GENERAL COMMENTS

The number of students who sat for the 2011 Physics examination 2 was around 7000.

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:

- magnetic fields produced by bar magnets
- calculations involving powers of 10
- conversion of units; for example, from nanometre to metre
- understanding of series and parallel circuits
- confusion about the distinction between matter and electromagnetic radiation, and which formulas can be applied to each
- electromagnetic induction, including Lenz's law
- understanding of some of the practical aspects of the photoelectric experiment.

Students and teachers should note the following points in relation to the 2011 examination 2 paper.

- 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.
- Students may respond to questions that require an explanation by answering in dot point format. This may help to ensure good, concise answers.
- 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.
- Answers should be simplified to decimal form.
- When choosing values from a graph to determine a gradient, students should select points with coordinates that can be easily read and that are a reasonable distance apart. The points must be taken from the line of best fit. Unless they lie exactly on the line of best fit, the data points should not be used.
- Arrows representing vector quantities must be drawn so they originate from the point of application.
- In electromagnetic induction it is the change in flux that induces an EMF. It is not sufficient to say a changing magnetic field. Current will be produced only if the circuit is complete.
- Students should be able to correctly spell key Physics terms.

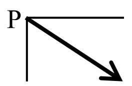
SPECIFIC INFORMATION

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	Average
%	56	44	0.5



Many students drew the complete magnetic field instead of an arrow to indicate the direction of the field at point P. Students' understanding of how to add fields as vectors needs improvement.

Question 2

Marks	0	1	2	Average
%	62	1	37	**0.8**

The Earth's magnetic field cancelled the effect of the lower magnet. So the resultant magnetic field at P was that of the horizontal magnet. P ⟶

Vector addition of magnetic fields was difficult for some students. Many drew curved arrows or attempted to draw the complete magnetic field.

Question 3

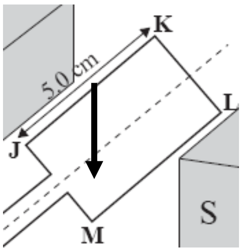
Marks	0	1	2	3	Average
%	9	6	17	68	**2.5**

The role of the commutator is to keep the motor rotating in the same direction. It does this by reversing the direction of the current through the coil every half turn when the plane of the coil is perpendicular to the magnetic field.

This question was generally well done, although a significant number of students confused the commutator with a generator.

Question 4

Marks	0	1	Average
%	30	70	**0.7**



Using the 'right hand slap' rule, the force was vertically down as shown. It should be noted that the vector arrow originates from the point of action of the force.

Common errors included arrows drawn vertically up or drawn somewhere other than on the side JK. Others drew an arrow at a tangent to the circular path of the side JK.

Question 5

Marks	0	1	2	Average
%	11	13	76	**1.7**

Using the formula F = n I l B the magnetic force was 4.5 N.

This question was well done. The most common errors were neglecting the 50 turns of wire or not converting the length to metres. Some students included 'sin 45' in the formula; however, the side JK and the magnetic field were perpendicular.

Question 6

Marks	0	1	Average
%	37	63	**0.7**

The device was now acting as a DC generator, so A was the correct answer.

Many students chose option B.

Question 7

Marks	0	1	2	Average
%	45	41	15	**0.7**

As the coil rotates, the changing flux induces an AC voltage. Since there is a commutator attached, the AC is converted to pulsed DC.

Common errors included neglecting the commutator or stating that the changing flux produced a current and hence a voltage.

Question 8

Marks	0	1	2	Average
%	27	0	73	**1.5**

In orientation C, the magnetic flux was somewhere between zero and the maximum value of $\Phi = BA = 0.020 \times 2.0 = 0.04$ Wb. The option that fitted this was option B.

Question 9

Marks	0	1	2	Average
%	12	19	69	**1.6**

Using Faraday's equation, the average EMF induced was 13.3 V.

This question was generally well done. However, some students forgot the 50 turns, while others used the answer from Question 8 as the flux change.

Question 10

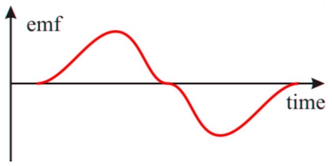
Marks	0	1	2	Average
%	21	15	63	**1.4**

As the magnet approaches the loop, the flux threading the loop changes. This induces an EMF according to Faraday's law.

