A-LEVEL
PHYSICS
7408/3BD

Paper 3 Section B Turning points in physics

Mark scheme

June 2022

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.

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. 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/Guidance	Mark	AO
01.1	Light consists of corpuscles that travel in straight lines ✓ (which means that) shadows are formed with sharp edges ✓	Condone 'particles' for 'corpuscles' Accept description of travelling in straight lines. In MP2 accept: no diffraction, **only**/**just** 2 lines/fringes seen, sharp shadows, lines are distinct Treat references to interference as neutral.	2	1 x AO1 1 x AO2

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidance</th><th>Mark</th><th>AO</th></tr>
<tr>
<td>01.2</td>
<td>The mark scheme gives some guidance as to what statements are expected to be seen in a 1 or 2 mark (L1), 3 or 4 mark (L2) and 5 or 6 mark (L3) answer. Guidance provided in section 3.10 of the ‘Mark Scheme Instructions’ document should be used to assist in marking this question.
<table>
<tr><th>Mark</th><th>Criteria</th></tr>
<tr><td>6</td><td>All three areas covered well.
6 marks can be awarded even if there is an error and/or parts of one aspect missing.</td></tr>
<tr><td>5</td><td>A fair attempt to cover all 3 areas, but one area may only be covered partially.</td></tr>
<tr><td>4</td><td>Two areas successfully covered, or one covered and two others covered partially. Whilst there will be gaps, there should only be an occasional error.</td></tr>
<tr><td>3</td><td>One area covered and one covered partially, or all three covered partially. There are likely to be several errors and omissions in the discussion.</td></tr>
<tr><td>2</td><td>One area covered, or two covered partially</td></tr>
<tr><td>1</td><td>Only one area partially covered.</td></tr>
<tr><td>0</td><td>No relevant analysis.</td></tr>
</table>
</td>
<td>Accept information seen in an appropriate diagram.
The following statements are likely to be present.

A alterations to experiment
Slits separation / width should be closer to wavelength of wave.
Make slits narrower and closer together.
Use monochromatic (red) light
use a single slit (to make the light coherent)
Use a laser as it is coherent/ monochromatic

B description of Huygens’ theory
Light is a wave.
The theory uses the idea of (secondary) wavelets.
Every point on wavefront acts as source of secondary wavelets.

C explanation in terms of Huygens
(When wave reaches slit) each point at slit produces secondary wavelets.
Wavelets overlap on screen.
Path difference due to different distances between a point on the screen and the two slits.
Path difference introduces phase differences.
Bright fringes form where path difference is whole number of wavelengths/waves arrive in phase.
Dark fringes where path difference is odd number of half wavelengths/waves arrive in antiphase. Do not accept ‘out of phase’.

The mention of destructive/constructive interference or diffraction on its own does not gain credit.</td>
<td>6</td>
<td>2 x AO3

4 x AO1</td>
</tr>
</table>

Question	Answers	Additional comments/Guidance	Mark	AO
01.3	(Most of the screen dark) Newton's theory predicts: (bright) central spot surrounded by partial shadow ✓ Huygens' theory predicts: (bright region with) fringes around the edge✓ edge of bright region/fringes coloured ✓	Credit labelled additions to diagram Condone MP1 for any suggestion of gradual decrease in brightness moving out from central region, e.g. suggestion it resembles a central maximum with no other maxima. Do not accept fringe.	3	1 x AO2 2 x AO3
Total			**11**	

Question	Answers	Additional comments/Guidance	Mark	AO
02.1	(Drop stationary so) Electric force is opposite (in direction) to the weight AND electric field downwards/top plate positive/(electric) force towards positive plate so Q negative ✓	Give credit to answers shown on the diagram Allow forces expressed in symbols Do not allow suggestion that viscous force is involved Accept idea that the drop is attracted towards the positive plate. Accept bottom plate negative as an alternative to top plate positive.	1	AO1

Question	Answers	Additional comments/Guidance	Mark	AO
02.2	(In free fall at terminal speed) $mg = 6\pi\eta rv$✓ Use of m = volume × density AND $V = \frac{4}{3}\pi r^3$ ✓ (to give $r = 5.9 \times 10^{-7}$ m) (use of volume of sphere and density) to give answer that rounds to $m = 7.7 \times 10^{-16}$ (kg) ✓	At least 2 sf.	3	3 x AO2

Question	Answers	Additional comments/Guidance	Mark	AO
02.3	$\frac{VQ}{d} - mg = 6\pi\eta r v_2$ ✓ Convincing algebra combining with $mg = 6\pi\eta r v_1$ to give v_2/v_1 = answer✓	MP2 is contingent on MP1	2	2 x AO2

