AS
PHYSICS
7407/2

Paper 2

Mark scheme

June 2021

Version: 1.0 Final

2 1 6 A 7 4 0 7 / 2 / M S

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	smooth line drawn within half grid square of points ✓ minimum between 32.6 and 32.8 cm ✓		2	AO3-1a

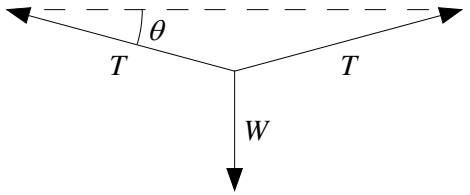
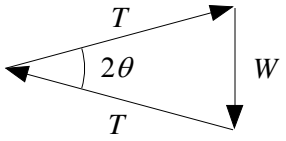
Question	Answers	Additional Comments/Guidance	Mark	AO
01.2	value of their minimum (cm) ✓	Within a half grid square	1	AO3-1b

Question	Answers	Additional Comments/Guidance	Mark	AO
01.3	doubles 0.2 **OR** calculates percentage uncertainty for 0.2 (half range) ✓ 0.8 $(\%)$ ✓	Correct answer earns both marks CAO	2	AO3-1b

Question	Answers	Additional Comments/Guidance	Mark	AO
01.4	recognises that node-to-node spacing = $\lambda/2$ ✓ recognises the need to divide by 8 ✓ 2.36×10^9 (Hz) ✓	 Condone use of 7 or 9 3 sf required For example: $\lambda = \frac{0.509 \times 2}{8}$ or $0.127(25)$ m seen; top line earns $_1$✓ and bottom line earns $_2$✓ $f\left(=\frac{3\times10^8\times8}{0.509\times2}\right) = 2.36 \times 10^9$ (Hz) earns all 3 marks $f\left(=\frac{3\times10^8\times7}{0.509\times2}\right) = 2.06 \times 10^9$ earns 2 marks $f\left(=\frac{3\times10^8\times9}{0.509\times2}\right) = 2.65 \times 10^9$ earns 2 marks Allow 2 marks for 4.72×10^9 (must be 3 sf)	3	2 × AO3-1a 1 × AO2-1h

Question	Answers	Additional Comments/Guidance	Mark	AO
01.5	(microwaves are) <u>polarised</u> ✓		1	AO1-1b
Total			**9**	

Question	Answers	Additional Comments/Guidance	Mark	AO
02.1	correctly deduces extension is 2.6 or 2.7 mm ✓	Should see $AC^2 = 1.50^2 + (6.34 \times 10^{-2})^2$; (new) AC = 1.50134; Extension of AC = $(1.50134 - 1.50 =)\ 0.00134$ m or 1.34 mm; and then doubles this Final value must be to at least 2 sf	1	AO2-1h

Question	Answers	Additional Comments/Guidance	Mark	AO
02.2	evidence of correct working: ✓ $\sin\theta = \frac{6.34\times10^{-2}}{\text{their new AC}}$ or $\theta = 2.42°$ seen **OR** $W = 2T\sin\theta$ seen **OR** suitable vector diagram with θ labelled tension correctly calculated from $\frac{1.0}{2\times\text{their }\sin\theta}$ ✓	For 1✓ acceptable diagrams are shown below   Correct final answer of 11.8 N or 12 N earns both marks	2	AO2-1h

Question	Answers	Additional Comments/Guidance	Mark	AO
02.3	ruled best-fit line between first and sixth points; line must pass above 2nd point **and** must pass below 4th point $_1$✓ gradient calculated from $\frac{\Delta(W/y)}{\Delta y^2}$ with $\Delta y^2 \geq 0.004$ $_2$✓ evidence of using E = $\frac{\text{their gradient} \times 1.50^3}{1.11 \times 10^{-7}}$ $_3$✓ E in range 1.10×10^{11} to 1.24×10^{11} (Pa) $_4$✓	for $_1$✓ withhold mark if line is thick, faint or discontinuous for $_2$✓ condone read off errors of $\pm$ 1 division for $_3$✓ note that $1.50^3 = 3.375$ so allow sub of 3.38 for $_4$✓ reject 2 sf 1.2×10^{11} (gradient ~ 3850)	4	2 × AO2-1h 2 × AO3-1b

