GENERAL COMMENTS:

The general feeling was that the examination was quite discriminating at the upper end and that well-prepared students appeared to have been amply rewarded for their thorough understanding of physics. As for previous years, the time management of some students is of concern and it is recommended that teachers assist students with this in their examination preparation.

Assessors marking the papers expressed the following concerns.

- Many students continue to experience difficulty with numerical calculations. That is, they are able to identify the correct equation to apply, substitute in the correct values, but then 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 correctly use the calculator. Either way, it is apparent that students need more practice with numerical calculations throughout Unit 3 studies.
- Written explanations continue to be 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 A4 sheet when drafting the words of their explanation. It is abundantly clear that students need to re-read their final explanations and check that they have actually answered the question asked.
- Diagrams are often roughly drawn and sometimes this makes the meaning of the answer unclear, particularly when specific directions are required. Students also need to be aware that annotated diagrams can be particularly powerful for answering such questions.
- Students are often unwilling to quote numerical values when providing a written explanation. They are encouraged to support written material with the numbers that may illustrate the point that they are trying to make. For example, an explanation about diffraction should have been supported by the appropriate numerical values for the wavelength, frequency and the gap size.
- Students need to be reminded to concentrate on conceptual understanding and also to concentrate on the context of the material. For example, the questions related to a voltage amplifier appeared to suggest that students understood some of the properties but did not understand the application of this knowledge in the real world.
- Some students seem to rely on the application of mathematical formula to solve questions and sometimes they need to be advised to rely on a conceptual understanding. An example of this is in dB calculations where application of the mathematics can sometimes obscure the intuitive understanding of the concepts.
- Electric circuits continue to be of concern. In particular, circuits involving parallel components continue to confuse many students.

Specific Information:

AREA 1 – Sound

Question 1

Marks	0	1	2	Average
%	26	21	53	**1.27**

The period of the signal is given by 5 divisions of the horizontal scale. Each division is 100 μs and so 5 divisions gives a period of 500 μs. $f = 1/T = 1/500 \times 10^{-6}$, resulting in a frequency of 2000 Hz.

This question was well answered by most students, with the exception of those who omitted to convert microseconds into seconds or those who misread the period from the graph.

Question 2 to Question 4

Marks	0	1	2	3	4	5	6	7	Average
%	12	4	7	6	4	29	20	19	**4.45**

Question 2

The equation for intensity versus distance from a point source of sound is $I \propto 1/r^2$. So, with double the distance the intensity will be ¼ of the original. ¼ of 100 mW m^{-2} is 25 mW m^{-2}.

This application of the inverse square law was well understood by students. The only difficulty encountered was due to errors in the unit of mW.

Question 3

When the intensity reduces to one half of the original the sound intensity level reduces by 3 dB ($10 \log_{10}0.5 = -3$). So, one quarter the intensity results in a sound intensity level drop of 6 dB. Alternatively, for one quarter (1/4) the intensity, $10 \log_{10}0.25 = -6.02$ dB.

Another, but longer, method was to calculate the sound intensity levels for each position of the microphone. This resulted in sound intensity levels of 100 dB and 94 dB respectively. Hence, a difference of 6 dB.

This question proved to be more difficult for students. It was anticipated that many students would solve by applying the rule of half the intensity results in a 3 dB drop in sound intensity level as described above, but this was not so. Many students attempted to solve by application of the equation $dB = 10 \log_{10}(I/I_o)$, and then often experienced difficulty in substituting the appropriate values. This highlights the problem of students who depend on formula-based solutions rather a conceptual understanding.

Question 4

At 6000 Hz the relative response was +5 dB and so the sound intensity level will be 5 dB louder. Substitution into the equation for determining sound intensity levels ($dB = 10 \log_{10}I/I_0$) results in a sound intensity increase of $10^{0.5}$, or 3.16 times greater intensity. Thus the sound intensity measured will be 316 mW m^{-2}.

