Physics: Written examination 1

GENERAL COMMENTS

The following concerns are worth noting:

- Many students are experiencing difficulty with numerical calculations. That is, they are able to identify the correct equation to apply, substitute in the correct values, but are unable to calculate the final answer. This may be due to an inability to transpose variables in an equation, or simply an inability to use the calculator correctly. Either way, it is apparent that students need more practice with numerical calculations throughout Unit 3 studies.
- Written explanations are often lacking in detail or are not sufficiently specific to the question asked. Students need to be encouraged to address the question and the context in written explanations. It is possible that students need advice about over-reliance on the prepared A4 sheet of notes when drafting the words of their explanation.
- Diagrams are often roughly drawn and sometimes this makes the answer unclear, particularly when specific directions are required.

SPECIFIC INFORMATION

Area 1 – Sound

Question 1

Students needed to recognise that the fundamental mode for a pipe open at one end and closed at the other is a wavelength four times the tube length. They needed to apply the equation $v = f\lambda$ in order to obtain a wavelength of 0.68 m. This results in a tube length of 0.17 m.

This question was well understood by the majority of students with the most common error being an answer of 0.34 m, corresponding to a pipe open at both ends. Another common error was an answer of 0.68 m, corresponding to the wavelength rather than the length of the pipe.

Question 2

A pipe open at one end and closed at the other resonates at odd multiples of the fundamental frequency. Hence, with a fundamental frequency of 500 Hz, the next resonant frequencies will be 1500 Hz and 2500 Hz. Answers **B** and **E** were the correct choices. Fifty-seven per cent of students correctly gave both choices. The most common error was to give **B** (1500 Hz) as the only answer.

Question 3

The open end of a pipe is maintained at the outside air pressure and hence does not experience any pressure variation – it is a pressure node. At a closed end, compressions are reflected as compressions and rarefactions as rarefactions. Hence, a closed end behaves as a pressure variation antinode. Thus, graph **B** best shows the maximum pressure variation. Fifty-eight per cent of students correctly answered this question.

The most common error was to give graph **A**, which shows an incorrect interpretation of pressure variation nodes and antinodes. Students who gave such answers may have possibly been confused with diagrams that show particle motion rather than pressure variation. The representation of sound waves ‘in terms of pressure variations’ is the only model of sound in the Study Design.

Question 4

The time between successive waves is the period of the wave. Hence, the period of this note is 5 m (5×10^{-3} s). This corresponds to a frequency of 200 Hz.

Sixty-six per cent of students scored the full 2 marks for this question, with a further nine per cent of students scoring 1 mark. The most common errors were in either failing to convert milliseconds to seconds, or interpreting the unit m as a velocity unit and then trying to apply the equation $v = f\lambda$ to this incorrect interpretation.

Question 5

The intensity drops according to the inverse square law. As the distance is changed from 0.10 m to 2.0 m, a factor of 20 times, the intensity will be reduced by a factor of $(^1/_{20})^2$. Thus the new intensity will be 1/400 of the original intensity. The calculated answer was 2.5 x 10^{-9} W m^{-2}.

This question was fully understood by half of the students who recognised that this involved the inverse square law. A number of students calculated 1/4 of the intensity rather than 1/400.

Question 6

An intensity increase of 1000 (10^3) corresponds to a sound level increase of 30 dB. Students should be aware that every tenfold increase in intensity results in a 10 dB increase in sound level. Less than half of the students fully answered this question. The majority of the students understood that they had to apply the formula sound level (dB) = 10 $\log_{10}(I/I_0)$ in some fashion, but were unsure just how to proceed from this point. A significant number of students calculated the actual sound level (original or new) rather than the sound-level increase.

Question 7

Inspection of the sensitivity graph reveals that the ear is most sensitive at 3500 Hz. Students also needed to be able to interpret the logarithmic scale of the frequency axis. Answers in the frequency range of 3300–3700 Hz were marked as correct.

The majority of students appeared to understand this question, with the major problem being errors in reading or interpreting the logarithmic scale of the graph. Another common incorrect answer (30 Hz) suggested that some students were either unsure of the meaning of the term 'sensitive' or incorrectly interpreted a number of 10^{-4} as being smaller than 10^{-12}.

