2005 Physics GA 3: Written examination 2

GENERAL COMMENTS

The number of students who sat for the 2005 Physics examination 2 was 6757. With a mean score of 62%, students generally found the paper to be quite accessible. Those who had thoroughly prepared themselves were well rewarded for their efforts. Three students achieved the maximum score of 90. The majority of schools predictably chose to limit the changes to their course in the first year of the accreditation of the new *Physics VCE Study Design* by selecting Detailed Study 3 – Sound.

Students and teachers should note the following points in relation to the 2005 examination 2 paper and for future reference.

- Students should only answer questions from one of the detailed studies. Some students attempted two or three detailed studies.
- Students need to be more careful with their handwriting – if the assessor could not decipher what was written, no marks were awarded. This applied particularly to multiple-choice questions where one answer was written over another.
- Written explanations must address the question. Students who simply copied generic answers from their note sheets did not gain full marks.
- In questions that required an explanation, one mark was generally awarded for each point made. Therefore, students could not expect to obtain full marks for giving a single phrase in response to a two-mark question.
- Students should be encouraged to show their working. Credit can often be given for working even if the answer is incorrect.
- Students must follow the instructions given in questions. A number of questions specifically stated that working was to be shown. If this was not done, marks were not awarded.
- A number of students did not answer Question 1 in each of the detailed studies. Perhaps this was because they were of a slightly different question style to what students have been used to; however, this very style of question was on the sample and final paper for last year's pilot course and should not have come as a surprise.

It was encouraging to see that the number of students with their calculators in the wrong mode had greatly reduced, and students were generally better able to convert units.

SPECIFIC INFORMATION

Section A – Core

Area of Study 1 – Electric power

Questions 1–2

Marks	0	1	2	3	4	Average
%	9	8	31	10	42	**2.8**

Question 1

The correct direction, D, was selected by the majority of students.

The most common incorrect response, A, may have been obtained by using the wrong hand or reversing the direction of the magnetic field.

Question 2

Using $\Phi = BA$, the area was determined to be 4 x 10^{-4} m^2.

The common incorrect answer of 4 x 10^{-6} resulted from the common misconception that the number of coils was associated with flux.

Questions 3–5

Marks	0	1	2	3	4	5	6	7	8	Average
%	8	7	8	15	9	18	11	15	10	**4.6**

Question 3
Since the frequency was 10 Hz, the period was 0.1 s. The required time interval was half a period, so the answer was 0.05 s.

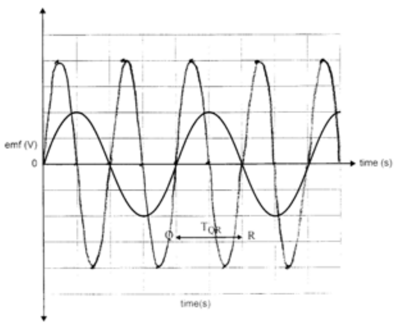
The most common incorrect response of 0.1 s resulted from students mistaking the required interval for the period.

Question 4
Using Faraday's law:

$$\text{emf} = (-)N\frac{\Delta\Phi_B}{\Delta t}$$
$$= \frac{100 \text{ x } 8.0 \text{ x } 10^{-6}}{0.025}$$
$$= 0.032 \text{ V}$$

This question was not well done. There was a wide variety of answers, with the most common errors arising from not correctly matching the change in flux with the time taken for that change. The most frequent example of this was using the flux change for a quarter of a turn, 8 x 10^{-6} Wb, with the time for a half a rotation, 0.05 s.

Question 5



Although most students realised the period had to be halved, a significant number did not realise the amplitude would be doubled.

Questions 6–8

Marks	0	1	2	3	4	5	Average
%	5	14	15	15	28	24	**3.3**

Question 6
Most students identified that Kris was correct.

Question 7
The commutator reversed the polarity of the output every half rotation to produce DC. Most students treated this as a motor instead of a generator.

Question 8
Most students selected the correct answer, C. The most common incorrect response was option B.

Questions 9–10

Marks	0	1	2	3	4	Average
%	5	1	11	5	78	**3.6**

Question 9
Substituting into $P = VI$, 1200 = 240 x I, therefore the current was 5 A.

