



2012

Physics GA 3: Examination 2

GENERAL COMMENTS

This examination was the final Unit 4 November examination for the *VCE Physics Study Design*. From 2013, a single examination covering both Units 3 and 4 will be held in November.

The number of students who sat for the 2012 Physics examination 2 was 6944.

Students and teachers should note the following points in relation to the 2012 Physics examination 2 paper.

- Attempting a question a number of different ways will not be awarded any marks unless all methods are correct. It is expected that students will make it clear which working is intended by crossing out the rest. Some students used an eraser to remove working; however, students are advised to neatly cross out the working they do not want marked.
- Students should be encouraged to set out their work clearly so the assessor can follow what they have done.
- In questions that require explanations, students should carefully consider what the question is asking and answer accordingly. They should not simply copy information from their A4 sheet of notes. Some students included irrelevant, contradictory or incorrect material and could not be awarded full marks.
- Many students responded to questions that required an explanation by answering in dot-point format. This may help to ensure good, concise answers.
- The use of equations or diagrams in questions that require an explanation can sometimes assist. It is important that diagrams are sufficiently large and clearly labelled.
- Students' attention should be drawn to the instructions for Section A, 'In questions where more than one mark is available, appropriate working should be shown'. Some credit can often be given for working even if the final answer is incorrect.
- Students are also reminded of the instruction for Section A, 'Where an answer box has a unit printed in it, give your answer in that unit'.
- It is important that students show the actual numbers substituted into formulas/equations.
- It is expected that formulas be copied accurately from the formula sheet provided with the examination or from the student's A4 sheet of notes.
- Derived formulas from the student's A4 sheet of notes may be used. However, they must be correct and appropriate for the question.
- Students need to be familiar with the operation of the scientific calculator they will use in the exam. In particular, they must ensure that it is in scientific mode and that it does not truncate answers after one or two decimal places.
- Rounding-off calculations should be done only at the end, not progressively after each step.
- Answers should be simplified to decimal form.
- Where values of constants are provided in the stem of the question or on the formula sheet, students are expected to use the number of significant figures given.
- Arrows representing vector quantities must be drawn so that they originate from the point of application.
- Students should ensure that their answers are realistic and are reminded to check their work.

Areas of concern from this exam included

- magnetic fields
- the ability to explain quantised energy levels in atoms
- the conversion of units; for example, from nanometre to metre
- understanding of series circuits
- understanding of the photoelectric effect
- applying the concept of path difference in interference patterns
- confusion about the distinction between matter and electromagnetic radiation, and which formulas can be applied to each, as well as which value of Planck's constant to use
- application of Lenz's law.

SPECIFIC INFORMATION

This report provides sample answers or an indication of what the answers may have included. Unless otherwise stated, these are not intended to be exemplary or complete responses.

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Area of Study 1 – Electric power

Question 1a.

| Marks | 0 | 1 | Average |
|-------|----|----|---------|
| % | 58 | 42 | 0.4 |

An arrow, originating at P and pointing to the right and up the page at an angle of approximately 45°, was required.

It was common for students to draw an arrow to the right or left, neglecting the effect of Earth's magnetic field. Some drew curved lines representing the shape of the magnetic field produced by the solenoid.

Question 1b.

| Marks | 0 | 1 | 2 | Average |
|-------|----|---|----|---------|
| % | 53 | 0 | 47 | 1 |

Option C. The small magnet free to rotate about its centre is a compass needle. This points in the direction of the magnetic field. Alternatively, the north end of the small magnet would be attracted to the south end of the solenoid and vice versa.

Options D and F were common incorrect responses.

Question 2a.

| Marks | 0 | 1 | Average |
|-------|----|----|---------|
| % | 32 | 68 | 0.7 |

Option B. Using the right-hand slap rule, the current was from J to K and the magnetic field was from left to right across the page, so the magnetic force was down. Therefore, the coil rotated anticlockwise. Since the current was connected via a commutator, the loop would continue rotating and would not oscillate.