Question 8

Students were required to determine the frequency values corresponding to a sound intensity of 1.0 x 10^{-11} W m^{-2}. These were 600 Hz and 10 000 Hz respectively. Answers within the specified frequency ranges 550–650 Hz and 9 800–11 000 Hz were accepted.

Some students experienced difficulty with the logarithmic scale of the axes and a number of students incorrectly gave an answer of 500 Hz. Also, a number of students chose the horizontal line on the graph representing the intensity 1.0 x 10^{-11} W m^{-2} as the one **above** 10^{-10} rather than the line below.

Question 9

The average mark for this question was 1.0/2. Students needed to understand that the line BC represented a line of constructive interference. Hence, moving from point C towards point B, the sound intensity would simply increase because of increased proximity to the speakers. Thus, statement **B** was the correct answer with statement **A** as the most popular incorrect answer.

The question tested both interference and intensity. Students need to be prepared for the possibility that answers may require more than one concept.

Question 10

In order to answer this question correctly, students needed to realise that, for the second minimum, a path difference of **$3\lambda/2$** was required. Applying simple trigonometry to the physical dimensions listed on the diagram results in a path difference of 4.0 m. Hence, the required wavelength is 2.7 m.

This question proved moderately difficult, with the average score being 1.6/4. About 20 per cent of students did not answer this question. A number of students chose the incorrect path difference, selecting either the first minimum ($\lambda/2$) or one of the maxima. Some students treated the line CD as representing a standing wave and then set up the incorrect equation $3\lambda/2 = 6$.

Question 11

The speed of sound was not given in this question and students needed to calculate this by applying the equation $\boldsymbol{v = f\lambda}$. This resulted in a speed of sound of 330 m s^{-1}. Application of the same formula for a frequency of 10 000 Hz resulted in a wavelength of 0.033 m.

The most common error was in taking the speed of sound as 340 m s^{-1}, whereas a careful calculation resulted in a value of 330 m s^{-1}. A problem with significant figures also appeared when students gave a final answer of 0.03 m. It would have been better to use standard form, 3.3 x 10^{-2} m. Students who attempted a ratio method of solving this question experienced greater problems than those who used a two-step process. However, most students understood the concept.

Question 12

This question required students to recognise and explain the following aspects:

- The spreading out of sound from the speakers is explained by the concept of diffraction.
- The spread of the diffraction pattern depends upon the ratio $\boldsymbol{\lambda/w}$.
- In order to calculate the ratio of $\boldsymbol{\lambda/w}$ it is necessary to calculate the respective wavelengths for frequencies of 200 Hz and 10 000 Hz. These calculate to 165 cm and 3.3 cm respectively.
- The larger speaker, P, has a physical dimension of 35 cm. This results in a very small diffraction spread for a sound of wavelength 3.3 cm.

This question was not particularly well done.

Only 12 per cent of students were able to score the full 4 marks. The concept of diffraction itself seemed familiar to the majority of students, but most did not exhibit an in-depth understanding of the semi-quantitative way that diffraction can be shown to work in this kind of situation.

A common problem for many students was to interpret this as an interference problem between the two speakers, rather than a comparison of the diffraction properties of each speaker. It was particularly disappointing to observe that very few students chose to calculate the wavelength of each sound and then compare them to the width of each speaker.

The use of diagrams as a method of explanation was also disappointing. Very few diagrams showed the appropriate scale to adequately represent the relative wavelength and speaker size aspects.

Area 2 – Electric power

Question 1

This question can be solved by two slightly different methods.

1. Using the method of power as energy/time, the energy for the lightning discharge is 3.0 x 10^7 J. This can then be substituted into the equation **U = qV**, to give a charge of 7.5 C.
2. Using the method of power as voltage × current, the current is 2.5 x 10^5 A. This can then be substituted into the equation **I = q/t**, to give a charge of 7.5 C.

The majority of students used the second method. The most common problem was in converting the unit of 30 microsecond to 30 x 10^{-6} seconds. Another common error was to interpret the power as 10^{-12} W.

Question 2

Diagram **A** best indicates the direction of the magnetic field due to the current of the lightning stroke.

The majority of students understood this question.

