A-LEVEL
PHYSICS
7408/3BB

Paper 3 Section B Medical physics

Mark scheme

June 2019

Version: 1.0 Final

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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 Assessment Writer.

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.

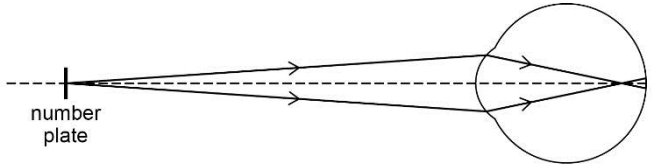
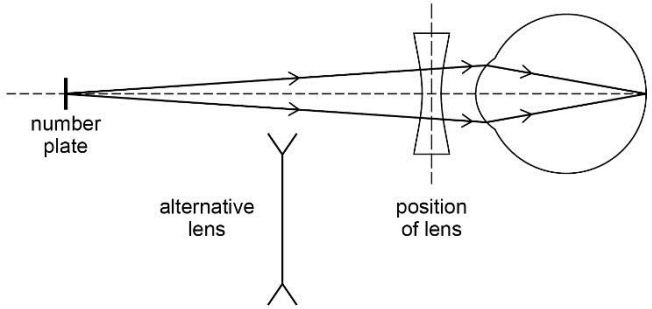
When assigning a level you should look at the overall quality of the answer and not look to pick holes in small and specific parts of the answer where the student has not performed quite as well as the rest. If the answer covers different aspects of different levels of the mark scheme you should use 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
01.1	Myopia		1
01.2	Rays bends inward at **cornea** on both diagrams ✓ Figure 1 image in front of retina ✓ Figure 2 image on retina ✓ Concave lens drawn, which bends rays outward ✓	Max 3, if light rays are not drawn with a ruler  	`

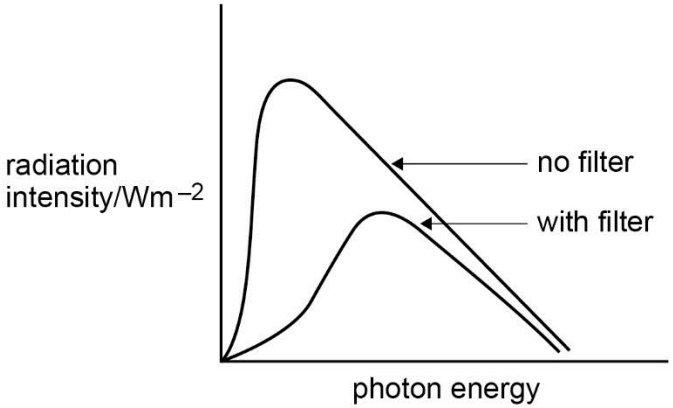
01.3	rejection of C / $+1.95$ D since it is the wrong shape / wrong sign / convex / corrects wrong defect ✓1 Any valid substitution demonstrating $P = \frac{1}{f}$ and evidence of the correct usage of u and v ✓2 1st valid calculation of either virtual image location or aided near / far point for A, B or C or calculation of lens needed to correct far point or calculation of lens needed to see number plate✓3 2nd valid calculations of either virtual image location or aided near / far point for A, B ✓4 **Lens B / –1.77 D** because it is the only lens where both number plate and speedometer can be seen (lens A cannot focus on speedometer) ✓5	✓1 must have a valid reason ✓2 f may be calculated and substituted or P used as $\frac{1}{f}$ in equation. Ignore use of $\frac{1}{x}$, correct use of u, v must be seen For virtual image location v must be subject For aided near/far point u must be subject Ignore PoT and sign errors ✓3 and ✓4 Mark 3 (options) Lens to correct far point $P = -1.82$ D or $f = -0.55$ m Lens to see number plate $P = -1.77$ D or $f = -0.57$ m Lens C speedometer $v = -20\ m$ Lens C number plate $v = 53$ cm (=0.53 m) Mark 3 or Mark 4 (options) Lens A speedometer $v = -24$ cm Lens A number plate $v = -45$ cm Lens B speedometer $v = -27$ cm Lens B number plate $v = -55$ cm Lens A aided far point $u = \infty$ (-2.76m) Lens A aided near point $u = 55$ cm Lens B aided far point $u = 2080$ cm (= 20.8 m) Lens B aided near point $u = 45$ cm ✓5 must be supported by calculations for B showing both number plate and speedometer can be seen Identification of the lens with no supporting evidence scores 0.	1 1 1 1 1
Total			**10**

