2010 Assessment Report

GENERAL COMMENTS

The number of students who sat for the 2010 Physics examination 2 was 6839. The mean score was 63 per cent; this indicated that students generally found the paper to be quite accessible.

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

- understanding of the effect that transformers have on voltage and current, and the distribution of voltage and power throughout an entire transmission system
- confusion about the distinction between matter and electromagnetic radiation, and which formulas can be applied to each
- conversion of units
- understanding of the photoelectric effect.

Students and teachers should note the following points in relation to the 2010 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.
- As the students' work is scanned and presented to assessors online, it is essential that students follow the instructions on the examination paper and write only in black or blue pen.
- In questions that require an explanation, students should carefully consider what the question is asking and answer accordingly. Written explanations must address the question. Generic answers copied directly from the student's note sheets generally do not cover the specifics of the question adequately. Also, if contradictory or incorrect statements are made students cannot expect to gain full marks.
- Students' attention should be drawn to the instructions regarding working. In questions worth more than one mark students should always show working. In these questions some credit can often be given for working, even if the final answer is incorrect. Some questions state that working must be shown and full marks will not be awarded if only the answer is recorded.
- 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.
- Where a question requires a number of calculation steps, students are encouraged to maintain some order in their working. If the assessor cannot follow what they have written, marks will not be awarded.

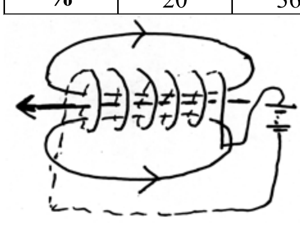
SPECIFIC INFORMATION

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
%	20	36	44	1.3



Students had to show three lines, at least one of which was continuous. It was encouraging that students ensured that the lines did not touch or cross.

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Question 2

Marks	0	1	2	Average
%	54	7	39	**0.9**

Since the magnetic field lines produced by the solenoid were parallel to the plane of the loop, the flux threading the loop was zero.

Some students immediately applied the formula $\Phi = BA \sin \theta$ but did not realise which angle was represented by θ. Another common error was to assume that because the loop was not moving through the magnetic field there was no flux. These students may have assumed that the question involved electromagnetic induction and that there was no change in flux.

Question 3

Marks	0	1	Average
%	35	65	**0.7**

Using the right-hand rule, the force on side PQ was vertically down.

Question 4

Marks	0	1	2	Average
%	18	27	55	**1.4**

The magnetic field was perpendicular to the side PQ so the force was $F = n\,I\,L\,B = 3 \times (4.0) \times (5.0 \times 10^{-2}) \times (0.04) = 0.024$ N.

Common errors included omitting the 3 or neglecting to convert the 4 cm to 0.04 m.

Question 5

Marks	0	1	2	Average
%	26	9	66	**1.4**

The force was zero because the side QR was parallel to the magnetic field.

Some students gave ‘the side QR was parallel to the current’ as their reason.

Question 6

Marks	0	1	2	Average
%	28	0	72	**1.5**

The answer was A.

Most students realised that the voltage depended on the rate of change of the flux.

Question 7

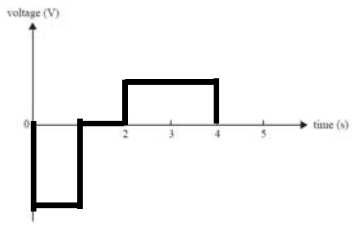
Marks	0	1	2	3	Average
%	11	20	38	31	**1.9**

The key points were that the split-ring commutator reversed the direction of the current every half turn, unlike the slip-rings which maintained the same external connection. The split-ring commutator is associated with DC, while the slip-rings are associated with AC.

Many students had trouble explaining the function of the slip-rings.

Question 8

Marks	0	1	2	Average
%	51	21	28	**0.8**



The diagram shows the expected answer, although it could also be inverted as no specific direction was specified as positive. It was important that the first voltage was about twice that of the second; however, many students missed this point. It was common for students to draw a variation of a sine graph.

Question 9

Marks	0	1	Average
%	56	44	**0.5**

Faraday's Law was used to determine the relative voltages, as described in the study design. It was also acceptable to mention Lenz's Law or write the mathematical equation.