This question was well done. Most of the incorrect responses were a result of students introducing a √2, presumably because the voltage was said to be RMS.

Question 10

The power loss $\Delta P = I^2R$
$= 1800$ W

Most students were able to determine the power loss correctly.

Questions 11–13

Marks	0	1	2	3	4	5	6	7	8	9	Average
%	7	4	8	8	9	8	9	10	15	21	5.8

Question 11

The voltage drop in the supply lines was 60 V (Ohm's Law). When this was subtracted from the supply voltage of 240 V, the voltage at the house was 180 V.

The alternative approach of using power calculations would give the same answer. A common mistake was for students to assume that the power supplied by the power lines was 12 000 W.

Question 12

Since the power demand was fixed, increasing the voltage would reduce the current. Since power loss was given by I^2R, reducing the current reduced the power loss.

While most students had the basic idea, many did not refer to the fact that the power supplied by the lines was constant.

Question 13

$V_{peak\text{-}peak} = 2\sqrt{2} \times 11\ 000$
$= 31\ 113$ V

A common error was for students to determine only the peak voltage.

Questions 14–16

Marks	0	1	2	3	4	5	6	7	Average
%	9	3	20	15	17	22	5	9	3.7

Question 14

By substituting the supplied information into the equation for an ideal transformer, $V_pI_p = V_sI_s$, the primary current was 0.1 A.

Some students confused the primary and secondary values, while others substituted correctly into the equation but then could not rearrange it correctly to get the required value.

Question 15

Faraday's Law gives the magnitude of the induced voltage, while Lenz's Law gives the direction.

Explanations of Lenz's Law were often unclear. Even when students knew that it had something to do with the direction of the induced EMF, their explanations were often incorrect. A large number of students referred to induced current rather than induced voltage.

Question 16

The correct answer was C. Many students selected B, but this would not work if the wiring was incorrect.

Question 17

Marks	0	1	2	3	Average
%	5	8	0	86	2.7

The coil was number 3, the loop was number 1 and the wire was number 2. Most students answered this correctly.

Area of Study 2 – Interactions of light and matter

Questions 1–2

Marks	0	1	2	3	4	Average
%	35	6	31	19	9	1.7

Question 1
Very few students obtained full marks for this question. Students were not able to relate the thermal/random excitation of electrons to the emission of a broad/continuous spectrum. Many wrote about bound electrons, apparently neglecting the fact that this would produce a discrete spectrum. Others seemed unaware of the term incandescent and wrote about discharge tubes.

Question 2
The light produced by an incandescent globe is incoherent, so the answer was B. A number of students chose A or D.

Questions 3–4

Marks	0	1	2	3	4	5	Average
%	20	3	13	9	4	51	3.4

Question 3
The work function corresponding to sodium could be found by drawing a line of best fit through the points on the graph to determine the *y*-intercept.

Question 4
The gradient of the line of best fit gave Planck's constant as approximately 4.5×10^{-15} eV s.

This question required students to show working. Therefore, simply stating the accepted value of Planck's constant as 4.1×10^{-15} received no marks. Some students used Einstein's equation and substituted for a point on the line of best fit. Others used $W = hf_0$ and read f_0 and W from the graph. These methods were also awarded full marks.

Question 5

Marks	0	1	2	Average
%	51	0	49	1.0

Only half of the students selected the correct option, B. Many chose A, which would affect the overall diffraction envelope but not the distance between the bands of the double slit pattern.

Questions 6–8

Marks	0	1	2	3	4	5	6	7	Average
%	4	4	6	11	12	19	16	28	5.0

Question 6
This question also required working to be shown. By substituting in the equation $\lambda = \frac{h}{mv}$, the de Broglie wavelength was found to be 3.64×10^{-11} m.

The question was well done, although some students made arithmetical or calculator errors. Others used the wrong Planck's constant. A number of students used 3×10^8 as the speed of the electron.

Question 7
For diffraction, the gap width must be the same order of magnitude as the wavelength. Since the wavelength was much smaller than the gap, no diffraction pattern would be observed.

A common misconception was that since the wavelength of the electron was smaller than the gap, the electron could fit through the gap and therefore produce a diffraction pattern.

Question 8
The correct answers were B and D.

Approximately one third of the students believed that light exhibited properties of mass (option A) and/or charge (option C).