Many students gave detailed explanations of Lenz's law, which is only relevant to determining the direction of the induced EMF. This was not required. It is important to realise that it is the change in flux that induces the EMF, not simply the flux. Nor is it sufficient to say that a changing magnetic field will induce an EMF. A common error was to have the reasoning completely reversed, stating that the changing flux induced a magnetic field, which in turn induced a current, which then induced an EMF.

Question 11

Marks	0	1	2	Average
%	32	40	27	**1**



Most students realised that the polarity would change after passing through the loop. However, many drew square graphs above and below the axis. If the flux was changing at a constant rate, it would not suddenly commence at an arbitrary distance from the loop.

Question 12

Marks	0	1	2	3	Average
%	25	43	16	16	**1.3**

As the magnet moves away from the loop, the flux through the loop to the left decreases. According to Lenz's law, the induced current will oppose the change in flux by creating a magnetic field to the left.

This question was very poorly done. Many students wrote generalities about Lenz's law instead of showing that they could apply their understanding to this particular situation. It should be noted that Lenz's law refers to the change in flux, not just the flux. The EMF induced results from a change in flux, not simply a change in the magnetic field. An alternative approach was to say that the retreating north pole of the magnet would cause a south pole to be induced on the right-hand side of the loop. As long as this was adequately explained students received full marks.

Question 13

Marks	0	1	2	Average
%	13	2	85	**1.7**

An application of the power formula gave the answer of 7.5×10^5 W.

Students handled this question well. However, a surprising number of students implemented a form of conversion using $\sqrt{2}$. The other common error was dealing with powers of ten.

Question 14

Marks	0	1	2	3	Average
%	22	14	35	30	**1.7**

For a given amount of power to be transmitted, by reducing the voltage the current would be increased. This would result in a greater power loss proportional to the current squared.

Many students simply copied information from their A4 sheet of notes, explaining how increasing the voltage reduces power losses. This did not address the question asked. A common misconception was that the resistance of the transmission lines would vary simply by changing the supply voltage. Others argued incorrectly that, according to Ohm's law, decreasing the voltage would increase the current.

Question 15

Marks	0	1	2	Average
%	13	3	84	**1.7**

Knowing the power loss in the lines and the current flowing, the resistance can be determined using $P = I^2R$, giving an answer of 40 Ω.

The most common error with this question was forgetting that the current was squared when doing the calculation, even though the correct formula had been written down.

Question 16

Marks	0	1	2	Average
%	22	9	69	**1.5**

$$\frac{I_{SEC}}{I_{PRIM}} = \frac{V_{PRIM}}{V_{SEC}} = \frac{49400}{250} = 198$$

The most common error was not realising that the current ratio was the reciprocal of the voltage ratio. Many students obtained the correct ratio and went on to substitute the primary current of 15 A to calculate the secondary current. Students should be encouraged to simplify answers to decimals; many left their answer as a fraction.

Question 17

Marks	0	1	2	Average
%	78	7	15	**0.4**

Option B. Because the current was AC, the electromagnetic force acting would also be sinusoidal. The maximum value of the force would be $F_{max} = I\ L\ B = 30\sqrt{2} \times 1 \times 1{\times}10^{-4} = 4{\times}10^{-3}$ N.

Students found this question very difficult. They had little concept of how the AC current related to the question. It should be noted that the question required students to show evidence for their choice of answer. Without the relevant calculation they did not obtain full marks. It was common for students to select option A. Most did not convert the 30 A RMS to get the peak current to find the peak force.

Question 18

Marks	0	1	2	3	Average
%	19	9	18	55	**2.1**

The power used in circuit A was 24 W and in circuit B 36 W. Therefore, circuit B used more power.

Series and parallel circuits continue to cause difficulties for some students. Many were unable to work out how much current was flowing in each circuit. It was common for circuit A to have 4 A and circuit B to have 1 A. Other students tried unsuccessfully to obtain the total effective resistance of the circuits.

Area of Study 2 – Interactions of light and matter

Question 1

Marks	0	1	2	Average
%	34	5	61	**1.3**

P was on the second nodal band so the path difference was 1½ λ = 1.5 x 560 = 840 nm.

Students should note that working was required for full marks. Common errors included the nanometre conversion and having 2½ λ.

Question 2

Marks	0	1	Average
%	20	80	**0.8**

Increasing the distance to the screen increases the separation of the bands.

Some students seemed to think that the spread of the pattern on the screen was the path difference.

