GENERAL COMMENTS

This examination proved to be slightly more difficult than previous years as the mean score of 55% indicates, compared with a mean of 61% in 2000 and 2001. Also the cut-off score for the grade A+ was 74/90 compared with 80/90 for the previous two years. The examination proved to be discriminating at the upper end and well-prepared students were amply rewarded for their thorough understanding of physics. No student achieved a perfect score of 90/90; the highest score awarded was 89/90 which was achieved by only one student.

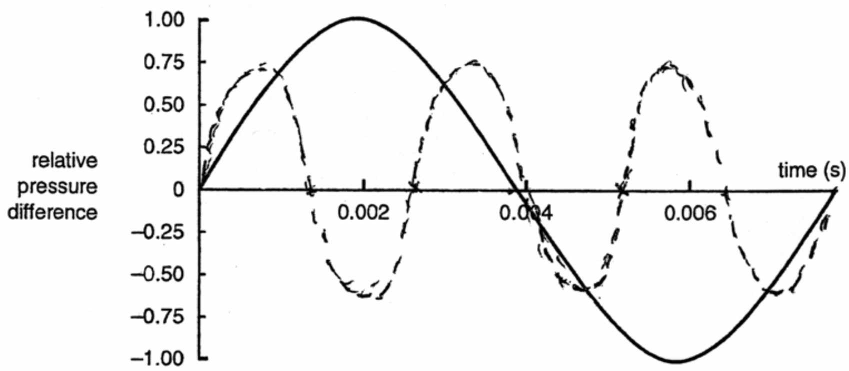
During the marking of the papers the following concerns were expressed:

- Many students continue to experience difficulty with numerical calculations. That is, they identify the correct equation to apply and substitute in the correct values, but are then 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. This was also a problem in 2001.
- 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. 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 some questions. Attention should be given to teaching the use of diagrams as part of an explanation
- 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 may well be supported by the appropriate numerical values for the wavelength and the obstacle or gap size.

SPECIFIC INFORMATION

Area 1 Sound

Question	Marks	%	Comments
Question 1	0/2 1/2 2/2	25 3 72	Students needed to realise that a drum rate of two per second was equivalent to 0.5 seconds between the beats. Hence, the sound travels 167 m in 0.5 seconds, resulting in an answer for the speed of sound of 334 m s^{-1}. An answer to three significant figures was required. The most common error was to interpret the time between the beats as 2 seconds rather than 0.5 seconds.
Question 2	0/4 1/4 2/4 3/4 4/4	8 11 20 31 30	Morgan's explanation was the correct one. Sound waves are longitudinal waves and this implies that the particles vibrate back and forwards in the same line as the wave direction or energy flow. Pat was incorrect because there was no understanding shown of the fact that the mean position of the particles does not change. Most students realised that Morgan was correct because of the longitudinal nature of the sound wave. The most common oversight was in not describing the direction of energy flow or the wave direction relative to the particle motion. Many students felt that simply identifying compressions and rarefactions was sufficient to fully answer this question and their explanations lacked sufficient detail to gain the available 4 marks.
Question 3	0/2 1/2 2/2	17 36 47	Diagram **E** corresponded to the sound wave at time t = T/4 and diagram **C** corresponded to the sound wave at time t = T/2. The most common error was to choose the diagrams corresponding to waves travelling to the right rather than the left.
Question 4	0/2 1/2 2/2	40 37 23	Diagram **D** corresponded to the standing wave at time t = T/4 and diagram **C** corresponded to the standing wave at time t = T/2. This question proved to be quite demanding. Clearly the pressure variations for standing waves are more conceptually difficult than for travelling waves.
Question 5	0/4 1/4 2/4 3/4 4/4	42 26 4 1 27	Students needed to realise that when the sound level first becomes a minimum the path difference is $\lambda/2$, or 1.0 m. Geometry then results in an answer of 4.0 m. This question was not particularly well done. Many students recognised the path difference of $\lambda/2$, but were unable to proceed from there. It was clear that the vertical nature of the speakers confused a lot of students. It seemed apparent that students would have been more comfortable with the idea of walking parallel to