Questions 9–11

Marks	0	1	2	3	4	5	6	7	Average
%	16	5	22	6	22	9	7	13	3.5

Question 9
The smallest energy gap was that from n = 3 to n = 2, an energy difference of 1.8 eV.

This question was generally well answered, although a considerable number of students opted for 3.4 eV. It was unclear whether this was just a slip or whether they believed that electrons had to drop to the ground state in one jump.

Question 10

The energy of the photon was 3.4 eV. By substituting this into the equation $E = \frac{hc}{\lambda}$, the wavelength was 3.65 x 10^{-7} m.

Common errors included using the wrong energy (1.8 from the previous question) or using one of the formulae that apply to matter and not photons.

Question 11
Electrons have a de Broglie wavelength. Electrons will only exist in states where a standing wave can be formed around the nucleus. Accordingly, only specific wavelengths and their associated energies would be allowed.

A diagram could have been used to explain most of this question. While not an easy concept, students' understanding of the meaning of the standing wave for electrons in stable states within atoms was weak. Many students referred to electrons moving in wave patterns around the nucleus.

Section B – Detailed studies
Detailed Study 1 – Synchrotron and its applications

Questions 1–2

Marks	0	1	2	3	4	5	Average
%	19	6	12	9	18	37	3.1

Question 1
'Electron gun', '99.99%' and 'a linac' were the correct answers.

This question was well done, except for the students who omitted to answer it.

Question 2

The magnetic field needed to maintain the arc was $B = \frac{mv}{rq}$

$= 0.97$ T

Questions 3–5

Marks	0	1	2	3	4	5	6	7	Average
%	35	5	4	8	7	14	15	12	3.1

Question 3

Using $E = \frac{hc}{\lambda}$, the answer was 10.8 k eV.

Some students gave the answer in joules, others left it in electron-volt.

Question 4

$$n\lambda = 2d\sin\theta$$

$$0.115 \times 10^{-9} = 2d\sin 9.6$$

$$d = 3.4 \times 10^{-10}\text{ m}$$

$$= 0.34\text{ nm}$$

Some students had difficulty converting the answer from metres to nanometres. A few students inexplicably halved the angle.

Question 5

The second maximum is represented by $n = 2$ in Bragg's Law. The path difference was two wavelengths. It was common for students to omit any reference to the path difference.

Question 6

Marks	0	1	2	Average
%	52	0	48	1.0

It was surprising that fewer than half the students selected the correct answer, B.

Question 7

Marks	0	1	2	Average
%	48	3	49	1.0

$$\text{Energy} = \text{Vq}$$

$$8.0 \times 10^{-16} = \text{V} \times 1.6 \times 10^{-19}$$

$$\text{V} = 5000$$

A common misconception was to use $E = \frac{V}{d}$, thinking that E represented energy.

Question 8

Marks	0	1	2	Average
%	53	0	47	1.0

Using one of the applicable rules the answer was found to be C.

Fewer than half of the students answered this correctly; possibly the negative charge caused the difficulty.

Question 9

Marks	0	1	2	3	Average
%	50	20	19	11	1.0

X-rays from the synchrotron are nearly monochromatic (less frequency spread), have a greater intensity and are more collimated or focussed.

In explaining this answer, some students simply listed every advantage of a synchrotron, whether or not it was relevant. Many believed that the frequency of X-rays from a synchrotron was vastly different to those from other X-ray sources.

Question 10

Marks	0	1	2	Average
%	46	0	54	1.1

Using $E = \frac{hc}{\lambda}$, the correct answer was B

Question 11

Marks	0	1	2	Average
%	40	0	60	1.2

Elastic scattering implies no energy loss, thus the answer was C.

Detailed Study 2 – Photonics

Questions 1–4

Marks	0	1	2	3	4	5	6	7	8	9	10	11	Average
%	22	5	5	6	5	6	7	8	10	9	10	5	**5.2**

Question 1
'Coherent', 'a population inversion' and 'photons of the same' were the three correct terms.

This question was well done, except for the students who omitted to answer it.

Question 2
Spectrum A was the sodium lamp, B was the red LED and C was the red hot slab of iron.

Only about half of the available marks were awarded for this question.

