GENERAL COMMENTS

The number of students who sat for the 2006 Physics examination 2 was 6589. The mean score was 62%, the same as last year. Students generally found the paper to be quite accessible. Twenty students achieved the maximum score of 90. The vast majority of schools again chose Sound for the detailed study.

Some areas of weakness that were noted included:

- sketching magnetic fields
- unit conversion; for example, cm^2 to m^2
- the origin of the broad band spectrum of light from a candle
- the distinction between matter and electromagnetic radiation. Many students were confused about which formulae should be used in a given situation.

Students and teachers should note the following points in relation to the 2006 examination 2 paper and for future reference.

- Students should answer questions from only **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 require an explanation, the number of marks generally equates to the number of relevant points that should be made. Simply answering 'yes' or 'no' is inadequate for a two-mark question. Some explanation of why the answer is yes or no is required.
- 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. Some questions specify that working is required or that units are to be given. If this is not done, marks are not awarded.
- It is important to read the questions carefully. It was apparent that in some instances students had only given the question a cursory glance and then proceeded to answer the question they expected to see.

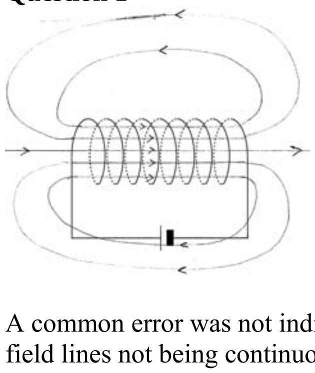
SPECIFIC INFORMATION

Section A – Core
Area of Study 1 – Electric power

Questions 1–6

Marks	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Average
%	3	4	4	5	6	7	7	6	6	7	7	8	9	10	9	8.5

Question 1



A common error was not indicating the direction of the field both inside and outside the coils. Other errors included the field lines not being continuous or crossing one another, or a number of lines joining into one.

Question 2

magnitude	direction
0 N	none

Since the wire was parallel to the magnetic field, there was zero force acting on it.

Question 3

magnitude	direction
2.0×10^{-3} N	Q or T

In this case the wire was perpendicular to the magnetic field, so a simple application of the formula F = BIl gave the answer above. Some students neglected to convert the length from centimetres to metres before substituting into the formula. The direction of the force could be either Q or T depending on how the diagram was viewed.

Question 4
0 Wb

This question was well done, although some students neglected to include the unit as instructed.

Question 5
1.0×10^{-7} Wb

The main error was not converting the area from cm^2 to m^2 before applying the formula.

Question 6
The commutator changes the direction of the current in a DC motor every half rotation in order to keep it rotating in the same direction. Effie's idea would not work since the motor would oscillate and then come to a stop.

This question was quite well done, although some students confused the motor with a generator.

Question 7

Marks	0	1	2	Average
%	39	0	61	**1.3**

The correct answer was A.

As the loop entered the magnetic field the flux threading it increased at a constant rate. Therefore a constant voltage would result and this would give a constant current. As the loop exited the field the change in flux was reversed, so the voltage and resultant current were in the opposite direction.

Questions 8–12

Marks	0	1	2	3	4	5	6	7	8	9	10	11	12	13	Average
%	8	3	3	2	4	5	5	8	10	11	13	10	9	11	**8.2**

Question 8

$$\varepsilon = \frac{(-)\Delta\varphi_B}{\Delta t}$$
$$= \frac{3.7\times10^{-3}\times4\times10^{-4}}{0.5}$$
$$= 2.96\times10^{-6} \quad \text{or} \quad 3.0\times10^{-6}$$

This was a challenging question. Calculating the area of the loop in m^2 proved to be difficult for many students, but determining the time interval was the real stumbling block. Instead of calculating the time for the loop to enter (or exit) the field, many used the time for it to pass through the entire field.

Question 9
400 A

100 kW of power had to be provided by the transformer. The potential difference across the secondary winding was 250 V. So, by applying the formula P = VI, the current was 400 A. Some students did not convert kW to W, while others tried to use Ohm's law but with inappropriate values.

Question 10
Some students used P = VI. Knowing that the power provided by the transformer was 100 kW and the potential difference across the primary side was 22 kV, the current had to be 4.55 A. Others used $\frac{I_1}{I_2} = \frac{V_2}{V_1}$, so $\frac{I_1}{400} = \frac{250}{22000}$, therefore $I_1 = 4.55$ A.

Question 11
$\Delta P = I^2 \times R = (4.55)^2 \times 2.0 = 41$ W

The power loss in the lines was calculated by applying the formula above. Some students used the wrong current (400 instead of 4.55); some made the arithmetic mistake of not squaring the current; and others neglected to provide the unit.