Question 2b.

| Marks | 0 | 1 | 2 | Average |
|-------|----|----|----|---------|
| % | 18 | 16 | 66 | 1.5 |

Since the current and magnetic field directions were perpendicular, the formula $F = nBIl$ could be applied to give a force of 0.30 N.

Common mistakes included omitting the number of turns, not converting the length of wire from centimetres to metres or using 3 cm instead of 6 cm for the length of wire. Some students said the force was zero; this may have been because they thought the wire and magnetic field were parallel.

Question 3

| Marks | 0 | 1 | 2 | Average |
|-------|----|----|----|---------|
| % | 14 | 36 | 50 | 1.4 |

With the AC supply the peak voltage was 150 V, so the RMS value was $150/\sqrt{2}$. So the power supplied was $P = V^2/R = 106^2/6 = 1875$ W. Using the DC supply, the power was $P = 120^2/7 = 2057$. Therefore, the DC option provided more power.

The most common error was not converting the peak AC voltage to RMS.

Question 4a.

| Marks | 0 | 1 | 2 | Average |
|-------|----|---|----|---------|
| % | 10 | 5 | 85 | 1.8 |

Using $P = VI$, the power was $45\,000\text{ W} = 45\text{ kW}$.

The main errors involved unnecessary conversions between peak and RMS values.

Question 4b.

| Marks | 0 | 1 | 2 | Average |
|-------|----|---|----|---------|
| % | 42 | 6 | 52 | 1.1 |

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The total resistance of the circuit was 25Ω ($18 \Omega + 7 \Omega$) and the voltage of the generator was 1000 V , so using Ohm's law the current was 40 A .

The most common errors involved using the wrong resistance, either 7Ω or 18Ω . Others assumed the motor would receive 900 V and therefore the voltage across the lines would be 100 V .

Question 4c.

| Marks | 0 | 1 | 2 | 3 | Average |
|-------|----|----|---|----|---------|
| % | 40 | 11 | 9 | 39 | 1.5 |

From the information given at the start of Question 4, the motor required 50 A for the pump to operate correctly. In Question 4b. the current supplied by the generator was only 40 A . Therefore, the pump would not operate correctly. This was the simplest way to answer the question. It was also possible to show that the voltage or power provided was insufficient for the pump to operate correctly.

The many and varied errors involved a misunderstanding of the operation of series circuits.

Question 4d.

| Marks | 0 | 1 | 2 | 3 | 4 | Average |
|-------|----|----|----|----|---|---------|
| % | 14 | 17 | 30 | 36 | 3 | 2 |

One possible way would be to install a transformer at each end. Thus, for the same power, increasing the transmission voltage would reduce the current. This would result in a reduced power loss ($= I^2 R$). The other method was to reduce the resistance of the connecting wires either by using thicker wires or a better conducting material. Since this would result in a lower overall resistance in the circuit, there would be a greater current. This greater current would mean more voltage and thus power available to the motor.

Most students successfully explained the use of transformers and many also identified the need to reduce the resistance of the connecting wires. However, most were unable to explain how reducing the resistance would provide more power to the motor.

Question 5a.

| Marks | 0 | 1 | 2 | Average |
|-------|----|----|----|---------|
| % | 18 | 15 | 67 | 1.5 |

From the graph, the period was 100 ms or 0.10 s . So the frequency was $1/0.10 = 10 \text{ Hz}$.

The most common error resulted from not converting the milliseconds to seconds.

Question 5b.

