2003 Physics GA 1: Written examination 1

GENERAL COMMENTS

The number of students who sat for the examination was 9578. The paper proved to be a little more difficult than in the previous few years. Despite this, two students achieved the maximum score of 90 and five were awarded 89. Most students had sufficient time to complete the paper; however, there were signs that some had to rush, while others left gaps in the 'Electronics' section. The 'Sound' section included a number of explanation questions which took some time. Some students found the 'Electric Power' section to be difficult.

A number of concerns became evident and some of these were mentioned in last year's report.

- Some students need to be careful with their writing; if the assessor cannot decipher it, there will not be any marks awarded.
- Written explanations must address the specifics of the question asked. There was considerable evidence that some students were simply copying generic answers from their A4 sheets. Students should be encouraged to re-read their explanations to ensure that they have answered the question asked and what they have written makes sense. Diagrams can be a valuable aid in answering these questions, but must be done with reasonable care to ensure that their key features are clear.
- There was a problem with numerical calculations. In many cases students were able to identify the correct equation and substitute properly, but were then unable to determine the final answer. This was either because of an inability to transpose the formula or a problem with using the calculator properly.
- Many students have trouble with unit conversions, e.g. from A to mA.
- Misunderstanding of simple electrical circuits was demonstrated repeatedly, particularly current in series and parallel circuits and voltage across components in these circuits.

SPECIFIC INFORMATION

Area 1 – Sound

Question 1

Marks	0	1	2	3	Average
%	9	19	33	39	2.02

The speaker created pressure variations which travelled away from the speaker as a longitudinal wave. These compressions and rarefactions caused the flame to oscillate. Many students relied too heavily on their A4 sheet as their answers did not directly address the specific question.

Question 2

Marks	0	1	2	Average
%	12	34	54	1.41

A quarter of a period and a half a period later correspond to a quarter and a half a wavelength respectively. So the answers were **B** and **C**. A reasonably common error was to select E instead of B. These students assumed the wave was travelling to the left instead of to the right.

Question 3

Marks	0	1	2	Average
%	33	25	42	1.08

For this question involving standing waves the answers were **D** and **C**. A common source of confusion among students was to treat them as travelling waves.

Question 4

Marks	0	1	2	Average
%	72	0	28	0.55

By doubling the distance, the sound intensity was quartered. This produced a reduction of 6 dB in the sound level. So the answer was **D**. The most common misconception was to assume that the sound level was quartered. Students did not convert their calculation of sound intensity to sound level.

Question 5

Marks	0	1	2	3	Average
%	15	21	36	28	**1.76**

Initially the sound was loud because Val was equidistant from the two speakers and therefore experienced constructive interference. As P moved toward Val the sound became quiet when the path difference was ½λ, and loud again when the path difference increased to λ. Most students understood that this was a two source interference question. Those who appeared to copy directly from their A4 sheet, gave answers that were very general and did not refer to the specific situation in the question. A number of students incorrectly equated low pressure with nodes and high pressure with antinodes.

Question 6

Marks	0	1	2	3	Average
%	31	10	5	54	**1.80**

The sound became soft when the path PX was ½λ less than QX. Since λ = 1, therefore PX = 0.5 some students assumed λ was 10, while others subtracted the correct answer (0.5) from 10 to get 9.5 this appeared to indicate confusion about the meaning of path difference.

Questions 7 and 8

Marks	0	1	2	3	4	Average
%	5	24	14	23	34	**2.55**

Question 7 required a straight forward application of $v = f\lambda$. The wavelength was 0.057 m.

Question 8 involved diffraction. This phenomenon now appears to be fairly well understood, although a number of students referred to nodal (and antinodal) lines. They had assumed there was an interference pattern set up by the two speakers. To obtain marks students could refer to the need for the sound to diffract to reach Mustafa, that the amount of diffraction depended on the ratio of wavelength to speaker width, that higher frequencies diffracted less than lower frequencies, and that Rebecca heard all frequencies well because diffraction was not a factor directly in front of the speakers. Clear diagrams could have been used instead of some of the written points. More successful answers included calculations to compare the relevant wavelengths with the size of the appropriate speaker, although this was not necessary to gain full marks. Few students used clear diagrams to aid their explanation. Some diagrams were so sloppy that they were not awarded any marks. The usual problem was that the long and short wavelengths were both drawn the same.