Question 3

Marks	0	1	2	Average
%	29	2	69	**1.4**

By decreasing the separation of the slits, the spacing of the fringes will increase.

Many students incorrectly referred to an increasing amount of diffraction. Many students used the equation for band separation, but some got confused by it, thinking that varying the slit separation somehow changed the wavelength. Others using the formula said that as d increases Δx decreased, which is true but not what the question asked.

Question 4

Marks	0	1	2	3	Average
%	14	10	33	43	**2.1**

Young's experiment demonstrated an interference pattern of bright and dark bands formed by constructive and destructive interference. Since this is a wave phenomenon, Young concluded that light had a wave nature.

There was much discussion about diffraction instead of the interference pattern observed. Many students appeared to have copied information from their A4 sheets instead of crafting an answer appropriate to the question.

Question 5

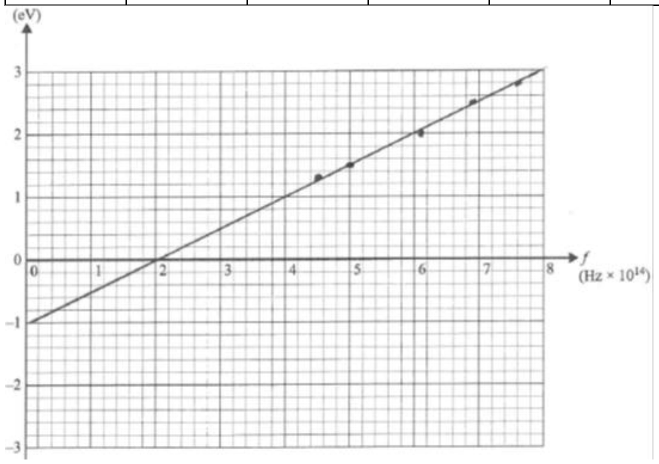
Marks	0	1	2	Average
%	71	24	5	**0.4**

Electrons were ejected from the metal plate with a range of energies. As the retarding voltage was increased, fewer electrons had sufficient energy to reach the collector and therefore the current decreased. When the voltage reached X (or stopping potential) even the most energetic electrons were stopped. So the current became zero.

Most students did not mention electron energy. Many thought the stopping voltage prevented electrons from being emitted from the plate. Answers to this question indicated that many students had a limited understanding of the details of the experiment.

Question 6

Marks	0	1	2	3	Average
%	17	7	8	67	**2.3**



Common errors included incorrect plotting of points, joining dot-to-dot and drawing straight lines that were not a line of best fit. Although the question was well done, there were some very unusual graphs drawn. These included series of parallel lines.

Question 7

Marks	0	1	2	Average
%	28	24	49	**1.2**

Planck's constant was the gradient of the graph. This was approximately 5 x 10^{-15} eV s. To get this answer, students needed to take two well-separated points on the line of best fit.

It is not appropriate to use data points unless they are on the line of best fit. Students who gave the accepted value from the data sheet did not score any marks.

Question 8

Marks	0	1	2	Average
%	51	12	38	**0.9**

The longest wavelength is the threshold frequency, which is the intercept on the frequency axis. Using this value and $\lambda = c/f_0$, the wavelength was about 1500 nm. Alternatively, the wavelength could be obtained by reading the work function from the energy axis and using $w = hc/\lambda$. With this method it was essential to use the value of Planck's constant obtained in the previous question rather than the commonly accepted value.

Question 9

Marks	0	1	2	3	Average
%	23	21	34	23	**1.6**

The key ideas were that light behaves like particles whose energy is proportional to the frequency. Students also had to explain one aspect of the photoelectric experiment that provided evidence for the conclusion.

Very few students mentioned that the energy of the photons was proportional to the frequency. Many instead said that the energy of the electrons was proportional to the frequency. While the experiment did show this, it was not part of Einstein's conclusion about the nature of light. It was common for students to simply list aspects of the experiment that disproved the wave model; they did not say what Einstein concluded.

The question related to Einstein's conclusions about the nature of light, not the details of the experiment.

Question 10

Marks	0	1	2	Average
%	16	15	68	**1.5**

Applying the formula $E = hc/\lambda$ the energy of the photon obtained was 6210 eV.

The question was quite well done, with the main errors involving converting 0.2 nm to metres or using the wrong Planck's constant and not converting the answer back to electron volts.

