

Physics GA 1: Written examination 1

GENERAL COMMENTS

Examination 1 continued the consistent style and standard of recent years. The means for 2000 and 2001 were the same (61%) and the cut-off scores for A+ (80/90 in 2001) were similar. Very able students found the examination accessible but discriminating. Well prepared students were generally well rewarded. Nine students achieved full scores.

The following concerns were noted:

- Many students continue to experience difficulty with numerical calculations. They appear able to identify the correct equation to apply, substitute in the correct values, but 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. Students need more practice with numerical calculations.
- Written explanations continue to lack detail or are not specific to the question asked. Students need to be encouraged to address the question and the context in written explanations. Students may need advice about over-reliance on the A4 sheet when drafting the words of their explanation. Students must re-read their final explanations and check that they have actually answered the question asked.
- The use of well constructed diagrams needs to be improved. Students should be aware that annotated diagrams can be particularly powerful for answering questions requiring specific detail. Diagrams are often too roughly drawn and make the answer unclear.
- Students need to be more familiar with appropriate numbers for physical qualities, i.e. they are often unwilling to quote numerical values in a written explanation. Students 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 1(Q1 and 2: Average mark 3.69/Available marks 4)

Students needed, initially, to recognise that the period of the loudspeaker cone was 0.005 s, and then calculate the frequency as 200 Hz. Most students readily understood both this question and the following question. Some students made the error of determining the wavelength directly from Figure 1, treating the horizontal axis as a position axis rather than a time axis.

Question 2

Using the frequency calculated in the previous question, application of the equation $v = f\lambda$ resulted in a wavelength of $\lambda = 1.7$ m. While errors were rare, some students answered 17 m, due to a simple arithmetic mistake or 68 000 m, obtained by confusing period and frequency.

Question 3 (1.17/2)

The time delay for the loudspeaker pressure variation to reach the microphone was 0.005 s. Hence, graph A best represented the pressure variation at the microphone. Students also needed to provide a correct explanation as to the cause of this time delay of 0.005 s.

Most students understood the concept of time delay. The most common incorrect response was answer C, obtained by students who assumed that the initial movement of the speaker cone produces an immediate pressure maximum and in their explanation these students generally linked the position of the cone directly to the pressure variation.

Nearly 20% of students scored 1 mark for this question, either by correctly choosing graph A and an incorrect justification or by choosing the incorrect graph, but showing an understanding of the time delay for the signal to reach the microphone.

Question 4 was not nearly as well understood as Question 5.

Question 4 (Q4 and 5: 3.67/6)

Students needed to address both aspects of the question as follows:

- The reason for the sound persisting could be explained in terms of reflection from the walls, floor and ceilings. An explanation that these are hard surfaces in a cathedral and hence are poor absorbers or good reflectors of sound was also required. The multiple reflections resulted in the sound travelling further distances and thus a time span between hearing the direct sound and the reflected sounds.
- The reason for hearing the high and low frequencies for a shorter time required an explanation in terms of the greater sensitivity of the human ear to mid-range frequencies, as indicated by the graph of Figure 3. If it is assumed that the orchestra produces a full range of frequencies at fairly similar initial intensities, then as the reflections ‘die-off’ the highs and lows will soon be below the threshold of hearing for the human ear and will be heard for a shorter time.

Most students understood that reflections from the surfaces were responsible for the sound persisting. However, the explanation for the shorter high and low frequency reverberation times proved far more difficult. While the connection with the sensitivity of the human ear was fairly clear, students generally found it difficult to relate the sensitivity characteristics to time delay in a coherent and convincing manner. Far too many students gave vague and general answers, particularly in relation to the high and low frequency aspect of the question; these did not earn full marks. Only a few students elaborated on the reflection aspects to relate multiple reflections to greater distances and hence longer time delays.

Question 5

Inspection of the sensitivity graph of Figure 3 showed that maximum sensitivity occurred at a frequency of 3500 Hz. Answers in the range 3000–4000 Hz were marked as correct.

This question was quite well understood by most students; the only difficulty worth noting being the ability to interpret a logarithmic scale correctly.

Question 6 (1.57/2)

This question required students to understand that 5 nodes and 5 antinodes implied a pattern for a pipe open at one end and closed at the other (a pipe which is open at both ends will always have one more pressure variation node than antinode). Hence, the correct answer was **one** open end.