Students found this to be a difficult question. Students certainly experience difficulty in reading and interpreting a logarithmic graph scale. And those who read the scale correctly experienced difficulty with what to the do with the number of 5 dB that they read off the scale. That is, many students were unable to calculate intensity from the sound intensity level. Another common error was to extrapolate from the frequency reading to the intensity value that is, incorrectly relating a six-fold increase in frequency to a six-fold increase in intensity.

Question 5

Marks	0	1	2	3	Average
%	20	23	6	52	**1.89**

Graph A best shows the variation in amplitude as Lee moves from position O to position P. OP is a line of constructive interference because the path difference is zero. So, as Lee moves further from the speakers the signal amplitude will decrease, resulting in graph A as the best choice.

This question was reasonably well understood with the majority of students selecting graph A as the best choice. A misunderstanding of serious concern was that of students confusing the sound pressure variation with the amplitude of the signal, these students tended to then select a graph with an amplitude variation. Some students incorrectly thought that moving along an anti-nodal line resulted in points of maxima (double compressions) and minima (double rarefactions)!

Question 6 and Question 7

Marks	0	1	2	3	4	5	6	7	Average
%	4	1	9	17	15	12	14	28	**4.66**

Question 6

Graph C best shows the variation of amplitude as Lee moves from position X to position Y. Lee crosses nodal and anti-nodal lines when he moves from X to Y and so the amplitude will vary accordingly. Midway between X and Y will be an anti-nodal position and so graph C best shows the variation in amplitude.

This question was reasonably well understood by students. They recognised that a series of nodal and anti-nodal lines were crossed. A number of students omitted to mention in their explanation that midway between X and Y would be a maxima.

Question 7

The graph of amplitude arises as a result of diffraction of the sound passing through the gap. Diffraction means that the sound spreads out after passing through the gap. The amount of diffraction depends upon the ratio of the wavelength to the gap size. For this example, the gap size is 0.30 m and so wavelengths greater than 0.30 m will show significant diffraction. Given that the speed of sound is 340 m s^{-1} then a wavelength of 0.30 m corresponds to a frequency of 1133 Hz. Hence, the approximate frequency used was about 1000 Hz. Answers in the range 500 – 1500 Hz were accepted.

This question was also well done by the majority of students. The concept of diffraction is clearly well understood, even if the spelling of the word is not! (It really is disappointing to read so many variations of the spelling of diffraction (defraction etc.)). The majority of students were able to correctly determine the approximate frequency used. The major omission from student explanations was a mention of the fact that the amount of diffraction depends on the ratio of wavelength to gap size.

Question 8

Marks	0	1	2	Average
%	48	0	52	**1.03**

The grey curve shows very little diffraction and so the wavelength is considerably less that 0.30 m. Correspondingly the frequency will be considerably higher than 1000 Hz, as calculated in question 7. Thus, the frequency of 10 000 Hz as listed in A is best fits with Lee's prediction.

This question was not as well understood as expected. Many students selected a frequency equal to or lower than the original frequency. It is possible that students understand that to exhibit less diffraction the wavelength should be shorter, but they then neglect to interpret a shorter wavelength with a higher frequency.

Question 9

Marks	0	1	2	Average
%	62	0	38	**0.75**

Sound waves are longitudinal waves whereby the air particles vibrate backwards and forwards in the direction of the wave, resulting in compressions and rarefactions moving out from the speaker. Hence, Chris' statement best relates the observation to the nature of sound waves.

The majority of students misunderstood this question and actually chose Jess for the correct statement. They clearly understood that sound is a longitudinal wave, but incorrectly thought that compressions and rarefactions behave in a similar way to the movement of the air molecules. It is recommended that teacher(s) conduct practical or AV demonstrations of longitudinal waves so that students can understand how the vibration of particles of a medium can result in a travelling wave.

