2009 Physics GA 3: Examination

GENERAL COMMENTS

The number of students who sat for the 2009 Physics examination 2 was 6705. The mean score was 68 per cent; this indicated that students generally found the paper to be quite accessible. Thirty-one students achieved the maximum score of 90.

It was encouraging to note that some areas of weakness highlighted in previous Assessment Reports had been addressed. Some areas of concern from this exam included:

- sketching magnetic fields
- the effect transformers have on voltage and current, and the distribution of voltage and power throughout a transmission system
- calculations involving powers of 10
- understanding which value of Planck's constant was appropriate in different situations
- the ability to transform simple equations
- understanding of the photoelectric effect.

Students and teachers should note the following points in relation to the 2009 examination 2 paper and for future reference.

- Students need to be careful with their handwriting – if the assessor cannot decipher what is written, no marks can be awarded.
- In questions that require an explanation, students should carefully consider what the question is asking. Written explanations must address the question. Generic answers copied directly from the students' note sheets generally do not adequately cover the specifics of the question. The number of marks generally equates to the number of relevant points that should be made.
- Students' attention should be drawn to the instructions for Section A: 'In questions worth more than 1 mark appropriate working should be shown'. Some credit can often be given for working even if the final answer is incorrect. Some questions state that working must be shown. In such cases, full marks will not be awarded if only the answer is recorded.
- In explanation-type questions some students wrote everything they could think of related to the topic, instead of answering the question asked. This often resulted in contradictions. When this occurred, full marks could not be awarded.
- Students need to be familiar with the operation of the scientific calculator they will use in the exam.
- Answers should be simplified to decimal form.
- When reading values from a graph to determine a gradient, students should be encouraged to select points with coordinates that can be easily read and which are a reasonable distance apart.

SPECIFIC INFORMATION

For each question, an outline answer (or answers) is provided. In some cases the method provided is not the only answer that could have been awarded marks.

Section A – Core
Area of Study 1 – Electric power

Question 1

Marks	0	1	2	Average
%	11	15	74	1.7

The device shown was an AC generator because it used slip rings.

Question 2

Marks	0	1	2	Average
%	10	5	86	1.8

Applying the formula $B = \Phi_B/A$, the strength of the magnetic **field** was 8.0×10^{-3}.

Although the question was well done, some students confused the magnetic flux with the magnetic field.

Question 3

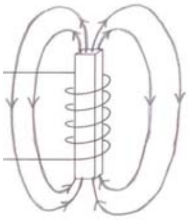
Marks	0	1	2	3	Average
%	20	18	6	56	2

The average voltage generated was $\Delta\Phi B/\Delta t$ = 7.2 x 10-6 / 0.020 = 3.6 x 10^{-4}.

A common mistake was to divide the correct answer by √2, attempting to convert it to RMS. Other students either multiplied or divided the correct time by 4, attempting to make an allowance for a complete rotation.

Question 4

Marks	0	1	2	Average
%	25	33	42	1.2



Students were required to have the polarity correct (as shown by the arrows), include at least four lines (some of which had to be complete) and ensure that the field lines did not touch or cross.

Question 5

Marks	0	1	2	Average
%	25	2	73	1.5

By application of the right hand rule, the force on side TU was up.

Some students applied the rule incorrectly to get an arrow going down or along the wire, while others drew a semi-circular arrow indicating the direction of rotation and not the direction of the force. A small number of students did not attempt this question.

Question 6

Marks	0	1	2	Average
%	8	3	89	1.8

Using F = I B l the force was 4.5 x 10^{-3}.

Some students used F = I B l sinθ and substituted an angle of 45°. Others transcribed the length of 0.0090 incorrectly.

Question 7

Marks	0	1	2	Average
%	14	0	86	1.7

In the position shown, the side UV was parallel to the magnetic field, therefore the force was zero.

Question 8

Marks	0	1	2	3	Average
%	11	7	18	64	2.4

The split-ring commutator reverses the direction of the current through the coil every turn, thereby keeping the coil rotating in a constant direction.