Question 3
Diode material has a specific energy gap between allowable levels, and light is emitted when electrons transition between the levels. Some students thought there was a wire inside that glowed and the red cover gave the colour.

Question 4
Using $E = \frac{hc}{\lambda}$, the wavelength was 5.9×10^{-7} m.

Most students obtained full marks.

Question 5

Marks	0	1	2	Average
%	51	0	49	**1.0**

For total internal reflection at the core-cladding boundary, the refractive index of the core must be greater than the cladding. Air will have the smallest refractive index, therefore the answer was B.

The most common incorrect response was option A.

Question 6

Marks	0	1	2	Average
%	67	24	9	**0.5**

The laser beam hit the hemispherical end at right angles and therefore did not deviate. At the plastic–air boundary the critical angle was given by:

$$\sin\Phi = \frac{1}{n}$$
$$= \frac{1}{1.60}$$
$$\Phi = 38.68^{\circ}$$

The required angle was $\alpha = 90 - 38.68 = 51.3°$.

This question was not well done. Some students calculated the 38.68° but did not complete the final step.

Question 7

Marks	0	1	2	Average
%	46	0	54	**1.1**

A smaller diameter fibre would reduce modal dispersion, thus the answer was B.

Question 8

Marks	0	1	2	Average
%	52	0	48	**1.0**

Fewer than half of the students selected the correct option, B.

Question 9

Marks	0	1	2	3	4	Average
%	65	9	14	9	3	**0.8**

9i.
Rayleigh scattering occurs when the wavelength is smaller than the size of the particles.
9ii.
Absorption occurs because light of this wavelength interacts with the electrons in the atoms and molecular bonds.

In explaining Rayleigh scattering and absorption, students did not link the wavelength to the size of the particles or to the molecular bonds.

Question 10

Marks	0	1	2	Average
%	49	0	51	**1.1**

The correct response was option D.

Detailed Study 3 – Sound

Questions 1–3

Marks	0	1	2	3	4	5	6	7	8	Average
%	2	3	4	8	9	10	17	19	27	**5.9**

Question 1
'Longitudinal', 'parallel to' and 'energy' were the three correct answers.

This question was well done, except for the students who omitted to answer it.

Question 2
The first microphone type was dynamic, the second was crystal and the third was electret-condenser.

Question 3
Sound from the back and front of the speaker was out of phase. The baffle prevented these from meeting and interfering.

Very few students referred to the sound produced at the front and back being out of phase. Many thought the baffle amplified the sound by increasing the area of vibration.

Question 4

Marks	0	1	2	Average
%	54	0	46	**1.0**

The correct answer was D, as the best response was in the high frequency range.

Question 5

Marks	0	1	2	3	Average
%	58	20	12	10	**0.8**

The amount of diffraction depends on the ratio $\frac{\lambda}{w}$. For a single speaker, the high frequencies would not diffract away from the centre line as much as the low frequencies. Using different speaker sizes for different frequency ranges would ensure that comparable spreading will occur for all frequencies.

Common mistakes included assuming that this was an interference effect, or writing about the frequency response of woofers, midrange and tweeters. The main problem was that students did not address the question asked.

Question 6

Marks	0	1	2	Average
%	27	0	73	1.5

Most students chose the correct answer, B.

Questions 7–8

Marks	0	1	2	3	4	Average
%	28	9	41	8	14	1.8

Question 7

The tube would resonate at odd multiples of 160 Hz. Thus the answer was 480 and 800.

Question 8

While the fundamental frequency was 2000 Hz, higher harmonics would exist. These affect the quality of the sound heard. Responses generally failed to address the presence of overtones.

Question 9

Marks	0	1	2	Average
%	51	0	49	1.0

The total power of 100 W was spread out over a sphere of radius 100 m^2, so the intensity was $\frac{100}{4\pi 100^2}$ which gives option C.

Questions 10–11

Marks	0	1	2	3	4	Average
%	23	2	30	3	43	2.5

Question 10

Doubling the distance quartered the intensity. Each time the intensity was halved the sound level reduced by 3 dB, so the total reduction was 6 dB.

Question 11

Applying the formula, $L = 10\log_{10}\left(\frac{1.0 \times 10^{-2}}{1 \times 10^{-12}}\right)$

$= 100 \text{ dB}$