Question 10

Marks	0	1	2	Average
%	18	4	78	**1.6**

Applying Faraday's Law gave an EMF of 3.0 V.

The most common error made by students was to omit the number of turns from the calculation.

Question 11

Marks	0	1	2	Average
%	33	36	31	**1**

The original flux was from left to right and was decreasing. To oppose this change in flux a current was required from Q→P.

Many students wrote about the induced flux opposing the original flux rather than the change in the original flux. Other students gave a correct reason but were unable to apply it to get the correct direction.

Question 12

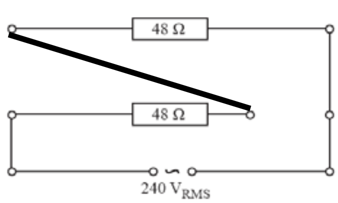
Marks	0	1	2	Average
%	15	2	82	**1.7**

Since only one element was connected, the potential difference across it was 240 V.

Some students used $P = V^2/R$ to get the answer of 1200 W. Others first calculated the current and then used a power formula. Some students seemed to think that because it was an AC voltage of 240 V_{RMS} they needed to multiply or divide by √2.

Question 13

Marks	0	1	2	Average
%	40	2	58	**1.2**



The elements needed to be connected in series as shown; however, many students connected them in parallel instead. Others added their own heaters into the circuit, showing no understanding of what the circuit represented.

Question 14

Marks	0	1	2	Average
%	19	32	49	1.3

Since there was a resistance in the transmission lines, there would be a voltage drop (or power loss) in the lines and therefore the globe would receive less than 2 V (or 4 W).

The question asked students to explain, hence there was no need for calculations. Many students attempted calculations to demonstrate what would happen.

Question 15

Marks	0	1	2	3	Average
%	44	9	7	40	1.4

There were a number of methods of doing this question. Generally students first needed to determine the current through the globe when it was operating properly. This meant using the formula $I = P/V = 2$ A. Using this current they could then determine the voltage drop across the transmission lines $\Delta V = IR = 8$ V. Therefore, the supply voltage needed to be 8 V for the lines and 2 V for the globe = 10 V. Many students could not correctly calculate the current which the globe needed to operate. Others used a line resistance of 2 Ω instead of 4 Ω and this indicated a misunderstanding of series circuits.

Question 16

Marks	0	1	2	Average
%	43	11	46	1

When the globe was operating properly at 4 W, the current would be 2 A and this would result in a power loss in the transmission lines of $P = I^2R = 2^2 x4 = 16$ W.

Common errors included getting the incorrect current or using the incorrect resistance.

Question 17

Marks	0	1	2	Average
%	42	33	25	0.8

For long-distance power transmission, AC is used because transformers are needed to reduce the current and therefore the power loss.

Many students simply stated that there was greater power loss in the transmission lines with DC than AC. Other students wrote long answers explaining how transformers operate.

Question 18

Marks	0	1	2	Average
%	34	0	66	1.3

The answer was D. The power supply was set to 20.8 V_{RMS} so the output was $V_{PEAK} = 20.8 \text{ x } \sqrt{2} = 29.4$ V, which was a peak to peak value of 58.8 V.

Question 19

Marks	0	1	Average
%	12	88	0.9

The secondary coil had 146 turns.

Question 20

Marks	0	1	2	3	Average
%	33	31	2	34	1.4

Since the voltage required by the globe was 2 V, the voltage on the primary side of the transformer must have been 20 V and the current in the primary side was $I = P/V = 4/20 = 0.2$ A. The power loss in the transmission lines was therefore $p = I^2R = 0.2^2 \text{ x } 4 = 0.16$ W. There were a number of other ways that students could have addressed this question.

Many students used the incorrect resistance for the transmission lines, for example, 2 Ω instead of 4 Ω. Others were unable to determine the current and some assumed that the voltage drop in the transmission lines was 20.8 V instead of 0.8 V.

Area of Study 2 – Interactions of light and matter

Question 1

Marks	0	1	2	3	Average
%	13	9	40	39	2.1

Young's double slit experiment demonstrated interference, which was a wave effect. The particle model predicted that two bands would appear on the screen behind the slits.