Students often referred to a constant torque, which was incorrect. Some students showed confusion about whether the device was a generator or a motor.

Question 9

Marks	0	1	2	Average
%	12	1	87	1.8

The generator produced a constant 500 V and 20.0A so the output power was P = V I = 10 000 W.

Some students attempted to use $P = I^2 R$ or $P = V^2/R$ by assuming R = 10 Ω, which neglected the resistance of the lights. Others began by incorrectly calculating the current even though it was given in the information.

Question 10

Marks	0	1	2	Average
%	18	16	66	1.5

The power loss in the transmission lines was given by $P = I^2 R = 20^2 \times 10 = 4000$ W.

A substantial number of students only worked out the loss in one line. Others assumed the two transmission lines formed a parallel combination.

Question 11

Marks	0	1	2	3	Average
%	26	15	8	51	1.9

The voltage drop in the power lines was V = I R = 20 x 10 = 200 V so the potential difference across the lights was 500 supplied by generator less the 200 drop in the lines = 300 V.

Once again some students only determined the voltage drop across one of the transmission lines. Another legitimate approach was to use the power loss to determine the voltage drop.

Question 12

Marks	0	1	2	Average
%	27	1	72	1.5

The alternator provided 500 V to the input of the 1:10 step-up transformer. Therefore the output of the transformer was 5000 V.

Some students used Ohm's Law or P = V I with some incorrect values of I, V and R. Others were confused by the fact that the voltage of the alternator was specified as RMS and multiplied or divided the value by $\sqrt{2}$.

Question 13

Marks	0	1	Average
%	26	74	0.8

The step-down transformer had a 10:1 ratio, so with 4800 turns in the primary there would be 480 turns in the secondary. While most students used this straightforward approach, some did calculations attempting to determine the input and output voltages of the transformer. Generally students neglected the load resistances.

Question 14

Marks	0	1	2	Average
%	43	11	47	1.1

The step-up transformer reduced the current from 20 A to 2 A. Therefore the power loss in the transmission lines was $P = I^2 R = 2^2 \times 10 = 40$ W.

It was common for students to use 5Ω as the resistance of the power lines instead of 10 Ω.

Question 15

Marks	0	1	2	3	Average
%	41	14	9	35	1.4

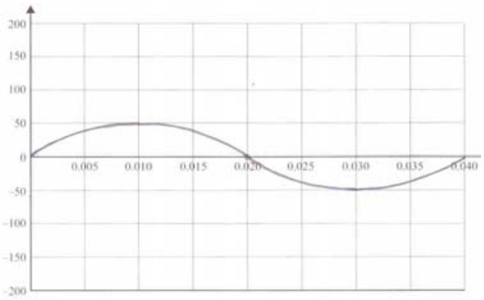
The voltage loss in the transmission lines was V = I x R = 2 x 10 = 20 V so the input voltage to the step-down transformer was 5000 – 20 = 4980 V and the output of the transformer was 4980/10 = 498V.

Another approach used power. The power supplied by the step-up transformer was 10 000 W, the power loss in the lines was 40 W, therefore the power available to the step-down transformer was 10 000–40 = 9960. Thus the input voltage to the step-down transformer was 9960/2 = 4980 V and the output voltage was 4980/10 = 498 V.

Once again, some students neglected the resistance of the second transmission line. There were also those who felt they needed to do something with √2 because the term RMS was mentioned in the stem of the question.

Question 16

Marks	0	1	2	Average
%	12	42	47	**1.4**



As the rate of rotation was halved, the period was doubled to 0.04 s. Since the rate of rotation was halved, the rate of change of flux was also halved, so the output voltage was halved to a peak of 50 V.

Area of Study 2 – Interactions of light and matter

Question 1

Marks	0	1	2	3	Average
%	13	9	38	39	**2.1**

Young’s experiment demonstrated interference effects, so his work supported the wave model of light. The particle model did not explain the interference effect.

A common mistake was to refer to diffraction rather than interference as the main concept.