Question 11

Marks	0	1	2	Average
%	70	12	18	**0.5**

This question involved lengthy calculations and/or formula derivation. It involved formulas for both matter and electromagnetic radiation. One method involved a stepwise approach. Since the spacing of the diffraction pattern was the same for both the X-ray photons and the electrons, they must have the same momentum. So the momentum of the X-ray photons could first be calculated using $p = h/\lambda$. This could then be used to determine the speed of the electrons using $v = p/m$. Hence $E_K = \frac{1}{2} mv^2$ can be used to determine the energy in joule, which can be converted to electron volt, giving an answer of 37.7 eV.

Another method was to use $E_K = \frac{p^2}{2m} = \frac{(h/\lambda)^2}{2m}$ to give 6.04×10^{-18} J and then convert it to 37.7 eV.

Students who attempted these calculations at some stage got lost. Common problems included using the wrong version of Planck's constant, not being able to deal with powers of 10 or using the speed of light for the electron.

The most common error was to assume that because the diffraction patterns were the same, the energy of the electron must be the same as that of the photon. It is not the energies that are the same but the momenta.

Question 12

Marks	0	1	2	Average
%	30	9	61	**1.3**

The electrons produce a similar diffraction pattern because their wavelength is the same as that of the X-rays.

The majority of students understood the key points. The most common error was to assume that the energies must be the same. Some students wrote about energy levels in atoms, which indicated direct copying from A4 sheets of notes.

Question 13

Marks	0	1	2	3	Average
%	21	21	10	48	**1.9**

The possible photon energies were 12.8, 12.1, 10.2, 2.6, 1.9 and 0.7 eV.

A common error made by students was to give three transitions from 4 to 1, 4 to 2 and 4 to 3. Some students simply drew arrows, while others had difficulty with the subtractions.

Section B – Detailed studies

Detailed Study 1 – Synchrotron and its applications

Question	% A	% B	% C	% D	% No Answer	Comments
1	9	7	68	17	0	
2	56	24	13	6	1	To accelerate the negative electrons, plate Y will have to be positive with respect to X. The kinetic energy of the electrons $\frac{1}{2}mv^2 = Vq$. By substituting the values provided, V = 1997. So the best answer was +2000.
3	5	86	7	2	0	
4	4	26	40	29	0	The magnetic force on the electrons acts perpendicularly to their velocity and so does not change their speed.
5	3	77	9	11	0	
6	19	35	33	13	0	The X-ray laser produces an extremely narrow range of frequencies; the X-ray tube, by its method of operation, produces a significant range of frequencies. A synchrotron has the advantage of producing a very wide range of frequencies from which experimenters can select for their particular research.
7	22	10	5	62	0	Some energy will be transferred to the electron, so the X-rays will have reduced energy and therefore a longer wavelength. $\lambda = hc/E$.
8	7	13	6	73	0	
9	6	81	10	4	0	
10	8	22	63	6	0	
11	12	10	73	5	0	
12	9	20	11	59	0	

Detailed Study 2 – Photonics

Question	% A	% B	% C	% D	Comments
1	12	3	80	4	
2	2	16	64	18	
3	5	8	12	75	
4	2	3	74	21	
5	7	6	50	36	From Figure 1, the potential drop across the LED when forward biased was 2.2 V. Therefore, the potential drop across the 100 Ω conductor would be 0.8 V. Applying Ohm's law to this conductor gave a current of 0.008 A or 8 mA.
6	7	38	11	44	The LEDs require 2.2 V each to operate. That is a total of 4.4 V in the series circuit. Since there is only 3.0 V available, neither of them will operate.
7	4	82	7	6	
8	4	4	10	82	
9	4	11	11	74	
10	21	60	13	6	
11	4	78	13	6	
12	14	17	65	4	

Detailed Study 3 – Sound

Question	% A	% B	% C	% D	% No Answer	Comments
1	81	5	9	5	0	
2	3	7	88	2	0	
3	8	7	13	71	0	
4	6	12	28	54	0	At 3000 Hz, a sound intensity of 40 dB is just above the 40 phon loudness line.
5	6	5	84	5	0	
6	9	68	16	6	0	
7	7	11	9	73	0	
8	8	76	7	9	0	
9	40	12	5	44	0	The long line of small speakers (system B) could be treated as a single wide source. Therefore system A, which is a narrow source, will produce far greater diffraction and allow people all over the oval to hear.
10	5	5	17	73	0	
11	85	6	2	7	0	
12	3	8	84	6	0	