Most students understood the standing wave patterns for open and closed pipes. Some students did not read the instructions to include a diagram as part of their answer. The most common error was to sketch a diagram with 6 nodes and 5 antinodes and then conclude that the tube had two open ends. However, most students correctly sketched the diagram and obtained the full 2 marks.

Question 7 (2.3/4)

Students needed to sketch a standing wave pattern showing 5 nodes and 5 antinodes along the length of the tube. The resulting pattern showed that there were $2\frac{1}{4}$ (9/4) wavelengths along the length of the tube. That is, the wavelength of the sound was $\frac{4}{9}$ the length of the tube. This resulted in a tube length of 1.1m (1.125m).

Quite a few students experienced some difficulty. About 40% of students obtained the full 4 marks for this question and a further 20% scored zero. Most students were able to determine the wavelength correctly as 0.5 m but the main difficulty was in the interpretation of the number of wavelengths along the tube. Quite a common error was to choose 2.5 wavelengths rather than 2.25 wavelengths. It was also disappointing to note that a number of students simply quoted and then used a formula for f or L without indicating how it was relevant to this context.

There was a reasonable degree of understanding of inverse square law and sound intensity levels. However, students appeared to experience more difficulty with Question 8 (inverse square law) than Question 9 (dB levels).

Question 8 (Q8 and 9 2.81/4)

An understanding of the inverse square law was required. The intensity ratio was calculated as $\frac{1}{4}$ and hence, Xena was double the original distance, 20 m, from the speaker.

Students who correctly answered Question 8 usually did so by simply spotting the intensity ratio as $\frac{1}{4}$ and then deducing the distance ratio as 2:1. A smaller group completed the task algebraically and set up an equation for the ratio of inverse squares, although this group generally experienced more difficulty in obtaining the correct answer. Students who attempted this algebraic solution often wrote the expression as proportional to the square rather than the inverse square.

Question 9

Application of the equation $dB = 10 \log_{10} (I/I_0)$ for the two different intensities was sufficient to calculate each intensity and show that the difference was 6 dB. Alternatively, a simpler approach was to note that halving the intensity resulted in drop of 3 dB, and so 6 dB resulted when the final intensity was one-quarter the original intensity.

A relatively small group chose this second, and far simpler, method. A much larger group calculated the original value as 49.54 dB and the final value as 43.52 dB, with a difference of 6.02 dB

Question 10 (2.03/4)

This question required students initially to recognise that the path difference (2.4 m) for a **minimum** was equal to

$$(n - \frac{1}{2}) \lambda.$$

Students then needed to adopt a ‘trial and error’

approach – equating $\lambda/2$, $3\lambda/2$, etc. to the path difference of 2.4 m and then determining the frequency for each separate value of λ . The first minimum resulted in a wavelength of 4.8 m and a corresponding frequency of 70.8 Hz, which was outside the given frequency range of 150–250 Hz. The second minimum resulted in a wavelength of 1.6 m and a corresponding frequency of 212 Hz.

The mark breakdown showed that students either fully understood it or had very little idea of how to proceed (35% of students scored zero). The most common error was in assuming that the path difference was in fact the wavelength, thus showing no understanding of path difference as it related to interference for two point sources.

Question 11 (1.12/4)

Students had to understand that the amount of diffraction was related to the ratio of wavelength to head size. Hence, for wavelengths longer than the head diameter, sound will diffract around the head, reaching the left ear at a slightly later time than the direct sound at the right ear. However, for wavelengths shorter than the head diameter, sound will be unable to diffract around the head and reach the left ear. Thus, for these shorter wavelengths the intensity at the right ear will be larger than that at the left ear. Hence, both John and Maria were correct depending on the wavelength of the sound. John was correct for longer wavelengths (lower frequencies) and Maria was correct for shorter wavelengths (higher frequencies).

This was certainly a very difficult question, with only 7% of students scoring the full 4 marks and about 40% scoring zero

Most understood the connection between diffraction and longer wavelength, but were not able to relate this to a time difference or phase difference between the right and left ears. Many students understood that short wavelengths did not diffract a great deal, but were unable to relate this to an intensity difference between the right and left ears.