Question 3

Graph **D** best shows the variation of the EMF with time produced by the on-off action of a lightning stroke. The induced EMF is determined by the gradient of the magnetic flux versus time graph. This question was generally well done, with the most common incorrect response being graph **A**.

Question 4

Application of the transformer equation $\mathbf{V_1/V_2 = N_1/N_2}$ results in a ratio of 20. The majority of students understood this question. The most common incorrect answer being 1/20, the reciprocal of the correct answer.

Question 5

Application of the equation for power dissipated in a resistor, $\mathbf{P = V^2/R}$, results in an answer of 8.0 W. The majority of students correctly answered this question.

Question 6

In order to calculate the RMS voltage across light 1, students needed initially to calculate the total resistance of the circuit (18 + 1.6 = 19.6 Ω). The current in the circuit could then be determined as 0.6122 A. This resulted in a potential difference across the globe of 11 V.

This question was poorly done. Only 14 per cent of students were able to score the full 4 marks for the question. Some typical errors were:

- calculating the wire resistance for 16 m rather than the full 32 m length of wire
- omitting the resistance of light 1 and just considering the resistance of the wire alone
- calculating the current for Question 5 and then incorrectly using this current in Question 6.

Question 7

In order to gain the 4 available marks, students needed to cover most of these points:

- The current through light 1 is 0.6122 A (0.61A).
- The current through light 2 is 0.6667 A (0.67A).
- The current through light 2 is greater than light 1 and hence light 2 will be brighter.
- Light 2 has a greater potential difference across it than light 1.
- The potential drop across the wires of the light 1 circuit results in a lower potential difference across light 1 compared to light 2.

Only 16 per cent of students scored the full 4 marks and a further 34 per cent scored zero. Most students experienced difficulty with this question. It highlighted a number of serious misconceptions that students have in regard to current and potential difference applied to simple electric circuits. Many students did not calculate the value of the currents, even though this was specifically asked in the question.

The explanations for why light 2 was brighter varied; some students determined the voltage across the connecting wires or the power lost in these wires, while others worked directly with the potential difference across the lights or the current through each light. It was also interesting to note a number of students incorrectly calculated the current in Question 6, were able to now correctly calculate the currents in Question 7.

Quite a few students confused the concept of total current in a parallel circuit with the separate currents in each component of the parallel arms, incorrectly equating the increased current for a parallel circuit as an increase in the current in each component of the parallel arms.

Question 8

For an ideal transformer the potential difference across light 2 always remains at 12 V; hence, the brightness of light 2 should remain unchanged. However, for a real transformer, light 2 will actually slightly increase in brightness. Thus, statements **D** and **B** were both accepted as correct.

This question was quite well done, although it was disappointing to observe that about 20 per cent of students chose statement **C**, whereby they believed that light 2 would get brighter and burn out.

Questions 9–12

In order, the correct answers were **H**, **I**, **G** and **H**.

This group of questions was generally well answered by most students, although the presence of a circular coil, as distinct to a rectangular coil, confused a number of students. Questions 9 and 10 were very well done, but Questions 11 and 12 proved to be a little more difficult. In fact, Questions 11 and 12 clearly indicated that many students do not understand the component nature of the magnetic field and electric current when applying the right hand slap rule or ‘Fleming’s left hand’ rule.

Question 13

For an electric motor in the initial orientation shown, the coil will begin to rotate. However, lacking a commutator, it will be unable to continue rotation and will finish up with the coil plane perpendicular to the direction of magnetic flux. Thus, statement **A** best describes the situation. However, for a motor with low-friction bearings, the coil will oscillate back and forwards a few times before finally coming to rest with the plane perpendicular to the direction of magnetic flux. Statement **B** was also taken to be correct.

A majority of the students correctly answered this question, although approximately 20 per cent of students chose statement **D**, wrongly suggesting that the coil will rotate continuously. These advocates of continuous rotation possibly confused slip rings with split rings.

Question 14

With the replacement of the slip-rings by a commutator, the motor will continue to rotate continuously. Thus, statement **D** best describes the situation after the switch is closed.