Question 2

Marks	0	1	2	3	Average
%	20	23	19	38	**1.8**

The photoelectric effect supports the particle (photon) model of light because it predicts a minimum frequency (energy) before electrons are emitted and the energy of the emitted electrons depends on the frequency of the incident light. The wave model predicts that increasing the intensity of light would increase the energy of the emitted electrons. It also predicts a time delay before electrons are emitted and that any frequency of light should emit electrons.

Students did not need to explain all these points to obtain full marks. Some students simply stated the photoelectric effect but did not explain how the results of it supported the particle model. Many had difficulty distinguishing whether specific results were supporting the particle model or disproving the wave model. It was clear that some answers were copied directly from the student’s A4 sheet of pre-written notes and did not address the question asked.

Question 3

Marks	0	1	2	3	Average
%	17	11	33	40	**2**

Thelma was correct; there would be a bright band in the middle. This was a result of constructive interference because the path difference from the two slits was zero wavelengths.

Once again many students relied on diffraction to attempt to explain the pattern and had the light diffracting around the barrier between the slits.

Question 4

Marks	0	1	2	Average
%	50	2	48	**1**

Since they were adjacent bands, the path difference must be one wavelength greater for A than for B. Therefore the wavelength was 496 nm.

The most common incorrect approach was to treat the difference between path differences as if it was the actual path difference to the first dark fringe. This led to $\lambda/2 = 496$ and $\lambda = 992$ nm.

Question 5

Marks	0	1	2	3	Average
%	29	24	26	21	**1.4**

$E_{K\,max}$ represented the maximum kinetic energy with which the electrons were emitted. Common errors included referring to the kinetic energy of the incident photon, the energy absorbed by the electron, or leaving out the word 'maximum'. Other students simply referred to it being the energy of the electrons in the circuit.

f was the frequency of the light after passing through the filter or the frequency of light incident on the potassium plate. The most common incorrect response was to simply state that it was the frequency of the light source. Other students referred to it as the cut-off frequency.

W was the minimum energy required to emit an electron. A common error was to omit the word 'minimum'.

In this question it was essential to explain the physical meaning of the terms in the context of the experiment detailed. Many students confused photons with electrons.

Question 6

Marks	0	1	2	3	Average
%	26	10	16	48	**1.9**

Planck's constant was the gradient of the graph, approximately 5.0×10^{-15} eV s. Some students tried too hard to make their value match the accepted value of 4.14×10^{-15}. Others had trouble determining the gradient because of the powers-of-ten calculation.

The work function was 1.5 eV, which was read directly from the y-intercept. A negative value was not acceptable. The work function could also be evaluated by substituting the coordinates of one point from the graph into Einstein's equation, ensuring that the calculated value of Planck's constant was used, not the value on the formula sheet.

Question 7i-ii.

Marks	0	1	2	Average
%	23	16	61	**1.4**

Doubling the intensity has no effect on the maximum kinetic energy of the emitted electrons. It increased the number of electrons emitted per second.

Question 8

Marks	0	1	2	Average
%	24	7	69	**1.5**

This was a straightforward question requiring students to apply the relationship $E=hc/\lambda$, which gave an answer of 8871 eV. Some students used the wrong value of Planck's constant. Others used formulae involving mass.

Question 9

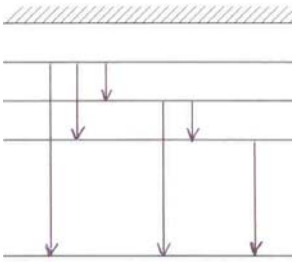
Marks	0	1	2	Average
%	41	4	55	**1.2**

The simplest approach was to apply the formula $p = h/\lambda$ to get the momentum of 4.7×10^{-24}. Many students were confused about which value of Planck's constant to use. Another approach was to use $p = E/c$ with the energy already obtained in Question 8. If this was used it was important to convert the energy from electron volt to joule. Other students incorrectly attempted to use formulae involving mass.

