A-LEVEL
PHYSICS

7408/3BB: Paper 3B Medical Physics
Report on the Examination

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General Comments

Overall, students performed similarly on this paper to last year. However, many students were unable to state why their knowledge was relevant to the context examined in Assessment Objective 3 (A03) questions. Nearly all students attempted all parts of the paper, suggesting that there was no problem with the time allowed.

Question 1

01.1 was a simple multiple-choice question requiring students to identify myopia as the eye defect from the data provided. The question was slightly more difficult than in the past due to the inclusion of the unaided near point, which students had to recognise as being normal. This did not cause a problem to most students. The question was answered correctly by around three-quarters of the students.

01.2 required students to complete ray diagrams, with and without a lens, for a number plate which was beyond the unaided far point of the eye. More able students answered this question well, with most students gaining at least 2 marks. Nearly all students were able to draw **Figure 1** correctly where the rays bent at the cornea and crossed to form an image in front of the retina. A small number of students continued the rays beyond the back of the eye and failed to gain a mark. In **Figure 2**, while most students knew that the image formed on the retina, many produced careless drawings with rays crossing in front of or behind the retina. Many students either did not draw the concave lens or drew a convex lens instead. Some students had the rays refracting correctly at the cornea in **Figure 1**, but incorrectly in **Figure 2**.

01.3 was a challenging question. In order to score full marks, the students had to select lens B, show that it was the only lens that allowed both the number plate and the speedometer to be viewed, and give a valid reason for rejecting lens C. The key to the question, which was missed by many students, was realising that when a lens is used to correct myopia, it also changes the near point of the eye. Most students either explicitly assumed that the near point did not change or did not consider the speedometer in their answer at all. The first mark was for giving any valid reason to reject lens C, either by stating it was the wrong type of lens or that it corrected the wrong type of defect. There were two main approaches to choosing between lenses A and B. Either the students could

- calculate the position of the images of the number plate and speedometer and compare them to the unaided near and fair points, or,
- calculate the aided near and far points and compare them to the positions of the number plate and speedometer.

A mark was awarded for any valid substitution of the data using $P = \frac{1}{f}$ and $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$, clearly showing u as the object distance and v as the image distance. A minority of students confused u and v, although a smaller number than in previous years. It was not enough to calculate f for the three lenses. Two marks were then awarded for the answers to two relevant calculations. These marks were independent of the previous mark. There were many possible calculations but, to gain two marks, at least one of these calculations had to be an image distance or an aided far or near point. Common mistakes in these calculations were a failure to use negative values for virtual images and the use of near and far points for u and v instead of object and image distances. It was common for students to calculate the correcting lens required to correct the unaided far point or to see the number plate and gain two marks when correct working was seen, with a further mark available for giving a valid reason to reject lens C.

Question 2

02.1 was answered well by more able students. There were two approaches possible:

- a calculation of power using $P = IA$ for a distance of 11 m, followed by a determination of the intensity for the same power at the new distance. Some students failed to gain a mark by using the wrong area, usually the area of a circle instead of the surface area of a sphere;
- a proportion calculation $I_1x_1^2 = I_2x_2^2$. Less able students confused intensity with intensity level and scored 0.

In 02.2, more able students answered well, converting the intensity levels in the question into intensities. A minority calculated the wrong ratio, but most were then able to gain two marks. Less able students calculated the ratio of the intensity levels instead of intensity. A minority expressed the ratio as 200:1 which was not penalised.

02.3 required students to discuss which measure, intensity level or intensity, was more appropriate to compare perceived loudness. Only the most able students were able to answer this question, stating that intensity level was more appropriate as it was a logarithmic scale which matched the ear's response. This required students to evaluate their knowledge of intensity level and intensity in the context of perceived loudness. However, the answers given suggested that many students did not have a good understanding of either intensity level or intensity. Some students confused the dB scale (which measures intensity level) with the dBA scale (which is adjusted for frequency). Answers which referred to a frequency dependence of intensity level could not gain full marks on this question. Some students did not realise that the ratio of intensities (= 200 from question 02.2) was not a realistic increase in loudness when moving from 11 m to 7 m, and therefore the answer could not have been intensity.

02.4 was answered poorly by most students, with only a few able to score full marks. There was a general familiarity with the concept of hearing loss resulting from age deterioration or loud noise; however, detail was either missing or incorrect. Most students knew that hearing loss due to age was most significant at higher frequencies. Many students thought that hearing loss due to loud noises was either at 3 kHz or the frequency at which the noise occurred. Only a few were able to quote the correct frequency of 4 kHz for this damage. Most students did not state that hearing loss occurred at all frequencies in both cases.