Question 10

Marks	0	1	2	3	Average
%	25	9	6	60	**2.02**

For a pipe open at both ends the standing waves must have pressure nodes at each open end. The fundamental standing wave has a wavelength of 2L and so this question can be solved by the following method:

$$v = f\lambda$$
$$340 = 510 \times 2L$$
and so, $L = 0.33$ m

This question was reasonably well understood. Some students confused an open pipe with a closed pipe and others attempted to use a travelling wave approach rather than the correct method of a standing wave.

Question 11

Marks	0	1	2	Average
%	30	0	70	**1.39**

A sound of frequency 765 Hz has a wavelength of 0.44 m. So, if 2L = 0.44 m, then L = 0.22 m. 0.22 m is exactly 2/3 of 0.33 m. Thus, tube C (2/3L) will result in a standing wave of frequency 765 Hz.

The majority of students were able to correctly answer this question. The most common incorrect answer was B.

Question 12

Marks	0	1	2	Average
%	52	0	48	**0.96**

With one end now closed the fundamental standing waves have a wavelength of 4L. A sound of frequency 510 Hz has a wavelength of 0.667 m. So, if 4L = 0.667 m then L = 0.167 m. 0.167 m is one-half of 0.33 m (1/2L), and so tube D will resonate at a frequency of 510 Hz if one end is sealed.

This question proved reasonably difficult. The most common incorrect answer was tube A, corresponding to an open ended tube rather than a closed ended tube.

AREA – Electric Power

Question 1 and Question 2

Marks	0	1	2	3	4	Average
%	17	4	27	3	49	**2.65**

Question 1

P = VI and so for a supply voltage of 240 V_{RMS} and a power of 48 W the RMS current will be 0.20 A.

The reference to RMS seemed to distract some students, resulting in an answer out by a factor of $\sqrt{2}$. That is, they correctly calculated the current value but then carried out a further, but incorrect, RMS conversion.

Question 2

All three parallel strings are identical and so the current in each will be the same. That is, each string carries 1/3 of the total current, 0.067 A.

The majority of students correctly answered this question. The most common errors were to either take the string current as the total current calculated in question 1 or to further divide the current by a factor of 12 for each of the 12 globes. Quite a few students had difficulty interpreting this circuit as a combination series and parallel circuit.

Question 3 and Question 4

Marks	0	1	2	3	4	Average
%	21	1	33	1	43	**2.43**

Question 3

The potential difference across each parallel string is the same (240 V). Within each string the globes are in series and so the potential drop across each will be the same. With 12 globes in series the RMS potential drop across each will be 20 V.

The majority of students correctly answered this question by simply dividing 240 V by the 12 globes. Some common incorrect approaches saw students dividing by the 36 globes or dividing the 240 V by the three strings and then further dividing by the 1 2 globes. Again, some confusion when dealing with a combination of a series and parallel circuit was apparent.

Question 4

The total power rating is 48 W and all globes will be of equal power rating with this circuit arrangement. Hence, each globe will be rated at 48/36 = 1.33 W.

This question was also well understood. Again, any misunderstanding involved the problem of how to deal with a combination of a series and parallel circuit.

Question 5

Marks	0	1	2	Average
%	70	0	30	**0.59**

When the circled globe is removed then no current can flow in that string and so all the globes in the middle string will not operate. The potential difference across the other two strings is unchanged at 240 V_{RMS} and so they will continue to operate at the same brightness as before. Hence, statement B best describes this situation with the globe removed.

This question was not at all well understood. In fact, statement C was a very popular (but incorrect) choice, presumably arising because of students thinking of the concept of internal resistance. It needs to be stressed that internal resistance is not a significant consideration for household supply circuits.

Question 6

Marks	0	1	2	Average
%	33	0	67	**1.34**

High transmission voltages are used so as to reduce the line current and so reduce power loss in the wires. Power loss in the wires can be calculated using the formula $P = I^2 R_{wires}$. Hence, statements B and D were the expected answers. Both B and D needed to be given to score the 2 marks for this question. Any other answer scored zero.