Question	Answers	Additional Comments/Guidance	Mark	AO
02.4	kg s^{-2} ✓	no credit for N m^{-1} correct answer only	1	AO1-1b

Total			**8**

Question	Answers	Additional Comments/Guidance	Mark	AO
03.1	9.65 mm ✓		1	AO1-1b

Question	Answers	Additional Comments/Guidance	Mark	AO
03.2	close jaws using ratchet without pencil (to find zero error) ✓ add/subtract zero error from each reading **OR** take multiple readings along pencil or around the pencil and find the mean ✓	Condone "close micrometer fully"	2	AO1-1b
Total			**3**	

Question	Answers	Additional Comments/Guidance	Mark	AO
04.1	arrow between block and belt pointing upwards along the belt ✓		1	AO1.1-a

Question	Answers	Additional Comments/Guidance	Mark	AO
04.2	$(F\ =)\ 19g\sin 23°$ to give 72.8 (N) ✓	Allow 2 sf answer.	1	AO2.1-f

Question	Answers	Additional Comments/Guidance	Mark	AO
04.3	uses $F = \frac{\Delta(mv)}{\Delta t}$ ✓ $F = 12$ (N) ✓ their **04.2** + 12 (N) ✓	Allow for MP1 use of appropriate kinematic equation for a **AND** use of $F=ma$ Expect 82 or 85 (N)	3	AO2.1-b

Question	Answers	Additional Comments/Guidance	Mark	AO
04.4	uses V and I to get total input power or energy ✓	P_{input} of motor = $110 \times 5.0 = 550$ W $E_{input} = 550 \times \frac{8.0}{0.32} = 13\,750$ J	4	AO3.1-a
	uses efficiency equation ✓	P_{useful} to belt = $550 \times 0.28 = 150$ W $E_{useful} = 3850$ J, from $154 \times \frac{8.0}{0.32}$, or $13\,750 \times 0.28$		
	determines power or energy to move one block ✓	$P_{block} = 22$ or 23 W $E_{block} = 560$ or 580 J		
	divides (total) useful power or energy by individual power or energy to give answer of 6 blocks ✓	Allow ecf for MP4 only for their **04.3**		
Total			**9**	

Question	Answers	Additional Comments/Guidance	Mark	AO
05.1	substitution into $E = hc/\lambda$ ✓ multiplies E by 3.0×10^{16} to give 0.0136 (W)✓	Condone POT error on MP1	2	AO2.1-f

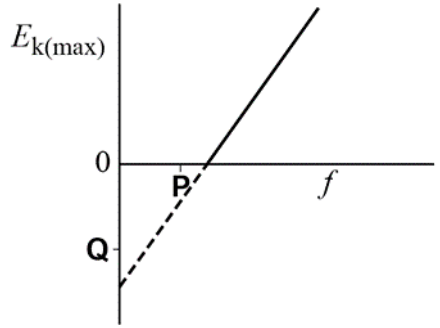
Question	Answers	Additional Comments/Guidance	Mark	AO
05.2	considers the effect of wavelength on power or emission rate ✓	Red photon energy calculated (3.0×10^{-19} J) and used with $P = E_{photon} \times$ rate of emission Alternative for MP1: red photon energy is $\frac{440}{660}$ times smaller (than blue photon energy)	3	AO3.1-a
	considers the maximum possible, or required, emission rate ✓	maximum emission rate is 6.9×10^{16} s^{-1} **OR** evaluates required emission rate as 9.0×10^{16} s^{-1}		
	combining MP1 and MP2 with reference to graph to reach the conclusion that it is not possible ✓	not possible as: max emission rate is 6.9×10^{16} s^{-1}, and required is 9.0×10^{16} s^{-1} max power is 0.021 W, and required is 0.028 W max current is 60 mA, and required is > 60 mA		