A common oversight made by students was to omit any discussion of the particle model. Young's modulus was also frequently quoted. Some students discussed waves diffracting through the slits without mentioning the actual observed interference pattern. Many students wrote long answers that did not directly address the question.

Question 2

Marks	0	1	2	3	Average
%	33	36	21	10	1.1

Observation 2 was not explained by the wave model. In the particle model the energy of the incident photons depends on frequency ($E = hf$). Since each photon interacts with one electron, the energy of the emitted electrons will depend on the frequency. Changing the intensity of the light only varies the number of photons, not their energy. Therefore, the energy of the emitted electrons is not affected, only the number emitted.

Students wrote many responses from their A4 sheet of notes that did not address the question. It was common for students to write about threshold frequencies and time delays, which were irrelevant. Many explained why the wave model did not work instead of why the particle model did work. Mixing up photons with electrons was very common, as was writing about the frequency of the electrons. Many students restated the observation as written on the examination paper, as if it explained the question asked.

Question 3

Marks	0	1	2	Average
%	18	9	73	1.6

By using $E = hc/\lambda$, the energy was 2.14 eV.

The main errors were using the wrong Planck's constant, not converting nanometres to metres or assuming that the 580 nm was the frequency, and using $E = hf$.

Question 4

Marks	0	1	2	Average
%	48	2	50	1

Y was on the third nodal line from the centre, so the path difference was $2.5\ \lambda = 2.5 \times 580 = 1450$ nm.

A common incorrect response was 290 nm, that is ½ λ. This may have been because the difference between the two path differences was ½ λ.

Question 5

Marks	0	1	2	Average
%	37	0	63	1.3

The answer was D. Doubling the intensity does not alter the energy of the incident photons and therefore does not affect the energy of the emitted electrons.

Question 6

Marks	0	1	2	3	Average
%	19	13	18	50	2

Graph A was correct. Possible explanations included: because the gradients had to be the same a lower work function would lead to the modulus of the *y*-intercept being smaller, a lower work function would lead to a lower threshold frequency or a lower work function the maximum kinetic energy of the emitted electrons would be greater at the same frequency. Students did not need to give all reasons for full marks.

Some students equated the work function with the stopping voltage, while others referred to the threshold frequency as the work function. It was important to relate concepts to the actual graphs.

Question 7

Marks	0	1	2	Average
%	18	32	50	1.3

The de Broglie wavelength was determined by $\lambda = h/p = h/mv = 4.86 \times 10^{-11}$ m = 0.0486 nm.

Many students obtained the correct answer in metres but could not convert it correctly to nanometres and gave an answer of 486 nm. Some students also used the wrong version of Planck's constant in the equation.

Question 8

Marks	0	1	2	Average
%	34	31	36	1

The correct option was A. Increasing the accelerating voltage and hence the speed of the electrons would increase their momentum. Increasing the momentum would decrease the wavelength of the electrons and result in less diffraction.

While many students were able to relate the increased speed to a smaller wavelength, they did not state that this would result in less diffraction. It was surprising how many students thought the diagrams represented the electron orbitals in an atom. Others believed that because the electrons were moving faster they would have less time to spread out.

Question 9

Marks	0	1	2	Average
%	40	5	56	1.2

They produce very similar diffraction patterns because they have the same (or very similar) wavelengths.

If students made incorrect statements in addition to a correct statement they could not receive full marks. Some students wrote lengthy answers on matter waves, referring to quantised energy levels in atoms and standing waves; however, the majority of this information was not relevant to the question.

Question 10

Marks	0	1	2	3	Average
%	72	16	1	12	0.6

There were a number of ways to approach this question. By using the relationship $p = \sqrt{2mE_K}$, the momentum of the electron was 1.322×10^{-23} and hence the energy of the X-rays was $E = pc = 3.97 \times 10^{-15}$ J = 2.48×10^{4} eV. An alternative method was to determine the momentum of the electron, then use it to get the wavelength of 5.015×10^{-11}. From this the energy of the X-rays could be determined from $E_{X\text{-Rays}} = hc/\lambda$.