Question 12
Because the power required is fixed, increasing the voltage reduces the current (P = VI). A smaller current means a reduced power loss in the transmission lines ($P = I^2R$).

Question 13

Marks	0	1	2	Average
%	26	0	74	**1.5**

C was the correct response.

The ratio of the number of turns on the primary side to the number on the secondary side had to be the same as the ratio of the voltages.

Question 14–15

Marks	0	1	2	3	4	5	Average
%	28	11	10	14	13	23	**2.5**

Question 14
A changing current in the primary produces a changing flux. This changing flux also threads the secondary and induces a voltage.

The main error was students not referring to the changing current, field or flux. Some wrote about the purpose of the transformer being to increase or decrease voltage without explaining how this was achieved.

Question 15
The transformers in the transmission system require AC, since a changing magnetic flux is needed to induce an EMF in the secondary.

Question 16

Marks	0	1	2	Average
%	77	0	23	**0.5**

The correct response was B.

The power demand increased but the voltage at the alternator remained the same, therefore the current supplied had to increase. Increasing the current in the transmission lines would mean an increased voltage drop along the lines, and therefore a lower voltage at the primary of transformer 2. Since the turns ratio of the transformer has not changed there will be a lower voltage across the secondary.

Question 17

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

The correct answer was B.

The output of the alternator was 250 V (RMS) and 50 Hz. Accordingly a peak voltage of around 350 was required and a period of 20 ms.

The most common incorrect response was D; presumably these students had assumed the output of the alternator to be the peak value.

Area of Study 2 – Interactions of light and matter

Question 1

Marks	0	1	2	Average
%	73	0	27	**0.6**

The correct answer was D.

Most students opted for B. Perhaps they saw the term incoherent and did not read any further. However, it seems more likely that they confused it with a discrete emission spectrum formed when excited electrons return to the ground state.

Questions 2–3

Marks	0	1	2	3	4	5	6	Average
%	2	5	11	16	21	21	24	**4.2**

Question 2

Prediction	Wave model	Particle model
The number of photoelectrons produced is proportional to the intensity of the incident beam.	**Y**	Y
Light of low intensity will give rise to the emission of photoelectrons later than light of high intensity.	Y	**N**
Light of high intensity will produce photoelectrons with a greater maximum kinetic energy than light of low intensity.	**Y**	N
Light of sufficient intensity of any frequency should produce the photoelectric effect.	**Y**	N

Question 3

1.8 eV

If students understood what the question was asking it was a simple matter to read the answer from the vertical axis of the graph. Alternatively, the threshold frequency could be read from the horizontal axis and multiplied by Planck's constant. No marks were deducted if students included a negative. A common incorrect response was 1.0, although where this came from is unclear.

Question 4

Marks	0	1	2	Average
%	37	0	63	**1.3**

B was the correct response.

The gradients had to be the same and silver had to intersect the vertical axis lower down because of the greater work function.

Questions 5–11

Marks	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Average
%	7	5	5	4	5	5	5	5	6	5	6	7	7	8	8	11	**8.8**

Question 5

8.7×10^{14} Hz

The highest frequency implies the greatest energy, so the transition would be from n = 4 to n = 1. Therefore $\Delta E = 3.61 = h f$. Hence $f = 8.7 \times 10^{14}$. It was surprisingly common for students to read the wrong energy level or even use the ionisation energy.

Question 6
Electrons have an equivalent or de Broglie wavelength. Only orbits of an integral number of wavelengths are allowed as these will form a standing wave.

It was not necessary for students to discuss the probability nature of the wave function. Many seemed to think the electrons actually moved in a wavelike pattern.

Question 7
5.6 cm

Since P_2 was the second maximum away from the central axis, the path difference must be $2\lambda = 5.6$ cm.

Question 8
Young's experiment demonstrated interference of light, which is a wave phenomenon.

Some students knew it was an interference effect but did not relate this to the wave nature of light.

Question 9

$$\begin{aligned} E &= \frac{hc}{\lambda} \\ &= \frac{4.14\times10^{-15}\times3.0\times10^{8}}{250\times10^{-12}} \\ &= 4.97\times10^{3}\text{ eV} \\ &= 4.97\text{ keV or }5.0\text{ keV} \end{aligned}$$

Since the wavelength was provided, the energy could be calculated using $E = \frac{hc}{\lambda}$. Some students did not convert their answer to keV. Others selected the correct formula and did the substitution, but could not perform the calculation. It was disappointing to note the number of students who still tried to apply formulae which involve mass.

Question 10
Electrons have a de Broglie wavelength which was the same (or very similar) to the wavelength of the X-rays.