A clear majority of students clearly understood this question, but about 20 per cent of the students thought that the motor would only rotate through 90° and then continue to oscillate backwards and forwards. There also appeared to be a high correlation between students who confused Questions 13 and 14, again suggesting a misunderstanding of the operation of slip rings and split rings (commutator).

Area 3 – Electronic systems

Question 1

This question was poorly understood. After one time constant, a capacitor charges or discharges by 63 per cent of the initial charge. Hence, the discharge current will have reduced to 37 per cent of the initial value after one time constant has elapsed, i.e. 37 per cent of 1.2 A is 0.44 A. Reading off the time value for a current of 0.44 A results in a time constant for the capacitor of 2.7 s, although a range of values from 2.4–3.0 s was accepted as correct.

It was noted that many students are taught that 37 per cent is approximately $^1/_3$ and hence read off the value corresponding to $^1/_3$ of 1.2 A (0.4 A). In this instance the students were not penalised. The Study Design refers to a 'qualitative description of charging and discharging'; however, there is no great benefit in teaching the quantitatively incorrect fraction.

This question was not well done, with the most common problem being to read off from the graph at the 63-per cent level rather than the 37-per cent level. Clearly, the figure of 63-per cent is reasonably well understood for the charging of a capacitor, but not so well understood for the discharging of a capacitor.

Question 2

This question was answered quite well, with the major error being a failure to convert the unit microfarad into farad. Once the students had calculated the time constant in Question 1, all they had to do was substitute into the equation $\tau = RC$. This resulted in a resistance value of $2.7 \times 10^4\,\Omega$. (An inconsistency in the given data was noted here; an initial current of 1.2 A implies a resistance of 10 Ω, this answer was also marked as correct.)

Question 3

The definition of a non-ohmic resistor is one that has a non-linear I-V graph, meaning that the magnitude of the resistance changes with voltage or current. However, the graph of Figure 3 was a resistance versus temperature graph, and this did not provide sufficient information for students to answer this question. As a consequence, all students were awarded 2 marks here. The vast majority answered that the thermistor was non-ohmic because the graph was non-linear.

Question 4

The value of the temperature can be read directly from the graph. For a resistance value of 400 W the temperature is 55˚C. A range of temperatures from 53˚–57˚C was accepted.

The vast majority of students answered this question correctly, with the only error of note being to misread the scale of the temperature axis.

Question 5

A current of at least 10 mA is required to activate the buzzer. This corresponds to a total circuit resistance of 1200 Ω at a potential difference of 12 V. Given that this is a series circuit, the variable resistance has a maximum value of 700 Ω. In fact, any value from zero to 700 Ω will result in an audible sound.

This question was reasonably well answered by many students. Common errors were to forget to convert the current unit of mA to A, or to forget to include the resistance of the buzzer.

Question 6

A frequency of 50 Hz has a period of 1/50 = 0.02 s (20 ms). The time difference between t_0 and t_1 represents half of the period, that is, 10 ms.

The majority of students understood the basic concept involved in answering this question, but with the most common problems being in forgetting to halve the period or converting to the unit, ms.

Question 7

One division of the oscilloscope screen corresponds to the peak voltage. The RMS voltage is given as 240 V. Hence, the peak voltage is $\sqrt{2} \times 240 = 339$ V.

This question was reasonably well understood by most students. The most common incorrect answer was 240 V, suggesting a confusion between peak and RMS values.

Question 8

The circuit shown in Figure 6 represents a half-wave rectifier circuit. Hence, graph **C** best represents the voltage across the resistor as a function of time.

The majority of students correctly answered this question demonstrating a clear understanding of the function of a diode as a rectifier.

Question 9

In order for a capacitor to smooth a rectified signal, it must be placed in parallel with the load resistor. Hence, circuit **D** has the capacitor correctly located.

The placement of the capacitor in parallel across the load resistor was understood by a majority of students.

Question 10

The larger the capacitor the better the smoothing. Thus, the 1000 μF capacitor (answer **A**) will provide the smoothest DC output.

The majority of students correctly answered this.

Question 11

Column Q: 0 1 1 1 Column R: 1 1 1 0

This question was very well done, with the only error being some confusion with the operation of a NAND gate.