			the speakers rather than towards the speakers.
Question 6	0/4 1/4 2/4 3/4 4/4	17 21 20 19 23	The reason why there is a difference in the sound is due to diffraction through the door opening. Longer wavelengths diffract more than shorter wavelengths and so the shorter wavelengths are reduced in intensity relative to the longer wavelengths. Further to this, the amount of diffraction depends on the ratio of the wavelength to the size of the opening. A door width of 1.0 m corresponds to a diffraction wavelength of 1.0 m and a corresponding frequency of 340 Hz. Hence, frequencies in the range 340–20 000 Hz will be reduced in intensity for Peta. Most students correctly recognised the concept of diffraction but were unable to relate this to the ratio of wavelength and size of the opening. Despite the question specifically requiring a response to the range of frequencies, very few students correctly answered this aspect of the question.
Questions 7 and 8	0/4 1/4 2/4 3/4 4/4	3 5 14 15 62	**Q7** Forty Hz is the lowest frequency and 20 000 Hz the highest frequency. These frequencies were obtained directly from the graph for a sound intensity of 10^{-5} W m^{-2}. Students generally did well on this question. The most common error was to read directly for the frequency end points of the graph. Another common error was to incorrectly read the powers for the sound intensity, that is, treating 10^{-7} as a larger number than 10^{-5}. **Q8** A sound intensity change from 10^{-5} W m^{-2} to 10^{-9} W m^{-2} corresponds to a change in sound intensity of 10^{-4} W m^{-2}. This is equivalent to a sound intensity level of 40 dB. The most common error was to calculate the initial (70 dB) or final (30 dB) sound intensity level and then forget to calculate the difference.
Question 9	0/2 1/2 2/2	28 0 72	The sound intensity falls off according to the inverse square law. Hence, the sound intensity at Y would be $I_0/4$, corresponding to **A** as the answer. The most common incorrect answer (**B**) corresponded to an inverse relationship, rather than an inverse square.
Question 10	0/2 1/2 2/2	25 4 72	A tube, closed at one end, has a pressure variation node at one end and a pressure variation antinode at the other end. Hence, the fundamental mode of vibration has a wavelength that is four times the length of the tube. Applying the formula: $v = f\lambda = f.4L$ $340 = 130 \times 4L$ $L = 0.654$ m The only common error noted was for students who treated the clarinet as an open-ended tube rather than a closed tube.
Question 11	0/2 1/2 2/2	37 0 63	Figure **C** best represented the 650 Hz overtone for the closed tube. 650 Hz corresponded to the 2nd overtone or 5th harmonic for the tube.
Question 12	0/2 1/2 2/2	72 8 20	For a closed-ended tube the first overtone corresponds to the 3rd harmonic. Hence, the 3rd harmonic has a frequency of 390 Hz (3 x 130 Hz). The expected sound wave sketch was:  This proved to be a difficult question (only 25% of students correctly sketched

			the first overtone). It was also apparent that students experienced some difficulty in understanding the difference between pressure variation versus distance and pressure variation versus time graphs. The most common incorrect answer was for students who worked on the scenario of the second harmonic rather than the third harmonic – these students did not understand the overtone structure for a closed tube.

Area 2 – Electric power

Question	Marks	%	Comments
Question 1	0/3 1/3 2/3 3/3	35 13 3 48	The resistance of the 120 V, 60 W light globe is 240 Ω. Hence, with the resistor (R) and the globe in series acting as a voltage divider, the resistance of R must also be 240 Ω in order for the voltage across the globe to be 120 V. The most common problems encountered were to use a potential difference of 240 V rather than 120 V or by careless use of the formulas $P = VI$ and $P = V^2/R$ without due regard to the values of V or I to substitute.
Questions 2 and 3	0/4 1/4 2/4 3/4 4/4	12 28 17 23 19	**Q2** The power loss in the transmission lines is calculated using the formula $P = I^2R$. Hence, using low line currents can reduce the power loss. The transmitted power, $P = VI$ is a given value and so high transmission voltages result in low line currents and less power loss in the lines. For example, when the transmission voltage is 220 kV compared to 240 V, the currents are in the ratio 1:920 and so the power losses are in the ratio $(1{:}920)^2$. Typically, students mentioned the power loss in the wires, $P = I^2R$, and the consequent need for low currents to reduce power loss. A number of students discussed that low I meant higher V without specifically referring to the power $P = VI$ as a fixed quantity. The most common problem was in not making a numerical comparison for transmission at 220 kV and 240 V as requested in the question. **Q3** Application of the turns-ratio formula $N_p/N_s = V_p/V_s$ results in an answer of 22 for the ratio N_p/N_s. Most students correctly used the turns-ratio equation to obtain the answer. The most common incorrect answer was the reciprocal 1/22.
Question 4	0/3 1/3 2/3 3/3	43 12 9 36	The length of the supply and return lines is 4000 m and this represents a total resistance of 1.6 Ω. Ohm's law gives a potential drop of $V = IR = 20 \times 1.6 = 32$ V. Hence, the voltage at the Smith's farm is 240 – 32 = 208 V. Most students understood that there was a potential drop across the lines due to the resistance of the lines. However, many experienced difficulty in calculating this potential drop and then relating it to the final voltage at the Smith's farm. Many students neglected to consider the resistance of the return line (not penalised in the marking scheme). Others incorrectly used the given resistance per metre value for the total line resistance. A few students attempted to calculate the answer using the power equation, rather that treating it as a simple series circuit and potential divider, and often got lost in the more complex calculations involved in using this method.
Questions 5 and 6	0/4 1/4 2/4 3/4 4/4	37 4 33 3 22	**Q5** The potential across each of the 16 series globes for group P is 10 V. Hence, the total potential drop across group P is 160 V. This means that the potential across the parallel groups of Q and R is 80 V. With 80 V across group Q there must be 8 globes, each with a potential drop of 10 V. A number of students did not attempt this question, probably because the circuit diagram may have appeared at first sight to be complex. About 20% of students gave '4 globes' as the answer and one assumes that these students were confused about potential drop across parallel arms of a circuit. Many students recognised the 80 V potential drop aspect of the question but found it difficult to relate this to the components of the parallel part of the circuit. **Q6** The current through each of the globes for group P is 0.50 A and this is the same as the current through the electricity supply. This question proved to be more difficult than anticipated. Nearly 20% of students left this question blank and