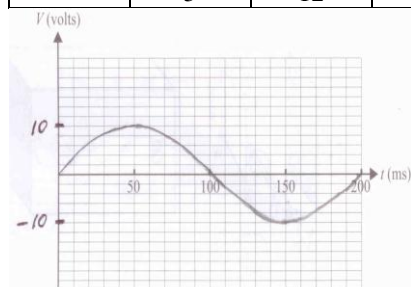
| Marks | 0 | 1 | Average |
|-------|----|----|---------|
| % | 11 | 89 | 0.9 |

Reading from the graph, the peak voltage was 20 V , so the RMS value was $20/\sqrt{2} = 14 \text{ V}$.

The question was well done. Some students multiplied by $\sqrt{2}$ instead of dividing.

Question 5c.

| Marks | 0 | 1 | 2 | 3 | Average |
|-------|---|----|----|----|---------|
| % | 5 | 12 | 32 | 51 | 2.3 |



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The voltage is halved because the rate at which the flux is changing has been reduced by halving the speed of rotation.

The most common error was not halving the voltage. Some students neglected to add a scale to the vertical axis.

Question 6a.

| Marks | 0 | 1 | Average |
|-------|----|----|---------|
| % | 15 | 85 | |

Using the turns ratio, the output voltage was $20 \times 150/600 = 5$ V.

Some students thought it necessary to introduce $\sqrt{2}$. This could have been because RMS was mentioned.

Question 6b.

| Marks | 0 | 1 | 2 | Average |
|-------|----|----|----|---------|
| % | 53 | 22 | 25 | |

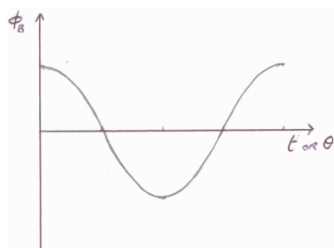
Because the battery produces a constant current, there would be a constant magnetic flux. Since there was no change in flux, no voltage would be induced.

Many students simply stated that a battery provides DC and transformers need AC to operate but did not explain why. Transformers will work with DC, provided it is a variable DC supply. The important part of this question was that a battery provides a constant current. It was common for students to explain how AC works but not why the battery does not work.

Question 7a.

| Marks | 0 | 1 | 2 | Average |
|-------|----|----|----|---------|
| % | 40 | 35 | 25 | |

Initially, the flux was a maximum to the right. After a quarter of a turn it reduced to zero, then returned to a maximum in the opposite direction through the coil. From then it reduced to zero, then back to a maximum in the original direction. A carefully labelled graph could also have been used to answer the question.



The most common error was neglecting to mention the reversal in direction of the flux through the coil. Some students described how the EMF varied instead of the flux. Students who used a graph to answer this question generally did better than those who did not draw a graph.

Question 7b.

| Marks | 0 | 1 | 2 | 3 | Average |
|-------|----|----|----|----|---------|
| % | 28 | 12 | 16 | 44 | |

Applying Faraday's equation $n \frac{\Delta \phi_B}{\Delta t} = n \frac{\Delta (B \times A)}{\Delta t}$ then $3.6 = n \frac{(0.030 \times 0.30 \times 0.40)}{0.125}$. So $n = 125$.

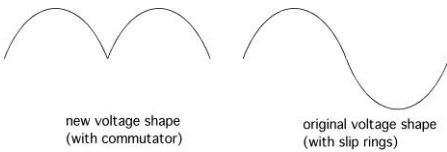
A common error was the time. Many students used the time for a complete rotation instead of the time for a quarter turn. Other errors resulted from not converting the dimensions of the coil correctly from centimetres to metres.

Question 7c.

| Marks | 0 | 1 | 2 | Average |
|-------|----|----|----|---------|
| % | 29 | 23 | 48 | |

The simplest way to answer this question was by using a sketch.

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The most common error was to omit any description or comparison with the original output.

Question 8a.

| | | | |
|--------------|----------|----------|----------------|
| Marks | 0 | 1 | Average |
| % | 23 | 77 | |

Option A. As the loop moves into the magnetic field at a constant speed, the flux increases at a constant rate. The flux then remains at this value until the loop starts to exit the field, which it also does at a constant speed so the flux reduces at a constant rate.