Question 9

Marks	0	1	2	3	Average
%	9	27	33	31	**1.86**

Barrier B absorbed and reflected sound, thus reducing the noise level at all houses. Some sound would diffract over the barrier to reach all houses, but more would reach house 3 because it does not have to diffract as much. Sound would also reflect from barrier A to reach house 3. This last point was essential to obtain full marks. Students obtained marks by drawing on the diagram provided.

Question 10

Marks	0	1	2	Average
%	23	33	44	**1.21**

The sound reflected by barrier A was now scattered (diffuse reflection) by the rough wall. Some extra sound was also absorbed by the wall. Some students did not read the question carefully and thought it was referring to barrier B. It was quite common for students to try to explain it in terms of diffraction, as though 'diffraction' is the answer to everything. Still others wrote every word they could think of in the hope of getting a mark for something – reflection, absorption, interference, refraction and diffraction.

Question 11

Marks	0	1	2	Average
%	14	9	77	**1.62**

Only the mouse and dog could hear the sound. At 20 000 Hz a sound level of 20 dB is well below the hearing threshold for the human and elephant.

Questions 12 and 13

Marks	0	1	2	3	4	Average
%	13	28	14	26	19	**2.09**

Most students were able to estimate the frequencies as approximately 700 Hz for the elephant and 4000 Hz for the human. Reading from the logarithmic scale without gridlines was a bit difficult so a generous range was allowed. To explain the reason for the difference in sensitivity students had to refer the resonant frequencies dependence on the lengths of the ear canals. Very few students managed to get the mark for this part of the question.

For Question 13 the speed of sound in the human ear would equal the speed in the elephant ear. So

$$f_H \lambda_H = f_E \lambda_E$$
$$4000 \times 8 = 700 \times 4L$$
$$11.4 = L$$

A common mistake was to assume the speed of sound was 340 m s^{-1}. This was not given in the information and cannot be assumed.

Area 2 – Electric power

Question 1

Marks	0	1	2	3	Average
%	37	26	17	20	**1.20**

This was basically a simple parallel circuit, although students had a lot of difficulty interpreting the diagram as such. The currents in sections P, Q and R were 700, 500 and 0. The idea of conservation of current appeared to be missing and it was worrying to see how many students believed there was a current in section R which did not go anywhere.

Question 2

Marks	0	1	2	Average
%	28	4	68	**1.39**

The current through tram 2 and the voltage across it were given in the stem of the question. The correct answer was 2.70×10^5 W.

Question 3

Marks	0	1	2	3	Average
%	86	10	1	3	**0.21**

This question required a couple of logic steps which combined with the difficulty students had interpreting the diagram made this the most difficult question on the paper. Knowing that the voltage at tram 2 was 540 V, therefore the voltage used in sections P and Q was 60 V. Using Ohm's law the voltage drop across P was 700R and voltage drop across Q was 500R where R is the resistance of 1 km of overhead wire. Accordingly the total voltage drop of 1200R must equal 60 and R is 0.05 Ω.

Question 4

Marks	0	1	2	3	Average
%	79	10	1	10	**0.41**

Using Ohm's law the voltage drop in P is 0.05 x 700 = 35 V. So the voltage at tram 1 was 600 – 35 = 565 V. Many students used the wrong current to determine the voltage drop in P. Students who obtained answers of 600 V or more did not seem to realise the impossibility of their answers.

Question 5

Marks	0	1	2	3	Average
%	82	4	2	12	**0.44**

This was a four stage problem which made it very difficult for students. To obtain the current through the globe they could use $P = I^2R$ which led to I = 1.06 A. This current could then be used to obtain the voltage drop across the globe with Ohm's law. V = 8 x 1.06 = 8.5 V. By subtracting this from the battery voltage the voltage across the variable resistor was found to be 3.5 V. This was then substituted into Ohm's law using the current calculated for the globe 3.5 = 1.06 x R to give the final answer of 3.3Ω. Two common problems were evident with student attempts. The first was assuming that the globe was operating at 18 W, and the other very serious mistake was to assume that the voltage across the globe was 12 V.