<table>
<tr><td></td><td></td><td>this backs up the comment made for the previous question about students being confused by the unfamiliar circuit diagram. The most common incorrect answer was 0.25 A, the current for each of the parallel arms. Another common incorrect answer was that of 1.0 A, obtained by students summing the currents 0.5 A, 0.25 A and 0.25 A.</td></tr>
<tr><td>Questions 7 and 8</td><td>0/6 18
1/6 13
2/6 27
3/6 15
4/6 5
5/6 13
6/6 8</td><td>Q7
The supply current for the circuit is 0.5 A and this means that the current through each of the parallel groups Q and R is 0.25 A. The potential difference across each globe is 10 V and so the power generated in each globe is
P = VI = 10 x 0.25 = 2.5 W. This question proved to be reasonably difficult with less than 20% of students obtaining the correct answer of 2.5 W. By far the most common error was to use a current value of 0.5 A for this part of the circuit, resulting in an answer of 5.0 W. This group of questions certainly highlights many students poor understanding of the series and parallel aspects of simple electric circuits.

Q8
When one of the globes in the parallel arm of group Q burns out the effect is to increase the total resistance of the overall circuit and so the supply current will actually decrease. Hence, the globes in group P will become dimmer. Because the globes in group P are now dimmer (less current and hence less voltage) the voltage across each of the globes in group R will have increased and these globes will now become brighter.
The answer becomes:
<table><tr><th>Group</th><th>ON/OFF</th><th>Brightness</th></tr><tr><td>P</td><td>ON</td><td>Dimmer</td></tr><tr><td>Q</td><td>OFF</td><td>- - - - - -</td></tr><tr><td>R</td><td>ON</td><td>Brighter</td></tr></table>
Most students understood the ON, OFF, ON aspect for globes P, Q and R and then realised that globe R would be brighter. However, many students mistakenly felt that globe P would be brighter rather than dimmer.</td></tr>
<tr><td>Question 9</td><td>0/2 50
1/2 26
2/2 24</td><td>The induced current flows from left to right through the resistor. The explanation needed to mention that moving the magnet in the direction shown results in an increasing magnetic flux to the left according to the diagram. The induced current will be such that it opposes this change and attempts to produce a magnetic flux to the right.

Generally, students showed the current direction correctly, although in some cases the direction was indicated by an arrow within the coil rather than through the resistor. The explanation for the direction of the induced current was not well done and it was disappointing to read explanations that referred to the induced flux opposing the flux of the magnet rather than opposing the change in flux within the coil. A number of students felt that simply mentioning a right-hand rule of some description was sufficient explanation; this was not the case.</td></tr>
<tr><td>Question 10</td><td>0/2 55
1/2 0
2/2 45</td><td>Diagram A best shows the induced current through the coil as a function of time. By far the most common incorrect response was that of diagram C. This suggests, as noted in the previous question, that the concept of change in flux is not well understood.</td></tr>
<tr><td>Question 11</td><td>0/2 18
1/2 24
2/2 58</td><td>The magnetic force can be calculated by substitution into the formula F = nBIl, resulting in a force of 3.8×10^{-2} N.

