A-LEVEL
PHYSICS

7408/3BB Medical Physics
Report on the Examination

7408/3BB
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Question 1

This question was well answered, with the vast majority of students being awarded at least one of the marks for relevant comments about the comparative properties of beta and gamma radiation. A two-mark answer required mention of ionisation at some point in the response, rather than less specific “damage” or “harm”. A substantial number of students forfeited their second mark for this omission.
A small minority of students confused the properties of beta and gamma radiation, some stating that either one or the other of them was not ionising.

Question 2

02.1
This question was answered poorly, with less than half of the students gaining any marks. Many unsuccessful students attempted to apply the lens equation which was not applicable for the context. Another common unsuccessful approach was to find the area of the cone cell. A significant number of students simply divided the eye length by the cone diameter. Since the eye length was not considered to be “their image size”, this approach was not awarded any credit. Most of the students who correctly approached the question by use of ratios did this successfully, obtaining one of the stated answers; hence the award of two marks was more common than one. Award of the final mark required the recognition that the diameter of the cone needed to be doubled in order to find the minimum separation required for resolution. Many students omitted this step; some used incorrect factors of three or a half.

Answers in which the distance on the screen was considered to be the distance from the centre of one dark pixel to the centre of the next dark pixel could obtain full credit. Answers with “reverse” working that used a $1\ \text{cm}$ object size on the screen in a correct ratio calculation could also gain full credit. Power of ten errors were common, particularly in the conversion into pixels per cm, again forfeiting the final mark.

02.2
More than half of the students gained some credit for this question. The majority of students who were awarded zero failed to link their answer to the eye at all, instead discussing the light levels on the pixels. Many students recognised that the key to this question was the eye’s use of cones in bright conditions and rods when the light level is reduced. Although the question referred only to “reduced” intensity rather than darkness, students were expected to infer from the stated decrease in resolution that cones were no longer in use and rods were exclusively in operation. Although students did not have to be explicit about this in their statement, they were penalised for suggesting that cones were still activated when the image could no longer be resolved.

Many students also recognised the relevance of the fact that cones have their own unique neurone whereas rods share their neurones; however many then struggled or did not attempt to explain why this would lead to a reduction in resolution. Some excellent answers were seen, which could be expressed in a variety of ways, but these were not common.
The inclusion of additional information about rods and cones, which had no relevance to the question, was not uncommon.

02.3
The majority of students made an attempt at this question and understood what was required.

Those who were not awarded the mark had most commonly failed to read carefully from the graph, with readings that fell outside the accepted range. This was despite an unusually large acceptable range being allowed on the green cone data due to the steepness of the graph at this point.
The other less common reason to fail to score the mark was a failure to manipulate the data. Given that this was a “show that” question, some quantitative comparison of the data was required.

02.4
Students found this question very challenging, with only a quarter of students gaining any credit. Many students simply read off where the two curves intersected, or found the mean value of the two pixel wavelengths, neither of which gained any credit. Some students gained one mark by making a suitable read-off at 520 or $650\ \text{nm}$, although these had to be seen to be linked in some way to the red or green pixel wavelength or colour in order to gain credit. Many students also ignored the response of the red-sensitive cones to the green light. Of the students gaining this mark, the majority were then unsure of how to progress, and either summed or found the mean of their read-off values.

Despite 02.3 having led them in this direction, only a handful of students correctly went on to consider the ratio of the responses of the red-sensitive cones to the green-sensitive cones in order to determine a wavelength.

Question 3

03.1
Less than half of the students were able to successfully define intensity. Many gave answers that were linked to human hearing limits or that referred to loudness rather than to power or energy. Some students incorrectly defined it as pressure per unit area, remembering a correct equation but not interpreting it correctly. “Power per area” or “power over area” were not sufficient for the mark to be awarded.

03.2
Almost half of students chose the correct answer.

03.3
This question was well answered with almost half of students gaining both marks and the majority gaining at least one mark. Of those who only obtained one mark, the most common errors were to ignore or to misuse the factor of 20. Full marks were also not awarded to those students who left their final answer in the form of a fraction. Of those students who failed to gain a mark, many incorrectly stated the relationship between pressure, force and area, using $F = \frac{p}{A}$. This physics error did not receive credit.