Area 2 – Electric power

Question 1 (Q1 and 2: 2.3/4)

Application of the equation $R = V/I$ resulted in a wire resistance of 0.001Ω . The most common error in Question 1 was in the incorrect interpretation of the unit, mA, for electric current.

Question 2

This question required students to understand that electric current is measured in the unit ampere, and that 1 ampere = 1 coulomb per second. Furthermore, students needed to realise or deduce that 1 coulomb of electric charge was equal to 6.25×10^{18} electron charges. Hence, a current of 100 mA was equivalent to 6.25×10^{17} electrons per second.

The most common error was to divide by the number of electrons in a coulomb of charge rather than multiplying. This simple arithmetic error may be a sign of a lack of understanding of the meaning of the coulomb. It points to the problems that students continue to experience with simple equations and arithmetic exercises, particularly those involving powers of ten manipulations.

Most students experienced little difficulty with the simple calculation for Question 3, but much greater difficulty with Question 4.

Question 3 (Q3 and 4: 2.87/5)

Application of the electric power equation $P = VI$ resulted in an expected current of 0.5 A.

Question 4

The reason for the light not operating at the rated 120 W needed to include the following points:

- the voltage across the globe was less than the required 240 V
- hence, the primary voltage of the second transformer was less than 12 V
- power loss in the wires carrying current to each transformer could explain why the output power was less than expected or

- potential drop across the wires connecting the two transformers could explain why the primary voltage of the second transformer was less than 12 V
- the long wires connecting the two transformers have a combined resistance that results in an appreciable potential drop across these wires.

Question 4 was not particularly well done. Although told that the transformers were ideal, a number of students wrote about energy loss in the windings. Students often wrote about power loss in the wires or mentioned the formula $P = I^2R$ without specifically discussing the resistance of the wires. Very few students approached this question from the perspective of potential drop across the wires, resulting in an input potential of less than 12 V to the primary of the second transformer. Teachers need to stress the concept of a potential divider for a series circuit in their future teaching.

Question 5 (1.16/2)

The turns ratio for the second transformer was $240/12 = 20$, and this does not depend on the values of the input voltage, or power losses in the lines. Hence, with a primary voltage of 10 V, the secondary voltage will be 200 V.

The most common error was in failing to note the turns ratio as being fixed and hence trying to solve via some odd manipulations of the transformer equations.

Question 6 (0.9/2)

Students needed to calculate the input power as $10 \times 8.3 = 83 \text{ W}$ and then equate this to the output power of $200 \times I_{\text{globe}}$, resulting in a globe current of 0.415 A.

Most students found difficulty with this question. Many students appeared fairly confused with incorrect responses ranging from the primary current of 8.3 A to current values obtained from various manipulations of the transformer equations using primary voltages of 12 V or even 2 V.

Questions 7 and 8 provided clear evidence that the concept of transformers and electrical energy transmission is not well understood by many students.

Question 7 (0.37/2)

The potential drop across the wires was 2 V and the current in the wires had been previously given as 8.3 A. Hence, the combined resistance of the wires was 0.24Ω .

This was a difficult question for most students. The most common incorrect answer was a resistance value of 1.2Ω , obtained by dividing the transformer input voltage of 10 V by the line current of 8.3 A. Some students even managed to double this incorrect value to obtain a value of 2.4Ω .

Question 8 (0.97/2)

The voltage across the globe could be increased by reducing the potential drop across the wires. This could be achieved by using wires of lower resistance or by having a lower current in the wires. The changes suggested by B and C would both achieve the desired result.

The most common error being made by students was incorrectly choosing D, a change that would actually increase the current in the wires and hence the potential drop across them.

Question 9 (1.08/2)

In order to produce the magnetic field pattern as shown in Figure 5, the current needs to flow in at Z and out at X. Hence, **B** was the correct answer.

Question 10 (1.37/2)

Application of the equation $F = n.IlB$ resulted in a force of 0.90 N on side JK of the armature.

The most common error, made by about 30% of students, was due to the omission of the number of turns for the armature coil.

Question 11 (1.21/2)

The magnetic field direction was given in Figure 5. When coupled with the current direction as shown, forces on sides JK and LM produce an anticlockwise torque. Hence, statement **A** was the correct answer.