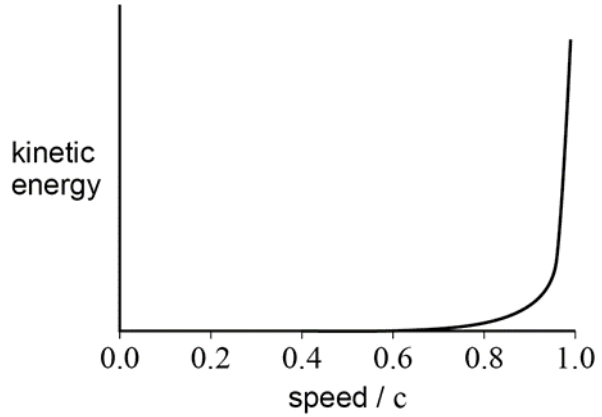
Question	Answers	Additional comments/Guidance	Mark	AO
02.4	Use of equation from **02.3** ✓ to show $Q = 4.9 \times 10^{-19}$ C ✓ Evidence of dividing their Q by 1.6×10^{-19} to give a consistent conclusion ✓	Use of means by substitution or manipulation Accept answer that rounds to between 4.8 and 5.0×10^{-19} C Using the 'show that' value for the mass gives $Q = 4.96 \times 10^{-19}$ C Only condone ecf in MP3 for an arithmetic error in the determination of Q.	3	2 x AO2 1 x AO3

Question	Answers	Additional comments/Guidance	Mark	AO
02.5	(Value of viscosity) affects calculation of mass/radius of droplet ✓ Smaller value of viscosity gives smaller force on droplet so smaller calculated weight/mass ✓ Ref to appropriate equation AND as mass is smaller then Q smaller (therefore e smaller). ✓	'affects' can be either increase or decrease in MP1 In MP2 allow use of relationship between the radius of the drop and the viscosity. Evidence of MP1 is likely to be seen in MP2. Do not condone use of $mg = 6\pi\eta rv$ on its own Appropriate means either the equation from **02.3** or relationship between weight and electric field force (e.g weight = $mg = EQ$)	3	3 x AO3
Total			**12**	

Question	Answers	Additional comments/Guidance	Mark	AO
03.1	frequency (of rotation) of W when no reflected light seen ✓ and idea that this is the lowest frequency✓	MP2 is contingent on MP1 Do not accept 'first frequency' for MP2	2	2 x AO1

Question	Answers	Additional comments/Guidance	Mark	AO
03.2	Either Calculate using equation (max measurable speed) $= 2.5 \times 10^{8}\ \text{m s}^{-1}$ OR Calculate value of f_0 (needed) $= 12(.25)\ \text{Hz}/735\ \text{rev min}^{-1}$ ✓ Conclusion: No as the largest possible speed is less than the speed of light OR the frequency required to find the speed of light is greater than the maximum frequency. ✓	Condone alternative methods e.g. comparison of times etc. Unit needed for MP1 Condone ecf in MP2 only for an arithmetic error in MP1 e.g. incorrect conversion to Hz.	2	1 x AO1 1 x AO3

Question	Answers	Additional comments/Guidance	Mark	AO
03.3	ε_0 related to electric field strength (due to charged object) in free space ✓ μ_0 related to magnetic flux density/magnetic field strength (due to current carrying wire) in free space ✓	Accept vacuum for free space If no other mark given, award MAX 1 for ε_0 related to electric field (in free space) AND μ_0 related to magnetic field (in free space)	2	2 x AO1
Total			**6**	

Question	Answers	Additional comments/Guidance	Mark	AO
04.1	C ✓  	Only answer	1	AO1

Question	Answers	Additional comments/Guidance	Mark	AO
04.2	KE = total energy – rest energy ✓ $m_0c^2 = \frac{m_0c^2}{\sqrt{1-\frac{v^2}{c^2}}} - m_0c^2$ ✓ To give $v = 0.87c$ OR 2.6×10^8 m s^{-1} ✓	MP2 requires the use of the idea that the KE is equal to the rest energy. (calculator values are 0.8660 and 2.59808×10^8)	3	3 x AO2

Question	Answers	Additional comments/Guidance	Mark	AO
04.3	mass is related to energy through $E = mc^2$ ✓ When an object stores energy this appears as an increase in observed mass. OR A spring gains (elastic potential) energy so observed mass must also increase. ✓	Treat any idea that 'the difference in observed mass is negligible' as neutral.	2	2 x AO3
Total			**6**	