining number of neutrons. ✓	Charge = $4.39 \times 10^{7} \times 8.02 \times 10^{-26}$ kg ($= 3.52 \times 10^{-18}$ C) Number of protons = charge/1.6×10^{-19} ($= 22$) OR Number of nucleons $= 8.02 \times 10^{-26} / 1.67 \times 10^{-27}$ ($= 48$) Number of neutrons $= 48 - 22 = 26$ Note use of 1.7 gives 27 neutrons and loses MP3	3	3×AO2.1f

Question	Answers	Additional comments/Guidelines	Mark	AO
01.2	Evidence of conversion of MeV to J ✓ Substitution into KE equation ✓ Correct final answer ✓	Energy = $2.15 \times 10^{8} \times 1.6 \times 10^{-19}$ ($= 3.44 \times 10^{-11}$ J) - allow POT error in MP1 $v^2 = 2E/m = 8.58 \times 10^{14}$ $v = 2.9(3) \times 10^{7}$ m s^{-1}	3	1×AO1.1b 2×AO2.1f

Question	Answers	Additional comments/Guidelines	Mark	AO
01.3	$\pi^+ \rightarrow e^+ + \nu_e$ OR charge: $1 = 1 + 0$✓ B: $0 = 0 + 0$ AND L: $0 = -1 + 1$✓ (S: $0 = 0 + 0$)		2	2×AO1.1b

Question	Answers	Additional comments/Guidelines	Mark	AO
01.4	$(K^+ \rightarrow \mu^+ + \nu_\mu)$ Correct strangeness $+1 = 0 + 0$ ✓ <u>Weak</u> interaction so strangeness can change (by 0, $+1$ or -1) ✓		2	2×AO1.1b

Question	Answers	Additional comments/Guidelines	Mark	AO
01.5	Decay consistent with Q B L conservation✓ Equation involving pions ✓	 e.g. $K^+ \rightarrow \pi^+ + \pi^+ + \pi^-$ $K^+ \rightarrow \pi^+ + \pi^0$	2	1×AO1.1a 1×AO1.1b
Total			**12**	

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	Rotate aerial in vertical plane ✓ When aerial vertical signal is a maximum When aerial horizontal signal is a minimum ✓ Max occurs when aerial aligned with plane of polarisation of microwave ✓	The first mark is for what needs to be done The second mark is for what is measured The third mark is for the link to polarisation	3	AO1.1b

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	Received signal goes through series of max and min✓ Reflected and direct microwaves interfere ✓ Path length of reflected wave/path difference increases as plate moved✓ Phase difference between reflected and direct waves changes (so signal strength changes.) ✓	First mark is for what is observed Accept 'both' for 'reflected and direct' If no other mark given, 1 mark can be awarded for mention of interference/ superposition/ out of phase	4	AO3.1a

Question	Answers	Additional comments/Guidelines	Mark	AO
02.3	Equation only valid if slit-screen distance is a lot greater than slit separation✓	Allow arguments in terms of angles Allow 0.45 m for slit-screen distance Allow use of standard symbols	1	AO3.1a

Question	Answers	Additional comments/Guidelines	Mark	AO
02.4	Maximum path length for first slit $= \sqrt{(0.45^2 + (0.25 - 0.06)^2)}$ $= 0.49$ m✓$_1$ Max path length for second slit $= \sqrt{(0.45^2 + (0.25 + 0.06)^2)}$ $= 0.55$ m✓$_2$ Path difference $= 0.55 - 0.49 = 0.06$ m Which is greater than half a wavelength – so yes✓$_3$	MP1 is for one path length correct MP2 is for both path lengths correct MP3 is for determination of path difference and conclusion. Alternative for MAX2 Young equation used to determine fringe separation. ✓$_{12}$ Idea that fringe separation < 0.25 m so wavelength can be determined. ✓$_3$	3	AO3.1a L2 Ma
Total			**11**	

Question	Answers	Additional comments/Guidelines	Mark	AO
03.1	Speed = $3.0 \times 10^8/1.47$ $= 2.0(4) \times 10^8$ m s^{-1} ✓	Do not accept 1 sf answer	1	AO1.1b