Sixty per cent of students correctly answered this question, with the most common incorrect answer (B) being that the coil would rotate in the opposite direction, that is, clockwise.

Question 12 (Q12 and 13: 1.91/4)

Application of the electric power equation $P = V^2/R$ resulted in a net resistance of 60Ω for the series circuit. Hence, each series element had a resistance of 30Ω .

The most common error was in forgetting to halve the final resistance value, resulting in an answer of 60Ω rather than 30Ω . Other incorrect responses involved using the formula $P_w = \frac{240^2}{R}$ for a dissipated power of 480 W, obtained by students who failed to consider the voltage divider aspect of resistances in series.

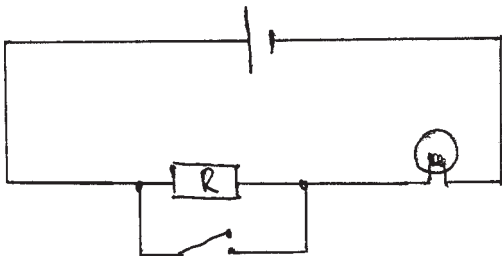
Question 13

The total power for the series circuit was already given as 960 W, resulting in a value of 30 W for each of the heating elements as calculated in the previous question. For the parallel circuit the effective resistance becomes 15 W and the total power dissipated can be calculated as 3840 W. Hence, the ratio was $960/3840 = 0.25$.

The major problem was a failure to determine the total resistance as 15W. It was also clear that students experienced some problem with the arithmetic calculations involved. The incorrect value of 4 was a common answer.

Question 14 (1.87/3)

The required circuit was as shown below:



About 50% of students sketched the correct circuit diagram and some students were able to gain part marks by demonstrating an understanding of some aspects of the circuit. The most common incorrect answer involved placing the resistor and switch in parallel with the globe rather than only the switch in parallel.

AREA 3 – Electronic systems**Question 1 (1.0/2)**

This question required an understanding of the circuit as a voltage divider. With the selected resistance of 40 W and the loudspeaker resistance of 10 W, the voltage divider relationship resulted in a voltage of 0.10 V across the loudspeaker.

Question 2 (0.83/2)

For a series circuit the current is the same in all parts of the circuit. Hence, the current ratio was 1.0, giving answer **C** as correct.

The three-pole switch and resistor combination managed to confuse a great number of students. The most common incorrect answer was **E**, a ratio of 2.0, which is simply the resistor ratio.

Question 3 (0.72/2)

With resistor R_3 selected, the total resistance for the circuit was 20 W, resulting a circuit current of 0.025A and a dissipated power of 6.25 mW for the loudspeaker.

Question 4 (1.17/2)

For a very large resistance the current value will be zero. Reading along the graph for a current of zero resulted in a solar cell voltage of 0.8 V. Because the solar cell and resistor are in parallel the potential difference across the resistor must also be 0.8 V.

The most common incorrect response was an answer of zero. Students who obtained an answer of zero usually did so from a mathematical perspective by indicating that zero multiplied by any value equals zero, rather than examining the physics of the solar cell circuit.

Question 5 (1.45/2)

When the voltage across the solar cell approaches zero, inspection of the characteristic curve shows that the current corresponds to a maximum value of 20 mA.

Question 6 (1.26/2)

Power calculations for each of the points A, B, C and D resulted in values of zero, 5.7 mW, 8.25 mW and zero respectively. Hence, 8.25 mW was the maximum value and this corresponded to point **C** on the characteristic curve.

Question 7 (2.02/3)

The value of the time-constant for the circuit was given as 9.87 s. Application of the time-constant equation $\tau = RC$ resulted in a capacitance value of 9.87 mF.

Most students were able to recognise and apply the time-constant formula. The most common errors were due to either incorrect transposition of the equation or use of an incorrect unit for capacitance, particularly the use of the unit C for capacitance rather than F or mF.

Question 8 (1.7/3)

The question required that the light stay on for a longer time, which means that the capacitor needed to discharge more slowly. This required a longer time-constant. A longer time constant could be achieved by increasing the value for the resistance R.

Most students indicated that the value of R should increase, but a number failed to justify this answer with an explanation that connected the time constant and the resistance.