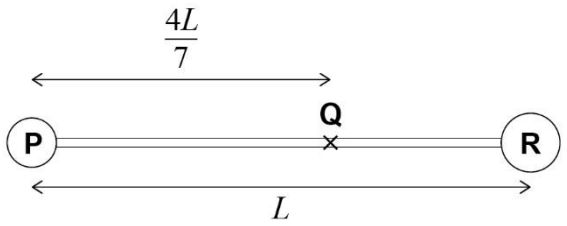
<table>
<tr><th>Question</th><th>Answers</th><th>Additional Comments/Guidance</th><th>Mark</th><th>AO</th></tr>
<tr><td>05.3</td><td>The mark scheme for this question includes an overall assessment for the quality of written communication (QWC). There are no discrete marks for the assessment of QWC but the candidate's QWC in this answer will be one of the criteria used to assign a level and award the marks for this question.
<table>
<tr><th>Mark</th><th>Criteria</th><th>QWC</th></tr>
<tr><td>6</td><td>All 3 areas A, B and C covered
Only allow minor omissions</td><td rowspan="2">The student presents the relevant information coherently, employing structure, style and SP&G to render meaning clear. The text is legible.</td></tr>
<tr><td>5</td><td>2 complete descriptions with one partial from A, B and C.</td></tr>
<tr><td>4</td><td>Full description of one area, with partial description of two other.
OR
Full description of two areas with very little on third or nothing at all.</td><td rowspan="2">The student presents relevant information in a way which assists the communication of meaning. The text is legible. SP&G are sufficiently accurate not to obscure meaning.</td></tr>
<tr><td>3</td><td>A full description of one area and a partial description of one area.
OR
A partial discussion of all three areas.</td></tr>
<tr><td>2</td><td>A full description of one area.
OR
A partial discussion of two areas.</td><td rowspan="2">The student presents some relevant information in a simple form. The text is usually legible. SP&G allow meaning to be derived although errors are sometimes obstructive.</td></tr>
<tr><td>1</td><td>Only one area covered, and that partially.</td></tr>
<tr><td>0</td><td>No relevant information</td><td></td></tr>
</table></td><td>Area A - Wavelength comparison:
• Red LED will emit longer wavelengths than $660\ \text{nm}$ (accept "longer than red light).
• Blue LED will emit wavelengths longer than $440\ \text{nm}$ (accept "longer than blue light).
• Blue LED will emit visible light. Accept named colours.

Area B - Excitation process:
• Excitation mentioned (as first step of fluoresence)
• Photons are absorbed by atoms in coating
• Atoms are excited/gain energy;
• Atomic electrons move to higher energy levels (than $n = 2$)
• Photons have sufficient energy to promote electrons to high enough levels

Area C - De-excitation process:
• De-excitation or relaxation mentioned (as subsequent step)
• Photons are emitted by atoms in coating
• Atoms de-excite/lose energy
• Atomic electrons move to lower energy levels
• Electrons move to ground state via other energy levels
• Emitted radiation consists of (a range of) lower photon energies/frequencies or longer wavelengths</td><td>6</td><td>4 × AO1.1-a

2 × AO2.1-a</td></tr>
<tr><td>Total</td><td></td><td></td><td>11</td><td></td></tr>
</table>

Question	Key	Answer
06	A	$-1.3 \times 10^{7}\ \text{C kg}^{-1}$
07	D	W^{+}
08	A	$\Lambda^{0} + \pi^{-}$
09	B	$1.2 \times 10^{-14}\ \text{m}$
10	B	$\sqrt{2}v$
11	D	$\frac{mv^{2}}{2}$
12	D	repulsive attractive negligible
13	A	$0.3 \times 10^{-19}\ \text{J}$
14	C	$p + e^{-} + \bar{\nu}_{e}$
15	B	above **MN** by $0.20\ \text{m}$
16	D	Only total momentum is conserved.
17	B	third
18	D	$70°$
19	C	using monochromatic light of higher frequency
20	B	$1.7\ \text{A}$
21	C	

22	C	
23	B	190 m
24	D	moving up with a decreasing velocity.
25	C	$80\ \text{m s}^{-1}$
26	A	$\frac{mg\Delta L}{2}$
27	C	The acceleration of **X** is the same as that of **Y**.
28	C	The terminal speed of **Y** is greater than that of **Z**.
29	D	6 A
30	A	$\frac{3R}{7}$
31	D	23.0 mA
32	A	$\frac{F\rho L^2}{m\Delta L}$
33	C	13.5%
34	C	produce strong magnetic fields.

35	A