Question	Answers	Additional comments/Guidelines	Mark	AO
03.2	Critical angle calculation ✓ sin $C = n_{clad}/n_{core} = 1.41/1.47 = 0.96$ critical angle = 73.6^o Angle of refraction calculation✓ $r = 90 - C = 16.4^o$ Angle of incidence calculation ✓ sin (i) = 1.47 sin (r) $i = 24.5^o$	Do not give MP2 if calculated answer is given as A Allow 2 sf answer; allow 24.6^o	3	AO2.1d

Question	Answers	Additional comments/Guidelines	Mark	AO
03.3	Correct path of light drawn showing partial reflection and transmission of ray when it encounters the boundary ✓ Angle of incidence on core–cladding boundary decreases✓ And will now be less than critical angle ✓ (Some light will escape/be refracted into cladding Some light will continue)	If the diagram is not annotated and no other mark is given, 1 mark can be given for correct description of partial reflection.	3	AO3.1b
Total			**7**	

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	Centripetal force acts inwards / towards the centre of rotation ✓ Links reaction force to centripetal force ✓		2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	Equates forces AND states **either** centripetal force with correct symbols✓ cancelling ω✓ $m_A r\cancel{\omega^2} = m_B(L-r)\cancel{\omega^2}$ $r = \dfrac{m_B L}{m_A + m_B}$	E.g. $F = m_A r\omega^2$ $F = m_B(L-r)\omega^2$ In MP1 condone: equations containing v; use of ω_A and ω_B for the angular velocities. In MP2 it must be clear that the angular velocity and not the velocity.	2	AO2 L2 Maths 2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.3	The angular speed is the same for A & B or Rotational radius for B less than that for A ✓ Both of these points AND $v = r\omega$ so velocity of A is greater.✓	Alternative for MP2: Both of points in MP1 AND A travels greater distance in the same time.	2	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.4	Use of safety factor e.g. maximum stress << $0.300\ \text{GPa}$ ✓ $F = ma = 1.32 \times 10^6 \times 3.7$✓ $(= 4.9 \times 10^6\ \text{N})$ $A = \frac{F}{\sigma}$ valid substitution ✓ $d = \sqrt{\frac{4A}{\pi}}$ ✓ (expect $> 0.144\ \text{m}$) Valid justification for selection of maximum stress used e.g. using a stress that is from the linear / elastic section of the graph or reference to either safety factor or trying to limit weight of cable. ✓	Alternative for MP1: they can work through for a stress of $0.3\ \text{GPa}$ and then increase the diameter, if justified as a safety factor. Do not allow use of stress ≈$0.3\ \text{GPa}$ for full marks. Allow ecf for stress and force	5	AO3 L2 Maths 2
Total			**11**	

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	horizontal velocity $= 20\cos 40° = 15.3$ ✓ (m s^{-1}) horizontal velocity (is constant) / minimum when vertical velocity $= 0$ ✓	Needs minimum 3 sf For MP1 it must be clear that the horizontal velocity has been determined.	2	AO2 L2 Maths 1

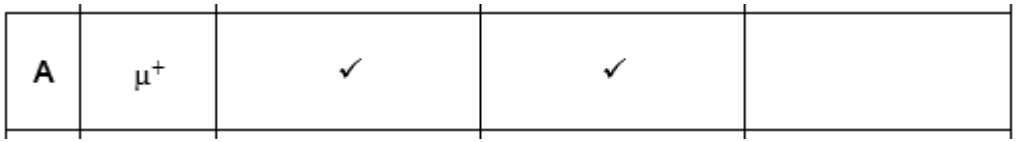
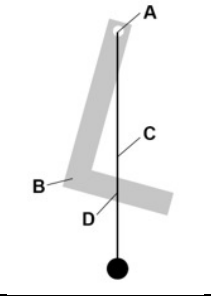
Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	(vertical velocity) $v = 20\sin 40°$ $(= 12.9)$ ✓ (m s^{-1}) $s = ut + \frac{1}{2}at^2$ $-3 = -12.9t + \frac{1}{2} \times 9.81t^2$ or $3 = 12.9t - \frac{1}{2} \times 9.81t^2$ ✓ $(4.91t^2 - 12.9t + 3.00 = 0)$	For second mark both suvat equation and substitution must be shown. Equation may be rearranged before substitution	2	AO1 AO2 L2 Maths 2