Question 4

04.1
The majority of students were able to state that the figure showed a B or brightness scan, with over half also giving the correct explanation, that the figure showed an image. Answers that referred only to bright dots being produced, whilst not incorrect, were deemed inadequate for the mark. Although not penalised for it, some students referred to “the baby” rather than the kidney, evidence of not reading the question carefully. Some students mentioned entirely different types of scan, with CAT, X-ray, ECG and PET all being seen on multiple scripts.

04.2

The majority of students attempted this with some success and accessed at least one mark. The most common reason for only obtaining one mark was the use of just a single heartbeat in order to determine the time period. This gave answers that consistently fell outside of the accepted range. For full marks, a student needed to use at least half of the full range of available data, taking T from either 3, 4 or 5 full heartbeats. Use of the full graph for 6 heartbeats was considered inaccurate as it is unclear where the first and last beat start and finish. This approach also led to answers outside of the accepted range. Some students struggled to convert the time period to beats per minute, confusing time period and frequency.

04.3
Although very few students gained full marks on this question, the specific marks which were awarded varied, with all separate marking points being awarded many times. Many students were able to correctly state the units on both sets of axes, although some then lost those marks through the use of incorrect prefixes. Abbreviations such as "*secs*" were not accepted. Many students were unsure of the range of values for the y-axis, and a common error was to label the origin as zero rather than the start of the line being at zero. A label at this point was not insisted upon, but the values shown needed to be consistent with this point being zero.

Of those students who knew the appropriate range of time values for the x-axis, many were not awarded the mark due to poor graphical work. Most commonly, students did not label the origin as zero. Some went up in uneven increments or used awkward scales, placing their number every third square. Others failed to put any vertical marks onto the axis leading to vaguely positioned, floating numbers.

04.4
Nearly all students gained some credit on this question, with the majority being able to explain how the skin is prepared for the application of the pad. Some students were clearly able to express the function of the gel in improving electrical contact. Many, however, missed this mark as they mentioned exclusion of air but did not link this to electrical contact. A significant number of students gave answers that referred to acoustic impedance, many making explicit references to sound or ultrasound. Students who made this error were not awarded full marks.

Question 5

05.1
This extended-response question was poorly answered, with over half of students scoring zero or one mark and less than a tenth of students gaining marks in the top band (5/6). This was due to fundamental misconceptions regarding the basic production of an X-ray image on photographic film. Most crucially and very commonly, students believed that the brighter areas on the image were due to a higher intensity of X-rays reaching the film. This was in fact more commonly seen than the correct response that X-rays will darken the film. The subsequent explanations based on this error resulted in confused and often contradictory answers, with, at most, one of the three areas of the answer being successfully discussed.

Another common misunderstanding was seen with many students who attempted to give explanations based on the image being formed by reflected X-rays. This again resulted in confusion as they attempted to apply this to the image and body parts.
A significant number of students used the term "thicknesses" to mean density of the tissue, with statements that "the ribs were the thickest part" and "the lungs the thinnest part" being seen frequently. The majority of these students then made no comments about the actual thickness of the tissues, making no use of **Figure 7** in their answers and thus limiting the scope of their answer to two areas.

Many students recognised that absorption increases with higher tissue density, and of the students who were awarded middle-band marks, most had provided clear explanations of the half-value thicknesses correctly applied to the body parts. However, a significant number of students demonstrated confusion when discussing $x_{0.5}$ for specific body parts, thus reversing the relationship. This was often in spite of having stated a correct definition. This was regarded as a partial attempt by examiners. Comments about the intensity of an X-ray decreasing as the thickness of the tissue increased were common and seen as a partial attempt at this area. Some excellent answers were noted, where students recognised the importance of both tissue thickness and half-value thickness in determining the level of absorption and were able to link these ideas to both images, correctly explaining the brightness of the body parts as seen in **Figure 6**. These answers made full use of the information presented in both figures.

05.2
Many students answered this well, gaining at least one mark for mention of a barium meal. For a two-mark answer, reference to higher atomic number of barium was considered inadequate; students were required to comment on the impact of barium on the X-rays' absorption or image. Students who were awarded no marks had often failed to appreciate the stated context of an image being formed on photographic film, suggesting other image-forming techniques. Mention of radio tracers was fairly common and did not receive credit.

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the Results Statistics page of the AQA Website.