Question 9 (1.16/2)

The time constant for the circuit remains the same and so the capacitor discharges at the same rate. Because the initial voltage is lower then it will take a shorter time to reach the turn-off value of 8.0 V. Hence, the correct estimate was C, a time less than 4.0 s.

Fifty-eight per cent of students correctly answered this question, with the remaining students choosing equally between the distracters A and B.

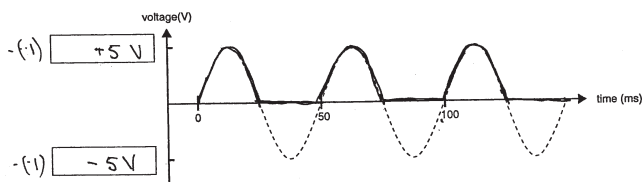
Question 10 (Q10 and 11: 2.47/4)

A peak-to-peak value of 10 V corresponds to a peak value of 5 V. Hence, +5 V and -5 V needed to be indicated on the vertical scale.

Most students were able to answer this question correctly. The most common error resulted from confusion with RMS values. The RMS confusion usually resulted in an incorrect value of 3.5 V or 7.07 V.

Question 11

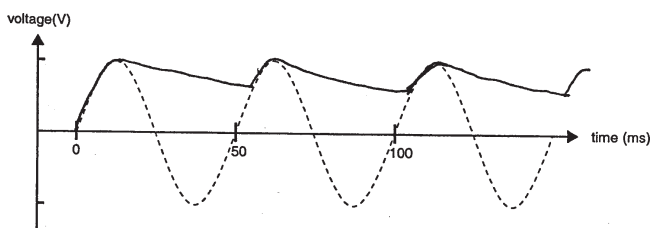
Students needed to show the correctly labelled half-wave rectified signal



This question was also reasonably well understood, with the most common error being to sketch a full-wave rectified signal rather than the half-wave signal.

Question 12 (1.12/2)

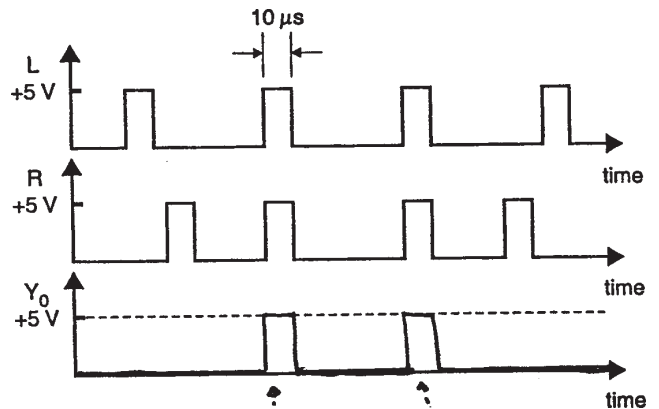
This question required students to interpret smoothing of the half-wave rectified signal. The period of the original signal was 50 ms and the time constant for the smoothing circuit was given as 100 ms, hence the smoothing time-constant was longer than the period of the input signal. Thus, students were expected to sketch a smoothed signal similar to that shown below. Sketches that showed too great or too small a drop during the discharge part of the signal were not awarded full marks.



The main problems experienced were many and varied, with some students showing too little or too large a drop-off during the discharge period, and others showing a complete misunderstanding of the gradual decrease from the peak voltage to the beginning of the next cycle of the ripple pattern

Question 13 (1.12/2)

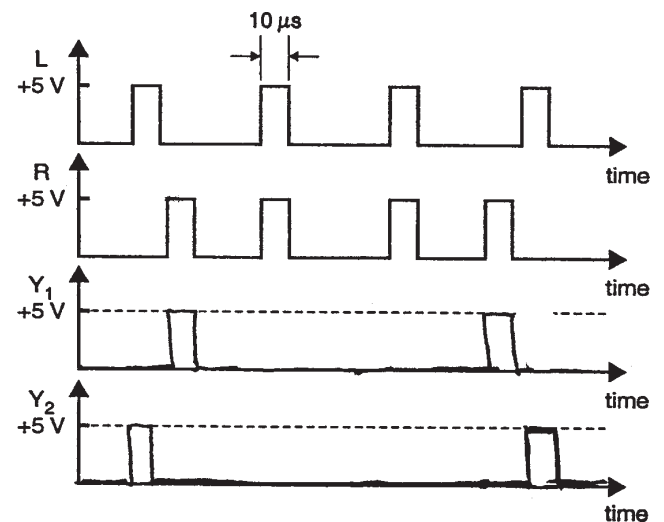
The AND-gate records coincident signals from the L and R detectors. The timing output diagram Y_0 shows the occurrence of simultaneous events.