Question 12

Common sense tells us that the alarm should sound when a child enters the gate or attempts to jump the lower beam. The logic inputs of (0 1) and (1 0) provide a logic output of 1, resulting in the alarm sounding. Hence, situations **B** and **D** will result in the alarm sounding.

This question was clearly understood by the majority of students. The major error was to choose situation **B** alone rather than **B** and **D**.

Question 13

Gain = V_{out}/V_{in} = 2.00/0.04 = 50.

This question was reasonably well answered, with the only problem being students inability to handle the scale of both axes.

Question 14

This question was well answered. Inspection of the input and output voltage graphs of Figure 10 indicates that the amplifier is both inverting and linear. Hence, graph **A** best indicates the input/output characteristics of the amplifier.

PH031 PHYSICS WRITTEN EXAMINATION 1

HISTOGRAM OF TOTAL SCORES 2000

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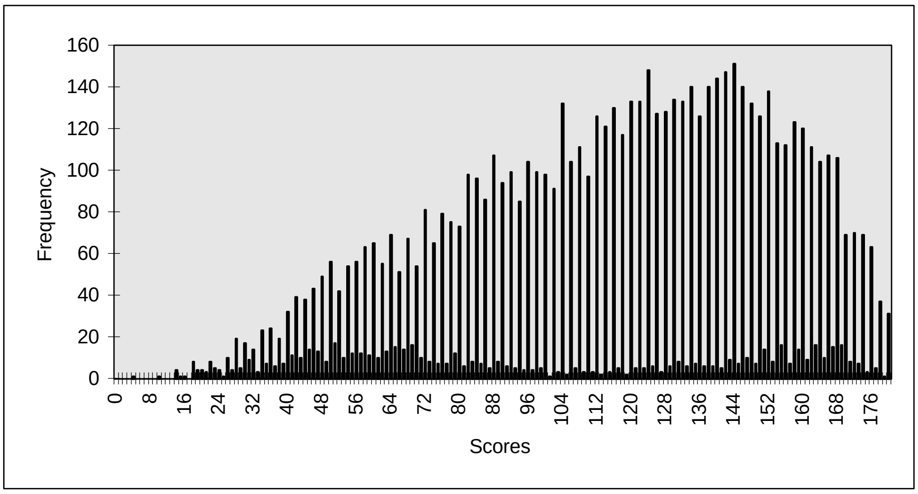

HISTOGRAM OF TOTAL GRADES 2000

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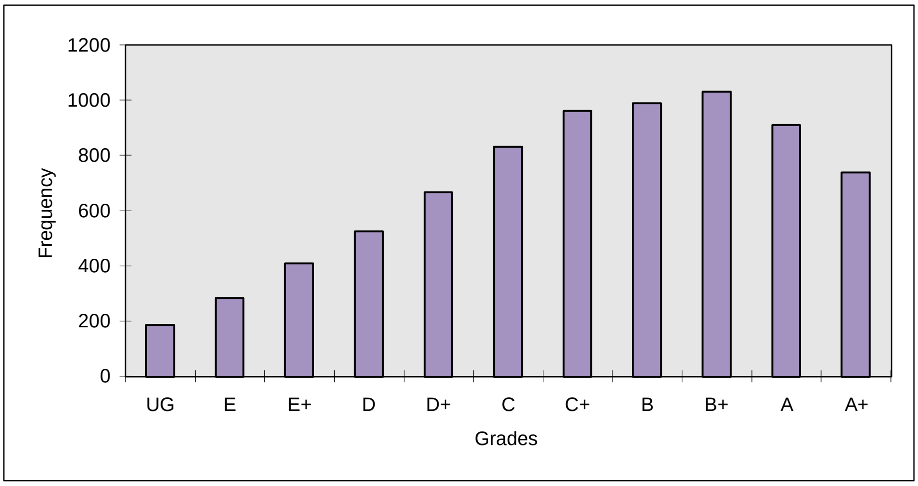

ENROLMENTS		%
Female	1989	25.9
Male	5676	74.1
Total	7665	

GLOSSARY OF TERMS

Count Number of students undertaking the assessment. This excludes those for whom NA was the result.

Mean This is the 'average' score; that is all scores totalled then divided by the 'Count'.

Standard Deviation This is a measure of how widely values are dispersed from the average value (the mean).