Question 10

Marks	0	1	2	Average
%	32	12	56	**1.3**

There were six possible transitions as shown.



It was common for students to miss at least one of the transitions, largely because they were not systematic in the way they drew them. Some students drew the arrows going up instead of down, while others drew arrows going up a level then down.

Question 11

Marks	0	1	2	Average
%	36	11	53	**1.2**

The initial state was the first excited state (or 1.85 eV) because the absorbed photons were the difference between the first and second or first and third excited states.

The most common error was for students to discuss photons being emitted instead of absorbed.

Question 12

Marks	0	1	2	Average
%	48	32	20	**0.7**

If the orbit was an exact multiple of the wavelength of the electron, a standing wave was formed, meaning that electrons of those particular wavelengths could exist in the atom. Since different wavelengths correspond to particular energies, only these energy states are possible for the atom.

Students struggled to explain the key aspects of this question clearly. It was common for students to believe that the electron followed a wave path around the nucleus. Some discussed standing waves being formed by reflections as if on springs tied to a wall.

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

Question	% A	% B	% C	% D	% No Answer	Comments
1	7	9	62	22	0	
2	5	92	2	1	0	
3	5	6	80	9	0	
4	16	46	24	13	1	The kinetic energy of the electron as it left the injector was equal to the work done by the electric force. ½ m v^2 = F x d. By substituting the known values, the length could be calculated as 0.1.
5	5	5	86	4	0	
6	8	7	6	79	0	

Question	% A	% B	% C	% D	% No Answer	Comments
7	9	24	15	51	0	Using the right hand rule for the electromagnetic force acting on a moving charged particle, with the thumb pointing in the opposite direction to which the electron travels, the magnetic field must be into the page. Alternatively, the left hand rule could be used with the thumb pointing in the direction of travel.
8	13	55	10	21	0	
9	4	12	63	21	0	
10	7	49	9	35	0	By applying Bragg's law to the first order peak $0.150 \times 10^{-9} = 2 \times d \times \sin 115°$, $d = 2.9 \times 10^{-10} = 0.29 \times 10^{-9} = 0.29$ nm.
11	48	17	13	22	0	The frequency of the x-rays was decreased so the wavelength increased. Bragg's law states that $n\lambda = 2d\sin\theta$. Since n and d have not changed, increasing λ means that $\sin\theta$ must also increase and therefore the angle θ will increase.
12	7	8	82	3	0	
13	10	75	9	6	0	

Detailed Study 2 – Photonics

Question	% A	% B	% C	% D	% No Answer	Comments
1	8	9	61	21	0	
2	10	13	57	20	0	
3	50	27	16	6	0	As electrons move from the higher energy conduction band to the lower energy valence band they emit the excess energy as a photon.
4	14	3	4	79	0	
5	4	80	12	4	0	
6	19	11	61	9	0	
7	7	75	6	12	0	
8	7	71	17	5	0	
9	19	58	20	4	0	
10	25	12	59	4	0	
11	4	58	15	23	0	
12	9	13	8	69	0	
13	67	11	15	6	0	

Detailed Study 3 – Sound

Question	% A	% B	% C	% D	% No Answer	Comments
1	7	86	3	3	0	
2	12	87	1	1	0	
3	4	4	87	6	0	
4	6	53	32	9	0	In a quarter of a period, the graph of pressure variation against distance would have moved forward a quarter of a wavelength. The wavelength indicated on the original graph was 2 m. Therefore the new graph would be translated 0.5 m forward.
5	7	8	75	10	0	
6	4	10	7	78	0	
7	19	4	74	3	0	

Question	% A	% B	% C	% D	% No Answer	Comments
8	7	8	81	4	0	
9	4	85	8	3	0	
10	3	4	81	13	0	
11	45	28	13	14	0	The air pressure at the middle of the tube will vary with a frequency of 385 Hz, which means a period of 1/385 = 0.0026 sec or 2.6 ms.
12	83	4	8	5	0	
13	75	9	8	8	0	