Some students incorrectly assumed the energy of the X-rays was the same as the electron (i.e. 600 eV). From this they deduced the wavelength and determined that the energy must be 600 eV. Many applied formulas using incorrect units for some of the quantities, for example E_K = 600 eV in $p = \sqrt{2mE_K}$, or the incorrect version of Planck's constant. Some students incorrectly assumed that they were dealing with the same electrons as in Question 7, where they knew the speed and wavelength.

Question 11

Marks	0	1	2	Average
%	39	7	54	1.2

The required answer was an arrow pointing down from n = 4 to n = 2.

Common errors included arrows pointing up or multiple arrows between various levels.

Section B – Detailed studies

Detailed Study 1 – Synchrotron and its applications

The table below indicates the percentage of students who chose each option. The correct answer is indicated by shading.

Question	% A	% B	% C	% D	% No Answer	Comments
1	10	61	21	7	1	
2	6	16	68	10	1	
3	5	78	11	5	0	
4	12	74	6	7	1	
5	7	6	79	8	0	
6	10	73	11	6	0	
7	85	5	6	3	0	
8	9	16	64	10	0	
9	71	7	6	15	0	
10	32	50	9	8	1	Where the electrons first enter the undulator the magnetic field is down. By using the right-hand rule, fingers point down, the thumb points in the opposite direction to which the electrons travel, and out of the palm is the direction of the force. So the electrons move a little in the direction 'out of the page'. As the magnetic field reverses direction, the beam will be pushed a little in the direction 'into the page'.
11	4	11	12	72	1	
12	21	7	3	68	1	

Detailed Study 2 – Photonics

Question	% A	% B	% C	% D	% No Answer	Comments
1	6	3	89	2	0	
2	5	8	76	11	0	
3	4	41	54	1	0	This was a series circuit. The potential difference across the diode will be 2 V, so the potential difference across the resistor will be 10 V. By applying Ohm's Law, the current through the resistor, and therefore the ammeter, will be 25 mA. The majority of students assumed that the whole 12 V would be across the resistor and gave a current of 30 mA.
4	27	33	37	4	0	The blue LED will require a higher threshold voltage; therefore there will be less voltage across the resistor. This will also mean less current through the resistor and the ammeter.
5	6	8	8	78	0	
6	6	75	13	5	0	

Question	% A	% B	% C	% D	% No Answer	Comments
7	8	42	34	15	0	For total internal reflection inside the plastic pipe, the angle at which the light is incident on the plastic wall must be greater than the critical angle. As the rod is bent, the intensity of light emerging at the far end decreased. Therefore some light has escaped through the walls of the pipe. This will occur when the light is incident at less than the critical angle.
8	34	13	37	17	0	Total internal reflection requires the initial medium to have a higher refractive index than the second medium. As the plastic has a lower refractive index than water, total internal reflection can no longer occur.
9	3	5	13	79	0	
10	9	2	39	50	0	From the graph, the attenuation at 1200 nm was about 1.3 W/km from Rayleigh scattering and 0.2 W/km from absorption, giving a total of about 1.5 W/km. This is lower than at the other suggested wavelengths.
11	15	70	7	7	0	
12	6	14	73	6	0	

Detailed Study 3 – Sound

Question	% A	% B	% C	% D	% No Answer	Comments
1	2	94	4	1	0	
2	9	1	9	80	0	
3	83	6	6	6	0	
4	4	19	70	8	0	
5	7	5	87	1	0	
6	2	12	8	78	0	
7	5	17	72	6	0	
8	12	4	81	3	0	
9	6	73	1	20	0	
10	50	32	6	12	0	From the frequency response curve (Figure 4) it could be seen that the microphone responds much better to a 3000 Hz sound than a 1000 Hz sound. Therefore, the oscilloscope display must show a much larger response for 3000 Hz. Also, since the 1000 Hz was played first, it should appear first on the time axis. The expected answer was option B; however, since it may not have been clear that the oscilloscope was connected to the microphone rather than to the variable frequency sound source, option A was also accepted.
11	84	5	6	5	0	
12	3	6	12	79	0	