Question 6

Marks	0	1	2	3	Average
%	71	7	1	21	**0.72**

This question also required a number of logic steps. There were two main approaches to the question which led to the correct answer. One involved getting the total resistance in the circuit R = 12/2 = 6 Ω. Now knowing the total resistance and the resistance of the globe it was possible to use the parallel resistor formula to calculate the resistance of the variable resistor as 24 Ω. The major problem with this method was that when students found the total resistance they did not go any further. The other method involved using Ohm's law to obtain the current through the globe I = 12/8 = 1.5 A. Now since the total current in the circuit was 2 A, therefore the current through the resistor had to be 0.5 A. This information was then applied to Ohm's law for the variable resistor. R = 12/0.5 = 24 Ω. The main problem students had with this approach was once they had determined the current through the globe they did not make the link with the total current of 2 A which burned out the fuse.

Question 7

Marks	0	1	2	3	Average
%	54	29	7	10	**0.72**

Circuit **A** was the correct choice because the variable resistor enabled the current to be varied in the circuit and therefore the brightness of the globe. B did not work because the variable resistor and the globe were in parallel. Changing the resistor did not vary the voltage to the globe and so would not affect its brightness. Students who selected A were often unable to give a credible reason. Those who selected B often said that current would still flow if the globe blew. This had no relevance to the question. Most other reasons given for choosing either A or B had little or no relevance to the question – statements like 'A is simpler', 'batteries last longer', 'fuse may blow in B', 'parallel is better', 'B is safer', 'because fuse in A blows', 'B has less resistance' and so on.

Question 8

Marks	0	1	2	Average
%	16	19	65	**1.49**

The answer was ϕ = B.A = 0.25 x (0.30 x 0.40) = 0.03. A reasonably common error was students using the formula ϕ = NBA. The amount of flux threading the space has nothing to do with how many loops of wire are present.

Question 9

Marks	0	1	2	3	Average
%	51	16	10	23	**1.04**

To determine the average voltage students had first to find out the time taken for ¼ of a revolution, 0.005 sec. Then using $\varepsilon = N\frac{\Delta\Phi}{\Delta t} = 20\frac{0.03}{0.005}$ = 120 V. The most common difficulty involved finding Δt. Some used 50, others 1/50, or ½ x 1/50.

Question 10

Marks	0	1	2	Average
%	38	0	62	**1.24**

The positive direction was from North to South so the flux began as a positive maximum giving the answer **B**. The most common incorrect response was A followed by D a fair way behind. Perhaps these students were trying to obtain the EMF instead of the flux.

Question 11

Marks	0	1	2	3	Average
%	43	34	18	5	**0.84**

From t = 0 the flux through the loop started as a maximum to the right (N → S) and was then decreasing. By Lenz's law, extra flux was needed to the right (N → S) to oppose the change. So using the right hand grip rule the current had to go from V → U. This is the negative direction. Also, the initial current had to be zero because the rate of change of flux at that time was zero. Therefore the answer was **D**. Very few students chose D and even fewer were able to explain why. Some students confused the generator with a motor, writing about the force that was produced as the coil turned. Many students just left the explanation bank. By far the most common choice of answer was A. Some credit for this and an appropriate explanation was given because according to Faraday's Law it is the negative gradient of the flux-time graph from Question 10. A was not the correct answer because it was not in accordance with what was given as the positive direction in the question.

Area 3 – Electronic systems

Question 1

Marks	0	1	Average
%	16	84	**0.84**

The current through the 1000 Ω was down the page. Most students got this correct; however, there were a number who for some strange reason drew a diagonal arrow through the resistor.

Questions 2 and 3

Marks	0	1	2	3	4	5	Average
%	18	9	15	9	5	44	**3.04**

In Question 2, students first had to determine the resistance of the temperature sensor from the graph to be 2000 Ω. The total current was then evaluated using Ohm's law $I = 6.0/3000 = 2.0 \times 10^{-3}$A. This then had to be converted to 2.0 m A. Common errors were using either just 2000 Ω or just 1000 Ω for the resistance of the circuit. Another worrying trend was that many students had trouble converting A to mA.