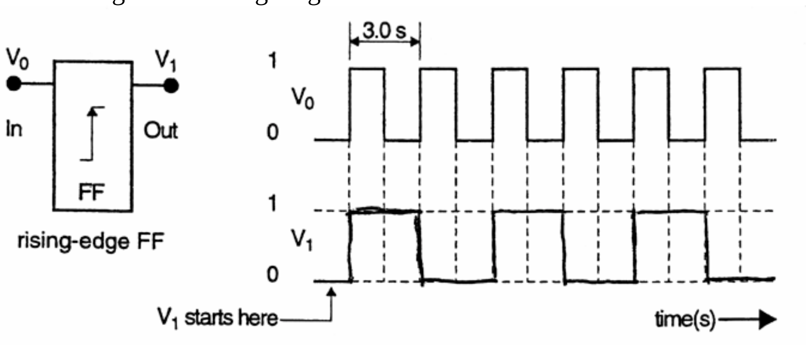
Students generally understood how to calculate the force on a current-carrying wire, with the main error being to overlook the 50 turns in the calculation.</td></tr>
<tr><td>Question 12</td><td>0/1 27
1/1 73</td><td>The force on side P is in the direction B.

The direction C was the most common incorrect answer and suggests that some students did not fully comprehend the geometry of the field lines and current directions.</td></tr>
</table>

<table>
<tr><td>Question 13</td><td>0/3
1/3
2/3
3/3</td><td>27
17
25
32</td><td>The commutator needs to maintain electrical contact as the coil turns; it must be able to rotate freely while remaining in contact. The commutator must be a ‘split-ring’ so that the polarity across the ends of the coil can change every half-cycle. The current through the rotor coil needs to change every half-cycle so that a continuous torque is maintained.

The idea of maintaining electrical contact and hence, continuity of current, was not mentioned by many students. Most students understood that the role of the commutator was to reverse the current every half-cycle but were unable to put this in the context of continuous rotation or direction of torque. Many students also mentioned what would happen if there was not a commutator present, that is, the coil would not continue to rotate but remain in a position perpendicular to the field lines. Of concern was the number of students who treated this as a generator rather than a motor. Only a few students chose to include a torque diagram as part of their answer, others choosing to provide only a written explanation.</td></tr>
</table>

Area 3 – Electronic systems

<table>
<tr><th>Question</th><th>Marks</th><th>%</th><th>Comments</th></tr>
<tr><td>Questions 1 to 3</td><td>0/6
1/6
2/6
3/6
4/6
5/6
6/6</td><td>10
7
11
7
22
5
39</td><td>Q1
A peak-to-peak voltage of 12 V implies a peak voltage of 6 V and an RMS voltage of $6/\sqrt{2} = 4.2$ V. Most students understood this question and the only common errors were to calculate using $12/\sqrt{2}$ or $6\sqrt{2}$. Both of these incorrect calculations demonstrate the need for students to read questions carefully.
Q2
The peak-to-peak voltage of 12 V covers a vertical displacement of 6 cm on the CRO screen. Hence, 1 cm represents 2 V. There were no serious problems noted with this question and any errors were usually due to carelessness on the part of the student.
Q3
The horizontal direction of 10 cm covers three cycles of the sinusoidal pattern. That is, 10 cm corresponds to 3 x 100 ms = 300 ms. Hence, 1 cm corresponds to 30 ms. This question proved to be more difficult and it was clear that many students did not understand how to attempt this question. A number of students tried to estimate the time for one period rather than taking the full three cycles and then working back from there.</td></tr>
<tr><td>Questions 4 and 5</td><td>0/4
1/4
2/4
3/4
4/4</td><td>14
2
52
9
24</td><td>Q4
The effect of the rising-edge flip-flop is to double the period of the input square wave resulting in the timing diagram:


This question was quite well done and it is clear that students understand the operation of flip-flops.

Q5
The input signal has a period of 3.0 s. After one flip-flop this will have doubled to 6.0 s. If we follow this doubling sequence: 3 – 6 – 12 – 24 – 48 – 96 – 192 we can see that 6 flip-flops are required to produce a period of 192 s. This question was not well done. Most students understood that the flip-flop acts as a frequency divider but some had trouble proceeding from this point. A number of</td></tr>
</table>