Question	Answers	Additional comments/Guidelines	Mark	AO
05.3	Use of quadratic formulae with $+$, $-$ or $\pm$ ✓ 0.258 s and 2.37 s✓ Time to reach 3 m once on the way up and once on the way down (OWTTE)✓ Larger value ✓	eg $t = \frac{12.9 \pm \sqrt{(-12.9)^2 - 4 \times 4.91 \times 3.00}}{2 \times 4.91}$ Two correct answers alone scores first 2 marks. ecf available for last 2 marks	4	AO1 AO1 L2 Maths 2 AO2 AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
05.4	$s = vt = 20 \cos 40° \times 2.37 = 36.3$ m so no✓	ecf from **05.3** Calculation must be seen	1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
05.5	Gradient is the acceleration **AND** area under graph = <u>vertical</u> distance travelled✓$_1$ Without air resistance: comment about gradient✓$_2$ comment about area✓$_3$ With air resistance comment about gradient✓$_4$ comment about area✓$_5$	For each comment on the graph a reason must be given not just a description. e.g for ✓$_2$ • constant gradient = g or $9.81\ \text{m s}^{-1}$ e.g. for ✓$_4$ • initially steeper gradient since air resistance in same direction as weight (so $a > g$) • when line crosses time axis, gradient = g /9.81 / gradient without air resistance as air resistance = 0 when $v = 0$ / • After crossing time axis, gradient decreases as air resistance increases with speed E.g. for ✓$_3$ or ✓$_5$ • total area under graph = 0 since ball starts and finishes on ground • area between graph and axis is max height/**vertical** distance • without air resistance reaches a higher height as area greater statement referring to area under both graphs gains ✓$_3$ and ✓$_5$	5	AO1 AO2 AO2 AO3 AO3
Total			**14**	

Question	Answers	Additional comments/Guidelines	Mark	AO
06.1	R_{LDR} without light = 300 kΩ ✓ $I = \frac{V}{R} = \frac{5}{310 \times 10^3} = 16.1 \times 10^{-6}$ A ✓	 Allow ecf for their R	2	AO3 AO1 L3 Maths 1
06.2	V with without light = $IR = 16.1 \times 10^{-6} \times 300 \times 10^3 = 4.84$ V✓ With light $V = \left(\frac{93}{93+10}\right) \times 5.0 = 4.51$ V ✓ Conclusion and calculate of change in voltage and comparison with 1.25 V✓	ecf from **06.1** Allow 92–100 kΩ 4.8 – 4.5 = 0.3 V so no. Allow 1 sf (allow ecf)	3	AO1 AO1 AO3 L3 Maths 2
Total			**5**	

Question	Key	Answer
07	D	1×10^{7} J
08	B	10^{-14} km
09	A	
10	A	$\alpha + \beta^- + \beta^- + \alpha + \alpha$
11	A	up quark down quark neutrino
12	B	It has a charge of -1.6×10^{-19} C.
13	B	3.3×10^{-19} J
14	D	It emits photons of UV light following ionisation or excitation.
15	C	1.6×10^{-18} J
16	B	muon electron
17	D	The frequency is 0.17 Hz.
18	A	**P** is in antiphase with **R** **P** has the same amplitude as **Q**
19	C	433 nm
20	D	9.6 N
21	B	2.25 m
22	C	
23	C	G F
24	A	the acceleration of the car increases.

25	C	250 J
26	C	$\frac{\rho}{4}$ $\frac{E}{4}$
27	D	4.2 V 1.4 V
28	B	0.47 A
29	D	24 V
30	B	$2T$ T
31	D	$\frac{2\pi^2 mA^2}{T^2}$