Question 3

03.1 was about the production of X-rays in an X-ray tube. It was clear that around one-third of students were unfamiliar with this, although students who were familiar proved able to answer the question well. For the continuous spectrum, most students knew that decelerating electrons produced X-rays, but very few of them were able to go on to explain why this was continuous. A common error was to state that a variation in incident electron energy was responsible, rather than assign the change to varying decelerations of electrons all with the same initial energy. Some students wrote about the electrons accelerating around the nucleus, and this was tolerated. However, the idea of electrons slowing down and transferring their lost kinetic energy into X-rays is a much clearer way of expressing what is going on. A small number of students thought the continuous nature of the spectrum referred to a continual emission of X-rays rather than X-rays of all energies up to a maximum being emitted.

For the characteristic spectrum, many students thought that electrons were excited by electron collisions with tungsten, rather than by the removal of inner electrons. Those students who had the right idea but did not refer to inner and outer electrons gained partial credit. Students had to mention electrons rather than merely exciting and de-exciting atoms to gain the mark here. A common mark awarded here was that it was the downward movement of electrons through the energy levels which led to the release of the photon.

03.2 showed a graph of photon energy against X-ray intensity and required students to sketch the curve produced when the anode pd was increased. Most students were able to gain one mark here, although only a minority were able to score both marks. Common mistakes were: curve not being larger at *all* frequencies; peak not shifting to the right; characteristic spikes not remaining in the same place, and maximum photon energy not increasing.

03.3 asked the students to sketch the graph produced when an aluminium filter was used. Many students seemed unfamiliar with the use of an aluminium filter and were not able to draw a sensible graph. Students were expected to draw a curve which removed some photons at all frequencies, but removed more at lower frequencies. This should have produced a curve which was lower at all frequencies and where the peak shifted to the right. Very few students were able to draw this correctly. Common mistakes were: peak not shifting to the right, and not taking sufficient care in drawing so that the line rose above the original intensity indicating an increase of intensity at this frequency.

Question 4

04.1 gave the students a simplified graph from an ultrasound A scan and asked them to calculate the diameter of an eye. Students had to identify the first pulse as the front of the eye and the last pulse as the back of the eye. Many students failed to do this, either ignoring the first pulse or choosing other pulses. A small minority of students did not read the scale correctly or did not know what the symbol μs meant; thus giving answers which were clearly ridiculous, giving the size of an eye ranging from several km down to 10^{-9} m. The second mark was more accessible, where students had to use the speed of sound with a time measurement from the graph to calculate a distance. The last mark was awarded for dividing the distance by two to account for ultrasound travelling in both directions.

04.2 was well answered, with most students able to describe A and B scans and state that a B scan was the more appropriate in this case. The majority of the students knew what an A and B scan was, with a small minority not realising that an A scan did not give a picture but a graph as in 04.1. Some students were also able to discuss how an A scan was generated from a single sensor, while a B scan was produced from multiple sensors. While most students knew that an A scan was more accurate for measuring distances, they were less well able to articulate the advantages of a B scan. Students struggled with applying their knowledge to amniocentesis and only a few wrote about the pictures of the B scan allowing the needle, foetus, uterus and placenta to be identified and their relative positions determined. In order to obtain marks in the top band the answers had to relate to amniocentesis and not just state why a B scan was better than an A scan in general terms. Students who stated that the A scan should be used were limited to 3 marks.

A common misconception among lower scoring students was a confusion between what was measured and how it was interpreted. Both A and B scans measure the intensity of the reflected pulse; in an A scan this is represented by the amplitude of an oscilloscope trace and in a B scan by the brightness of a pixel. In neither case is amplitude (or ‘brightness’) measured. A small minority incorrectly stated that a B scan was in 3D, many of those going on to say that an A scan produced a 2D image rather than a graph. Examiners did not accept a ‘1D image’ as a synonym for ‘graph’.

Some students described the oscilloscope electron beam moving horizontally in an A scan and vertically in a B scan. In reality it moves both horizontally and vertically in both scans. In an A scan the horizontal movement is related to time, while the vertical movement is related to the intensity. In a B scan the horizontal movement is related to horizontal position and the vertical movement is related to depth.

Mark Ranges and Award of Grades

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