Question	Answers	Additional Comments/Guidelines	Mark
02.1	$I \propto \frac{1}{A} = \frac{1}{r^2}$ or $P = IA = 3.4 \times 10^{-8} \times 4\pi 11^2$ ✓ $(= 5.17 \times 10^{-5}\ \text{W})$ Either ($I = \frac{3.4 \times 10^{-8} \times 11^2}{7^2}$ or $I = \frac{P}{A} = \frac{5.17 \times 10^{-5}}{4\pi 7^2}$) = $8.4 \times 10^{-8}\ \text{W m}^{-2}$ ✓	M1 Working mark Evidence of either a proportion calculation or calculation of power from intensity Use of $I \propto \frac{1}{r^2}$ with the wrong factor for r still scores M1 (but not M2) M1 cannot be awarded if πr^2 is used for the area but M2 can still be awarded.	1 1
02.2	One from $I_1 = I_0 10^{\frac{IL}{10}} = 10^{-12} \times 10^{4.2} = 1.58 \times 10^{-8}\ \text{W m}^{-2}$ or $I_2 = I_0 10^{\frac{IL}{10}} = 10^{-12} \times 10^{6.5} = 3.16 \times 10^{-6}\ \text{W m}^{-2}$ or $\frac{I_2}{I_1} = 10^{6.5-4.2}$ or $\frac{I_2}{I_1} = \frac{10^{6.5}}{10^{4.2}}$ ✓ $\frac{I_2}{I_1}\left(= \frac{3.16 \times 10^{-6}}{1.58 \times 10^{-8}} \text{ or } 10^{6.5-4.2}\right) = 200$ ✓	Correct values for I_1 or I_2 or a correct rearranged substitution can gain M1 Ignore any units given Accept anything from a correct calculation that rounds to 200 to 2SF	1 1
02.3	<u>Intensity level</u> must be stated uses a **logarithmic** scale ✓ which matches the response of the human ear ✓	Do not allow matches the **frequency** response of the human ear for the second mark. Mark 2 is dependent on mark 1	1 1

02.4	**P and Q** would hear (all frequencies) at lower volume/quieter than **R**. ✓ **P** would experience most hearing loss at high frequencies (compared to **R**) ✓ **Q** would experience most hearing loss at/around $4\ \text{kHz}$ (compared to **R**) ✓	If no other marks are given allow 1 mark for P hears at a lower volume/quieter than R and Q's hearing loss is frequency dependent✓	1 1 1

Total			**9**

Question	Answers	Additional Comments/Guidelines	Mark
03.1	Smooth curve/continuous spectrum is due to the deceleration of the electrons / transfer their kinetic energy to X-ray photons ✓1 Maximum energy limited by kinetic energy / accelerating voltage of electrons. ✓2 Electrons are decelerated by different amounts so a continuous spectra is emitted. ✓3 Spikes/discrete/characteristic spectra due to electrons knocking <u>inner electrons</u> from atoms. ✓4 <u>Outer electrons</u> drop down to fill the gaps left behind. ✓5 Emitting X-ray photons (with the energy lost) by the electrons moving downwards (producing specific energies only/discrete spectrum) ✓6 (Max 4)	Bremsstrahlung is not expected but is allowed for smooth curve or continuous spectrum. Condone acceleration for deceleration in ✓1 and ✓3 If candidates are missing inner and outer but would otherwise gain ✓4 and ✓5 award one mark ✓45	1 1 1 1

03.2	Peak **and** final point moves to the right ✓ Intensity larger at all points (except 0,0) and location of spikes remain the same ✓		1 1
03.3	Peak moves to the right, start at 0,0 end at or before end of existing curve, curve at or below at all points ✓  	Ignore spikes even if incorrectly placed (penalised in question 03.2) Be tolerant of shape if marking criteria are met.	1
Total			**7**

Question	Answers	Additional Comments/Guidelines	Mark
04.1	$t = (32.5 - 3.0) \times 10^{-6} (= 29.5 \times 10^{-6}\ \text{s})$ ✓ $s = vt = 1560 \times 29.5 \times 10^{-6}$ ✓ $(= 46 \times 10^{-3}\ \text{m})$ Eyeball length $= \frac{46 \times 10^{-3}}{2} = 23 \times 10^{-3}$ ✓ m	1st mark is for correctly using the timing from the first and last reflection. ecf for 2nd and 3rd mark if wrong reflections used. 3rd mark is for dividing by 2 and is independent	1 1 1

<table>
<tr>
<td>04.2</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>Select the B-scan,

Cover all 3 areas in detail, referring to both scans in at least 2 areas, without error.

It must relate to amniocentesis.</td></tr>
<tr><td>5</td><td>Select the B-scan,

Cover all 3 areas, referring to both scans in at least 2 areas. May contain minor errors.

It must relate to amniocentesis.</td></tr>
<tr><td>4</td><td>choose the B-scan

Cover at least 2 areas, referring to both scans
Or cover all 3 areas referring to one scan</td></tr>
<tr><td>3</td><td>Cover at least 2 areas referring to one scan
Or Cover 1 area referring to both scans in detail

It may or may not choose the B-scan.</td></tr>
<tr><td>2</td><td>Cover 1 area referring to both scans

It may or may not choose the B-scan</td></tr>
<tr><td>1</td><td>Cover 1 area referring to one scan.

It may or may not choose the B-scan</td></tr>
<tr><td>0</td><td>No relevant comments</td></tr>
</table>
</td>
<td>
Difference between the A-scan and B-scan

Multiple sensors in B-scan as opposed to one sensor in A-scan
A scan intensity determines amplitude
B scan intensity determines brightness

Advantages/Disadvantages
A-scan

An A-scan only produces a graph
Good for accurately determining distances (where a limited number of surfaces lie along a straight line)
With complex structures it is difficult to identify which surface produces which echo
The structures may not lie along one line

B-scan

B-scan produces a picture
A 2D cross section is obtained rather than a single line
Allows the structures to be identified more easily
Allows features that are not along one line to be identified
Harder to accurately determine distances along a straight line

Suitability
Why a B-scan is suitable

Multiple features of needle, foetus, uterus and placenta require an image to identify

Why an A-scan is not suitable

Multiple features of needle, foetus, uterus and placenta
are complex structures
which do not lie along a straight line
cannot be easily identified on a graph

</td>
<td>6</td>
</tr>
</table>

Total			**9**