This question was quite well understood with the majority of students answering correctly. It was clear that an overwhelming majority of students identified statement D (small current leads to small power loss), but fewer students identified statement B (voltage and current relationship for a given power) as also being correct.

Question 7

Marks	0	1	2	Average
%	39	24	37	**0.97**

The turns ratio can be calculated via the formula $N_P/N_S = I_S/I_P$ resulting in a vaue of 1/16 or 0.063.

This question proved to be more difficult than expected. The most common incorrect answer was the reciprocal of the correct answer. Assessors were left to wonder whether students expected that any ratio answer must be a whole number and so chose 16/1 rather than 1/16. It was also clear that a number of students assumed that the turns-ratio was directly related to currents, like it is for voltages, rather than inversely related.

Question 8 and Question 9

Marks	0	1	2	3	4	Average
%	8	4	34	6	48	**2.82**

Question 8

The voltage drop across the wires can be determined by using Ohm's law $V = IR_{wires}$. Substitution into this equation gives V = 5.0 x 0.32 = 1.6 V.

This question was generally well understood with the major error being due to students choosing the secondary current of 80 A rather than the current in the transmission wires (5 A).

Question 9

Magnetic flux is calculated by substituting into the equation $\Phi = B \times A$. Which gives a magnetic flux of 0.12 x 0.30 x 0.40 = 0.0144 Wb.

The majority of students answered this question correctly, indicating that the concept of magnetic flux is well understood.

Question 10

Marks	0	1	2	Average
%	47	0	53	**1.05**

The examiners decided that the connections of the coil at P and Q were ambiguous. Hence, the graphs A or D were both marked as correct.

Given that either A or D was accepted then it was disappointing to note that just over 50% of students correctly answered this question. It was clear that many students did not understand that the rate of change of area (and hence flux) is least when the plane of the coil is perpendicular to the field and greatest when it is parallel to the field.

Question 11

Marks	0	1	2	Average
%	37	9	54	**1.16**

Induced EMF can be calculated via the formula $\xi = -n\Delta\Phi/\Delta t$, resulting in an average voltage of 0.014/0.15 = 0.096 V.

The main error here was to include a factor of 0.25, presumably resulting from the quarter-turn context for this question.

Question 12

Marks	0	1	2	3	Average
%	21	43	2	35	**1.51**

The induced EMF is related to the rate of change of magnetic flux by the formula
$\xi = -n\Delta\Phi/\Delta t$. Doubling the frequency of rotation halves the period of the rotation and so effectively halves the effective time for the change in magnetic flux. This doubles the induced voltage. Hence, students were expected to sketch a graph showing half the period and double the amplitude.

The vast majority of students sketched a graph showing half the period, but many failed to show double the voltage.

Question 13

Marks	0	1	2	Average
%	50	0	50	**1**

The direction of the force arising from the interaction between a magnetic field and a current-carrying wire can be determined using either the 'right hand slap' rule or Fleming's left hand rule. Either method shows that the coil will move in a direction down the page as given by statement B.

About half of the students answered correctly, with the incorrect answers split equally across the three distractors.

Question 14

Marks	0	1	2	3	Average
%	15	16	55	15	**1.69**

The magnitude of the force on the coil can be calculated via the formula F = nBIL. For the case of a radial field the length is in fact the circumference of the wire so substituting into the formula gives $F = 200 \times 0.4 \times 0.5 \times \pi \times 0.04 = 5.03$ N.

The majority of students understood the method of calculating the force on a current-carrying wire in a magnetic field. However, very few students understood that the length of the wire in a radial field was in fact the circumference. It was also disappointing to note that a number of students were unable to correctly calculate the circumference of a circle, often because they used an incorrect formula!