The simplest approach was to use $P = I^2R$ where R was 1000 Ω and the current was 2.0×10^{-3}A from Question 2. This gave an answer of 4.0×10^{-3} W which converted to 4.0 mW. Some students used the correct current with the wrong resistance. Students who used this approach were more likely to get the question correct. The second method involved first calculating the voltage used by the 1000 Ω, $V = 2.0 \times 10^{-3} \times 1000 = 2.0$ V. This voltage was then substituted into the power formula $P = V I = 2.0 \times 2.0 \times 10^{-3} = 4.0 \times 10^{-3}$ W which converted to 4.0 mW. The problem was that students did not calculate the voltage used by the 1000 Ω, they just substituted in the entire 6 V. This was indicative of the inability of many students to apply either Ohm's law or the power formulae to individual resistors in a series circuit.

Question 4

Marks	0	1	2	Average
%	28	4	68	**1.40**

At 20^0C the sensor had a resistance of 2000 Ω. By using a voltage divider approach $V_{Air} = 6\frac{2000}{3000} = 4$. Although this was the most common method there were others including the reverse engineering approach, i.e. work backwards from the answer. There was also the fudge approach where you throw numbers and random operations onto the page until the correct answer appears.

Question 5

Marks	0	1	2	Average
%	28	8	64	**1.35**

At a temperature of 30^0C the resistance of the sensor was 4000 Ω (from graph). So the resistance of the two 4000 Ω components in parallel would be 2000 Ω.

Question 6

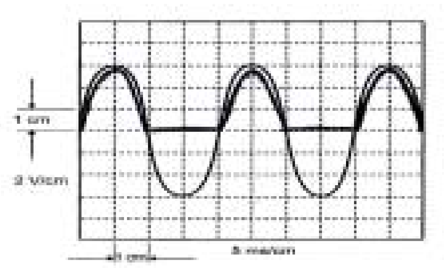
Marks	0	1	2	3	4	Average
%	51	9	6	2	32	**1.56**

A voltage divider approach gave the resistance of the parallel combination (1500 Ω). By using the parallel resistance formula 1/1500 = 1/4000 + 1/R, the resistance of the water sensor was 2400 Ω. So from the graph the water temperature was 24^0C. The fact that this was also a multi-stage problem caused difficulty for students. Some students were unable to correctly determine what voltage would be used by each component in the circuit. A common mistake was to assume that the battery voltage (6 V) could be applied to each component.

Questions 7 and 8

Marks	0	1	2	3	4	Average
%	22	7	17	14	40	**2.43**

Question 7 was a half-wave rectifier.
The most common error was to omit the zero voltage line between the pulses.



The purpose of the added capacitor in Question 8 was to smooth the output voltage of the rectifier. This question was generally well done.

Questions 9 and 10

Marks	**0**	**1**	**2**	**3**	**4**	**5**	**Average**
%	15	7	24	28	4	22	**2.64**

Students were mostly able to use the time constant formula to calculate the necessary resistance as 2000 Ω. The main source of error related to the prefix ‘micro’.

From the graph the peak-peak amplified ripple voltage was 0.6 V. So the unamplified voltage must have been 0.6/100 = 6×10^{-3} V which converted to 6 mV. While many students obtained the amplified voltage from the graph as 0.6 V they then simply converted this to 600 mV without considering the action of the amplifier at all. Other incorrect answers attempted an RMS conversion.

Question 11

Marks	**0**	**1**	**2**	**Average**
%	16	1	83	**1.67**

The water pump was only to come on if the air temperature was 20^0C or above and the water temperature was 30^0C or below. So to complete the last two rows of the table required 0 and 1 respectively. While most students got this question correct some gave the answer 1 and 0. This could possibly have been because they did not refer back to the requirements given in the original stem on page 18 of the examination booklet.

Question 12

Marks	**0**	**1**	**2**	**Average**
%	13	0	87	**1.73**

To satisfy the conditions in the table a simple AND gate was required. The answer was **A**.

Question 13

Marks	**0**	**1**	**2**	**3**	**Average**
%	71	3	1	25	**0.80**

This question required students to first make the reasonable assumption that the LED would require 2 V across the terminals. Therefore 2.5 V would be available across the 100 Ω resistor. Applying Ohm’s law to the resistor then gave a current of 0.025 A. This converted to 25 mA. When this is checked against the characteristics of the LED the original assumption is verified.

Most students who attempted this question said the 100 Ω resistor would need 4.5 V across the terminals. They then applied Ohm’s law and obtained an answer of 45 mA. This question demonstrates that students need to have a good understanding of voltage in a series circuit.

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