The most common incorrect response was option D. It is possible that students who chose this option were determining the EMF.

Question 8b.

| | | | |
|--------------|----------|----------|----------------|
| Marks | 0 | 1 | Average |
| % | 26 | 74 | |

The correct answer was option D. As the loop entered the field, the flux increased at a constant rate, so the EMF was constant. Between the jaws of the magnet there was no change in flux, so the EMF was zero. As the loop exited the field, the flux reduced at a constant rate, so the EMF was once again constant, but in the opposite direction.

Question 8c.

| | | | | | |
|--------------|----------|----------|----------|----------|----------------|
| Marks | 0 | 1 | 2 | 3 | Average |
| % | 47 | 26 | 15 | 13 | |

As the loop moves from position 2 to position 3, the flux is out of the page (or south) and decreasing. The induced current will produce a magnetic field out of the page (or south) to oppose the decrease. Therefore, the current must flow anticlockwise through the loop.

It was common for students to omit reference to the initial flux and how it was changing. Students also seem to have had problems deciding whether the direction of the current was X to Y or Y to X through the loop.



Area of Study 2 – Interactions of light and matter

Question 1a.

| Marks | 0 | 1 | Average |
|-------|----|----|------------|
| % | 35 | 65 | 0.7 |

The threshold frequency for zinc was given as 7.40×10^{14} . So using $\nu = f\lambda$, with $\nu = 3.0 \times 10^8$ the maximum wavelength was 4.05×10^{-7} m, which converted to 405 nm.

A common mistake was not converting the unit from metre to nanometre. Some students completed the calculation for aluminium instead of zinc.

Question 1b.

| Marks | 0 | 1 | 2 | 3 | Average |
|-------|----|----|----|----|----------|
| % | 42 | 26 | 22 | 10 | 1 |

There were two aspects to this question: to explain how the observation supported the particle model of light and to explain how it did not support the wave model of light. The wave model predicted that by increasing the intensity of light sufficiently it should have provided enough energy to eject electrons. This did not happen. However, the particle model predicted that increasing the intensity would simply increase the number of photons, not their energy. So there would still be insufficient energy to eject electrons.

Many students focused on the particle model and did not compare the predictions of the wave model. Another common error was to discuss the relative energies of emitted electrons. This question was very poorly done, with many students simply copying, from their A4 sheet of notes, generic statements that did not address the question.

Question 1c.

| Marks | 0 | 1 | 2 | Average |
|-------|----|---|----|------------|
| % | 18 | 5 | 77 | 1.6 |

Substituting into $E_{Kmax} = hf - W = 4.14 \times 10^{-15} \times 7.5 \times 10^{14} - 2.28 = 0.825$ eV.

This question was generally well done, but some students made calculator errors.

Question 1d.

| Marks | 0 | 1 | Average |
|-------|----|----|------------|
| % | 59 | 41 | 0.4 |

Since the maximum kinetic energy of the electrons had been determined to be 0.825 eV in the previous question, the required stopping voltage was therefore 0.825 V.

Some students confused the stopping voltage with the work function, while others attempted a conversion from electron-volt to joule.

Question 2a.

| Marks | 0 | 1 | 2 | Average |
|-------|----|---|----|------------|
| % | 59 | 5 | 35 | 0.8 |

Using $E = \frac{hc}{\lambda}$ the energy of each photon was calculated to be 3.25×10^{-19} J. Since the output of the laser was $5.0 \times 10^{-3} \text{ J s}^{-1}$, the number of photons per second was $5.0 \times 10^{-3} / 3.25 \times 10^{-19} = 1.54 \times 10^{16}$.

Many students did not determine the energy of a single photon. Some calculated the momentum, while others determined the frequency. Those who obtained the energy of a single photon did not always know what to do with it in regard to the power of the laser.