AREA 3 – Electronic systems

Question 1 and Question 2

Marks	0	1	2	3	4	Average
%	18	14	22	14	32	**2.27**

Question 1

Students needed to recognise this as a voltage divider circuit and then apply the voltage divider formula $V_{OUT} = V_{IN} \times R_1/(R_1 + R_2)$. In this circuit $V_{OUT} = 30$ V, $V_{IN} = 6$ V and $R_1 = 5$ kΩ, resulting in an answer of $R_2 = 20$ kΩ.

This was a reasonably straightforward question that was not done as well as expected. The most common error was due to students confusing R_1 and R_2, possibly because they anticipated that R_1 would be the upper of the two resistors.

Question 2

Two 10 kΩ resistors in parallel result in an effective resistance of 5 kΩ. Students were expected to sketch a circuit diagram similar to figure 1, except with the resistor R_1 replaced by two10 kΩ resistors in parallel.

This was another fairly straightforward question that was not as well done as expected. The same problem of confusing the two resistors R_1 ands R_2 was apparent in this question. Another very serious error was observed in the number of students whose sketches showed a short-circuit element in some part of the circuit. It was disappointing to note that about 20% of students made no attempt to answer this question.

Question 3

Marks	0	1	2	Average
%	12	11	76	**1.64**

The time constant is calculated by substitution into the formula τ = RC, resulting in an answer of 0.22 s.

Students clearly understood how to calculate the time constant for an R-C circuit with the clear majority answering correctly. The most common problem was due to errors in applying the prefixes for k and μ, resulting in answers out by varying powers of ten.

Question 4

Marks	0	1	2	Average
%	37	0	63	**1.26**

Sketch D correctly shows the voltage across the capacitor as a function of time. Students needed to understand that when the voltage increases at t = 1.0 s, the charge on the capacitor increases exponentially with a time constant of 0.22 s. That is, at t = 1.22 s the capacitor will be at 63% of the full voltage (1.0 V) and it will reach a voltage of 1.0 V after about 5 time constants.

The majority of students correctly answered this question, with most common incorrect distracter being C, most likely occurring due to students interpreting the signal being repetitive prior to t = 0. The stem of the question stated quite clearly that the input voltage was zero for all time up to t = 1.0 s, and so answer C could have been discounted on this ground alone.

Question 5 and Question 6

Marks	0	1	2	3	4	5	6	7	Average
%	21	14	18	16	11	10	8	3	**2.55**

Question 5

40 mV peak-to-peak converts to a peak voltage of 20 mV and an RMS voltage of 14.14 mV. Using Ohm's law results in the equation $I = V/R = 14.14 \times 10^{-3}/1000 = 14 \times 10^{-6}$ A = 14 µA.

Students found this to be a difficult question, usually because they neglected to convert the peak-to-peak voltage to a peak voltage prior to converting to an RMS value. Other errors occurred because of a failure to correctly convert units to give an answer in µA.

Question 6

The explanation of how the capacitor smoothes the output voltage across the load resistor needed to cover the following points.

- During part of the forward voltage cycle charge builds up on the capacitor
- At other parts of the voltage cycle the capacitor discharges through the load resistor
- Smoothing refers to the conversion of a varying DC voltage into a constant voltage, usually with a small ripple component

This proved to be an extremely difficult question and it was certainly apparent that the concept of smoothing and the operation a capacitor was not at all well understood by the vast majority of students. Very few students explained that charge built up on the capacitor during part of the cycle and even fewer compared the charging time constant with the discharging time constant. It was also disappointing that many students omitted to explain what smoothing meant or did not sketch a smoothed voltage signal as part of their explanation.

Question 7 and Question 8

Marks	0	1	2	3	4	Average
%	41	13	24	11	10	**1.36**

Question 7

The LED is a non-ohmic device. The characteristic curve (figure 6b) shows that for a current of 10 mA the voltage across the LED will be 1.5 V. Hence, the voltage across R_D will be 8.5 V. Applying Ohm's law to R_D gives $R_D = V/I = 8.5/10 \times 10^{-3} = 850\ \Omega$.