The most common error was that students treated this as a flip-flop question, rather than a simple AND gate question. The pulsed input confused a number of these students and misled them into treating it as a flip-flop circuit.

Question 14 (0.93/2)

The timing diagram for non-simultaneous events is shown by the outputs Y_1 and Y_2 below.



For this final and more difficult question, the most common mistake was to interpret the question as involving a flip-flop, rather than a combination of AND and NOT gates. The complexity of the circuit diagram also appeared to confuse a number of students.

STATISTICAL INFORMATION

Year 2001

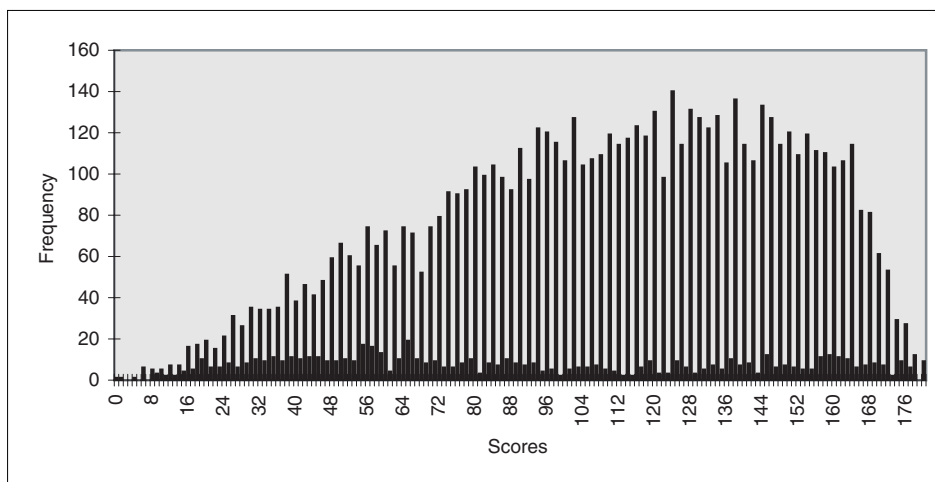
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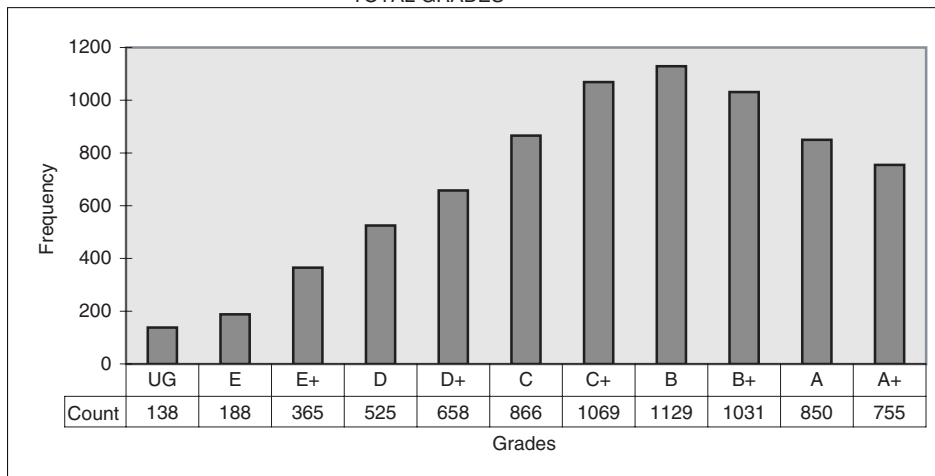
WRITTEN EXAMINATION 1

COUNT	7574	Female	1989 (26.3%)	Male	5585 (73.7%)
Mean score	107 (C+)	Standard Deviation	40.5		
Median Grade	C+	NA Result	127		

TOTAL SCORES



TOTAL GRADES



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).