Question 2b.

| Marks | 0 | 1 | 2 | Average |
|-------|----|----|----|------------|
| % | 19 | 41 | 40 | 1.2 |

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There was a bright band at C because of constructive interference, resulting from a path difference of zero.

Some students gave generic answers, from their A4 sheet of notes, that referred to any of the bright bands. The question specifically asked about point C, the central band.

Question 2c.

| Marks | 0 | 1 | 2 | 3 | Average |
|-------|----|---|---|----|---------|
| % | 36 | 3 | 7 | 53 | 1.8 |

The path difference = $2.142 \times 10^{-6} / 612 \times 10^{-9} = 3.5\lambda$, and the point needed to be shown on the diagram.



Many students attempted to use a formula to do this question. They appeared to be unsure of the meaning of 'n' in the formula, and the meaning of 'n' varied, depending on which formula they were using.

Question 2d.

| Marks | 0 | 1 | 2 | Average |
|-------|----|----|----|---------|
| % | 55 | 10 | 35 | 0.8 |

The path difference from the two slits to point Y was the same in each situation. In the original case it was equivalent to 1.5 wavelengths, whereas with the unknown wavelength it was equivalent to two wavelengths.

So, $2\lambda_{\text{NEW}} = 1.5\lambda_{\text{OLD}} = 1.5 \times 612 \times 10^{-9}$ and $\lambda_{\text{NEW}} = 459 \text{ nm}$.

Many students got the ratio of the path differences reversed. Some used the path difference from part c., while others simply calculated $\lambda_{\text{OLD}}/2$, $2\lambda_{\text{OLD}}$ or $1.5\lambda_{\text{OLD}}$.

Question 3a.

| Marks | 0 | 1 | 2 | Average |
|-------|----|----|----|---------|
| % | 28 | 25 | 47 | 1.2 |

Kinetic energy was given by using the formula $E_K = \frac{1}{2}mv^2$. Substituting the values provided gave a value of $1.024 \times 10^{-20} \text{ J}$. To convert this to electron-volt it was necessary to divide by 1.6×10^{-19} to give a value of 0.064 eV.

Some students did not convert from joule to electron-volt. Others forgot to square the speed when doing the calculation. It was also common for students to use the formula $E = pxc$, which does not apply to matter.

Question 3b.

| Marks | 0 | 1 | 2 | 3 | Average |
|-------|----|---|---|----|---------|
| % | 55 | 7 | 6 | 31 | 1.2 |

Since the diffraction patterns were the same, the momentum (and wavelength) of the X-rays must have been the same as that of the electrons, $p = (9.1 \times 10^{-31})(1.5 \times 10^5) = 1.36 \times 10^{-25} \text{ kg m s}^{-1}$. From this, the wavelength could be determined from $\lambda_{\text{X-ray}} = h/p_{\text{electron}} = 4.857 \times 10^{-9} \text{ m}$. Hence, the $E_{\text{X-ray}} = hc/\lambda = (4.14 \times 10^{-15})(3 \times 10^8) / 4.857 \times 10^{-9} = 256 \text{ eV}$.

Alternatively, once students had determined the momentum they could apply the formula $E_{\text{X-ray}} = p_{\text{electron}} c = 4.095 \times 10^{-17} \text{ J}$ and then divide by 1.6×10^{-19} to convert it to eV.

There was much confusion about which formulas applied to matter and which applied to radiation, as well as about which value of Planck's constant could be used in different equations.


Question 4a.

| | | | | |
|--------------|----------|----------|----------|----------------|
| Marks | 0 | 1 | 2 | Average |
| % | 18 | 20 | 63 | |

The energy transition was 2.6 eV. By applying the equation for the energy of the photon $E = \frac{hc}{\lambda}$, the wavelength was 4.78×10^{-7} m or 478 nm.