This question also proved to be difficult for many students. Many students correctly read the graph to obtain the voltage across the LED as 1.5 V, but then used this value of 1.5 V rather than 8.5 V for the rest of the calculation. Failure to convert mA to A was another problem with this question.

Question 8

If the value of R_D is slightly lower then the current in the circuit will be slightly higher, but the voltage across the LED remains at 1.5 V. With increased current the light output through the LED increases.

This also proved to be quite a difficult question even though the majority of students appeared to understand that the current through the LED would increase. Many students felt that because the current increased then the LED would 'burn out' or 'blow'. Many others understood that even though the current increased the voltage across the LED remained unchanged, but then incorrectly interpreted this as though the brightness would remain unchanged. It remains very clear that many students do not understand non-ohmic devices!

Question 9 and Question 10

Marks	0	1	2	3	4	Average
%	26	10	26	15	23	**2**

Question 9

The term **linear** in the context of an amplifier means that there is no distortion to the output signal. That is, the output signal has the same characteristics or 'shape' as the input signal.

Quite a number of students did not attempt this question. Many students mentioned that the voltage graph would be linear, as would be required for the following question, but omitted to discuss the properties of the output signal. It was certainly clear that students understood the relationship between V_{OUT} and V_{IN} but did not fully appreciate that an amplifier exists so as to produce a non-distorted amplified signal.

Question 10

The graph axes needed to be labeled with V_{OUT} on the vertical axis and V_{IN} on the horizontal axis. The sketch graph needed to include a linear sloping section. Inverting or non-inverting sketches were both accepted.

Students generally understood this concept and any errors were due to a failure to label the graph axes or to confuse the labels for the horizontal and vertical axes.

Question 11

Marks	0	1	2	Average
%	55	10	35	**0.8**

For 4 bar codes, the number of possibilities was 2 x 2 x 2 x2 = 16.

This question was not as well done as anticipated. Many students did not show their reasoning or working for this question, which was fine if they had the correct answer, but not useful in obtaining part marks for an incorrect answer. By far the most common incorrect answer was 15 for the number of wine types. The number 15 was most probably given because students removed the code 0000, mistaking this binary code for the number zero in terms of wine bottles. That is, they confused the labeling and identifying system with a counting system. Another incorrect response was the answer $2^3 + 2^2 + 2^1 + 2^0 = 15$.

Question 12

Marks	0	1	2	Average
%	58	0	42	**0.84**

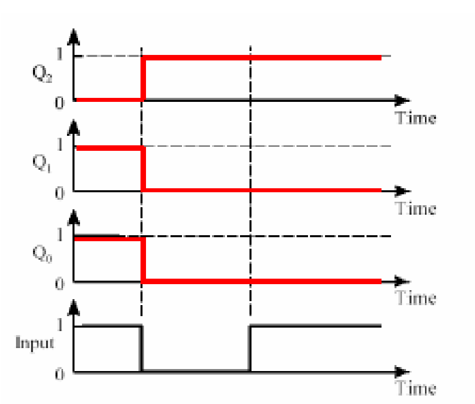
Truth table B provides the correct output. That is, whenever the bottle bar-code bit matches the computer code bit, then a 1 is produced. A zero is produced when the codes do not match.

Students found this to be a difficult question and the most common incorrect answer was truth table D. Assessors felt that a number of students were unable to relate the written information in the introduction to the question to the meaning of the truth table.

Question 13

Marks	0	1	2	3	Average
%	47	12	5	36	**1.3**

The correct set of timing diagrams are shown below.



Even though some concern was raised about the relevance of falling-edge flip-flops to the study design, most students appeared to understand what was intended by this question. The most common error was in students changing the output for both rising and falling edges of the input.