			students clearly understood the period doubling but simply made an error in their start or finish values, resulting in incorrect answers of 5 or 7 flip-flops. Another very common incorrect answer (16% of students) was 64 flip-flops, obtained by students treating it as a linear device and simply calculating 192/3 as their final answer.
Question 6	0/1 1/1	39 61	Logic circuit **C** will turn ON the green light for only the last 96 s. The most common incorrect circuit was **D**. These students recognised that it gives logic 1 (ON) for the last 96 s but they failed to notice that it gives logic 1 (ON) for the first 6 s as well.
Questions 7 and 8	0/4 1/4 2/4 3/4 4/4	22 3 49 5 21	**Q7** Either of the following two logic circuits would activate the yellow traffic light according to the given sequence. It was disappointing to note that many students did not attempt this question. Those who did attempt it found it difficult. ***Please see diagram below.*** **Q8** Completing the truth table resulted in the pattern 0 0 1 0 for the Green-light controller column. Most students correctly answered this question.
Questions 9 to 11	0/5 1/5 2/5 3/5 4/5 5/5	52 10 18 11 4 5	**Q9** The voltage across the 100-Ω resistor is 2.0 V. Application of Ohm's law (V = IR) results in a current of 0.02 A (20 mA) in the resistor and hence the nonlinear device. This question was not answered well. Students find nonlinear devices difficult but this was not helped in this question by a number of students failing to indicate the point on the graph at all. Careful reading of questions is strongly recommended. The bend on the curve of the graph was frequently chosen, probably because this was interpreted as the start of the 'nonlinear region'. **Q10** The power dissipated in the 100-Ω resistor is P = VI = 2 x 0.02 = 0.04 J s^{-1}. Hence, in 10 s there will be 10 x 0.04 = 0.4 J (400 mJ) of electrical energy converted to heat energy. Students experienced some difficulty with this question and many were unable to convert the unit of J into mJ correctly. **Q11** The nonlinear device is limited to a maximum of 3.0 V across it. The voltage across the 200-Ω resistor will remain as 2.0 V. With 2.0 V across the 200-Ω resistor the circuit current will be 2.0/200 = 0.01 A (10 mA) that still results in a voltage across the nonlinear device of 3.0 V. Students found this question very difficult. Many incorrectly treated the nonlinear device as a fixed-value resistance.
Question 12	0/1 1/1	74 26	The nonlinear device will still have a voltage of 3.0 V across it. The resistor will now have a voltage of 3.0 V across it. Hence, the current in the resistor is I = V/R = 3.0/100 = 0.03 A (30 mA). This corresponds to **D**. This proved to be a difficult question. In fact, **C** was the most common incorrect response. This suggests that students knew that the current would increase but were unclear about how to calculate that increase.
Question 13	0/2 1/2 2/2	41 4 54	The 'usual' half-wave rectified waveform was expected for this answer. This question was not as well done as anticipated. Some students sketched a smoothed and rectified signal.
Question 14	0/2 1/2 2/2	23 21 56	The time-constant can be calculated according to: T = RC = 100 x 100 x 10^{-6} = 10 ms. A typical problem was an error in converting the unit to ms. Some students incorrectly calculated for 5 time periods, confusing smoothing with the concept of 'full' charge or discharge time for a capacitor.
Question 15	0/1 1/1	85 15	When the resistor R is removed from the circuit this effectively implies a very large resistor (open-circuit) and hence a very large smoothing time-constant. Hence, **D** represents the output voltage.

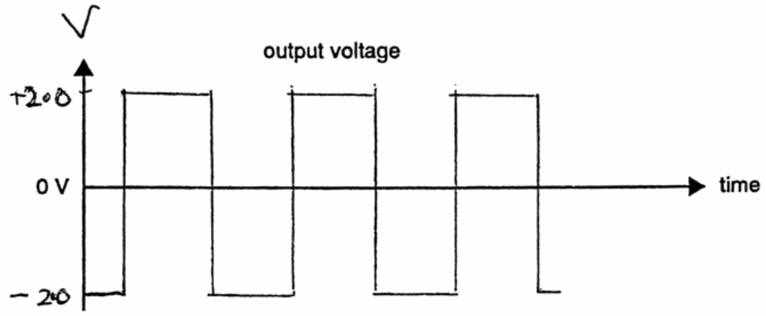
			This was a difficult question. By far the most common incorrect response was waveform **C**, the ‘typical’ smoothed waveform that students may well have studied. Another common error was to choose waveform **A**, corresponding to a smoothing time constant of zero. Clearly most students do not interpret an open circuit as a very large resistance and a consequently large smoothing time constant. Most teachers will be well aware of the difficulty that students have with this concept.
Question 16	0/2 1/2 2/2	35 7 58	The voltage amplifier amplifies the input voltage from 0.1 to 2.0 V. With 2.0 V across a 1000 Ω resistor the current is 2/1000 = 0.002 A = 2 mA. The most common error was in changing A to mA.
Question 17	0/2 1/2 2/2	31 15 54	The expected sketch of the output voltage was:  While some students did not answer this question, those who did answer generally understood the concept.

Diagram for Question 7