A common error was to neglect to convert the wavelength to nanometre. Others were confused about which value of Planck's constant to use. Some students thought the energy transition of 2.6 was a momentum and used the formula

$$\lambda = \frac{h}{p}$$

Question 4b.

| | | | | | |
|--------------|----------|----------|----------|----------|----------------|
| Marks | 0 | 1 | 2 | 3 | Average |
| % | 53 | 7 | 14 | 27 | |

An electron has wave properties. Only when the circumference of the orbit is a whole number of wavelengths will standing waves be formed. Only electrons with energies related to those particular wavelengths will form stable levels.

A common misconception was that the electrons moved around the orbit in a wave pattern.

Section B – Detailed studies

Detailed Study 1 – Synchrotron and its applications

| Question | % A | % B | % C | % D | Comments |
|----------|-----|-----|-----|-----|--|
| 1 | 75 | 5 | 4 | 17 | |
| 2 | 4 | 15 | 63 | 17 | |
| 3 | 80 | 11 | 6 | 3 | |
| 4 | 10 | 18 | 4 | 68 | |
| 5 | 4 | 13 | 63 | 20 | |
| 6 | 5 | 9 | 80 | 5 | |
| 7 | 16 | 14 | 11 | 59 | A path difference of a whole number of wavelengths will produce constructive interference. Option C would produce cancellation. |
| 8 | 44 | 18 | 29 | 8 | The synchrotron produces a wide spectrum of X-rays. The energy of the photons is related to their wavelength and has nothing to do with the source of production. |
| 9 | 10 | 15 | 67 | 8 | |
| 10 | 16 | 10 | 26 | 48 | Electric fields are required to provide electrons with energy. The force on a moving electron produced by a magnetic field will change its direction of motion but not its energy. |
| 11 | 6 | 78 | 10 | 6 | |
| 12 | 18 | 12 | 6 | 64 | |



Detailed Study 2 – Photonics

| Question | % A | % B | % C | % D | Comments |
|----------|-----|-----|-----|-----|--|
| 1 | 4 | 6 | 88 | 2 | |
| 2 | 21 | 7 | 10 | 62 | |
| 3 | 10 | 54 | 29 | 7 | |
| 4 | 68 | 21 | 7 | 4 | |
| 5 | 3 | 4 | 87 | 6 | |
| 6 | 8 | 78 | 8 | 6 | |
| 7 | 8 | 67 | 10 | 14 | |
| 8 | 9 | 21 | 58 | 12 | The refractive index for green light was greater than for infrared light. Therefore, green light travelled more slowly and thus took longer to reach the end of the fibre. |
| 9 | 9 | 5 | 8 | 78 | |
| 10 | 12 | 73 | 8 | 7 | |
| 11 | 69 | 11 | 12 | 8 | |
| 12 | 7 | 4 | 12 | 77 | |

Detailed Study 3 – Sound

| Question | % A | % B | % C | % D | Comments |
|----------|-----|-----|-----|-----|--|
| 1 | 1 | 98 | 0 | 1 | |
| 2 | 20 | 17 | 52 | 11 | For options A and B, loudness is a result of variation in air pressure. If it did not vary there would be no sound. Option D was incorrect because the sound wave causes the air particles to oscillate. |
| 3 | 3 | 5 | 89 | 4 | |
| 4 | 64 | 20 | 8 | 7 | |
| 5 | 1 | 1 | 4 | 94 | |
| 6 | 2 | 24 | 59 | 14 | While the 1000 Hz at 40 dB was on the 40 phon line, the 3000 Hz at 40 dB was above the 40 phon line. Therefore the 3000 Hz would sound louder. |
| 7 | 8 | 3 | 12 | 77 | |
| 8 | 68 | 13 | 13 | 6 | |
| 9 | 4 | 74 | 13 | 9 | |
| 10 | 9 | 16 | 65 | 10 | |
| 11 | 87 | 5 | 5 | 3 | |
| 12 | 8 | 9 | 77 | 6 | |