Question 11

$$\begin{aligned} p &= \frac{h}{\lambda} \\ &= \frac{6.63\times10^{-34}}{250\times10^{-12}} \\ &= 2.7\times10^{-24}\text{ kg m s}^{-1} \end{aligned}$$

The diffraction patterns were the same, so the wavelength of the electrons must equal that of the X-rays. Therefore the momentum was $p = \frac{h}{\lambda}$. A common error was using the wrong value for Planck's constant. Other students assumed that the energy of the electrons must equal that of the X-rays. Still others used p = mv, assuming the speed of the electron was 3×10^8.

Section B – Detailed studies

Detailed Study 1 – Synchrotron and its applications

Questions 1–2

Marks	0	1	2	3	4	5	6	7	Average
%	6	5	10	11	13	23	16	17	**4.5**

Question 1
The correct terms were **linear accelerator**, **bending magnets** and **electromagnetic**.

Question 2
There were a range of possible answers including:
- brightness or intensity – allows shorter exposure time or to select an almost monochromatic beam or clearer images
- tuneable – can select out the frequency needed
- polarised – some experiments require this
- low divergence – sharp spot on target
- more penetrating – can get higher energy/shorter wavelength X-rays
- broad spectrum – can select the frequency needed
- pulsed – short exposure
- coherent – interference effects.

Students were awarded one mark for each advantage nominated and one mark for explaining each advantage.

Question 3

Marks	0	1	2	Average
%	15	0	85	1.8

The correct answer was B.

Question 4

Marks	0	1	2	Average
%	50	0	50	1.1

The correct answer was D.

Question 5

Marks	0	1	2	Average
%	74	6	19	0.5

This was a result of Compton (or inelastic) scattering. The X-rays give some energy to electrons and so now have less energy, and thus a longer wavelength.

Question 6

Marks	0	1	2	Average
%	55	0	45	0.9

The correct answer was D.

Questions 7–8

Marks	0	1	2	3	4	5	6	Average
%	24	7	7	12	12	8	29	3.5

Question 7
4.2×10^7

Students first had to convert the energy to Joule and then apply the formula for kinetic energy to get the speed.

Question 8
1.9×10^{-18} kg m s^{-1}

Students were required to apply the formula $p = reB$ to obtain the answer above.

Question 9

Marks	0	1	2	Average
%	40	0	60	1.3

The correct answer was B.

Question 10

Marks	0	1	2	Average
%	33	12	55	**1.3**

$d = 2.0 \times 10^{-10}$

Use of $n\lambda = 2d \sin \theta$ and substituting for $n = 1$ provided the correct answer.

Detailed Study 2 – Photonics

Question 1

Marks	0	1	2	3	Average
%	15	13	28	43	**2.1**

The correct terms were **greater than**, **lowest** and **reduced**.

Question 2

Marks	0	1	2	Average
%	17	0	83	**1.7**

The correct answer was A

Question 3

Marks	0	1	2	Average
%	26	0	74	**1.5**

The correct answer was A.

Decreasing energy results in decreasing frequency and therefore increasing wavelength.

Questions 4–8

Marks	0	1	2	3	4	5	6	7	8	9	10	11	12	Average
%	10	6	11	4	5	5	5	6	7	11	10	10	10	**6.8**

Question 4

Possible advantages were:

- more intense
- monochromatic (nearly)
- less divergence
- coherent.

Question 5

In graded index fibres, light which travels to the outer part of the cable travels further but faster because of the lower refractive index. Hence longer distance (higher order modes) and shorter distance (lower order modes) rays still arrive at the end at the same time, reducing modal dispersion. In step-index fibres all modes (rays) travel at the same speed, so higher order modes take longer to reach the far end and the signal spreads out (modal dispersion).

Question 6

$n_1 \sin \theta_1 = n_2 \sin \theta_2$

$\sin \theta = 1.48 \sin 10^\circ$

so $\theta = 14.9^\circ$ or 15°

The application of Snell's law was required to obtain the correct answer.

Question 7

83.3°

Again using Snell's law, $1.48 \sin \theta_c = 1.47 \sin 90^\circ$ which leads to a critical angle of 83.3°.

Question 8
The acceptance angle would **change** as the relative refractive index will be different. The critical angle would **remain the same** as there is no change in the relative refractive index between the core and the cladding.

Question 9

Marks	0	1	2	Average
%	44	0	56	**1.2**

The correct answer was B.

Questions 10–11

Marks	0	1	2	3	4	Average
%	32	13	18	19	18	**1.9**

Question 10
Rayleigh scattering dominated at these wavelengths and scattering increased as the wavelength decreased (i.e. red).

An alternative way of obtaining the first mark was to say that absorption was not significant at these wavelengths.

Question 11
For the first mark students had to indicate that it was due to total internal reflection. The second mark could be obtained either by stating that the refractive index of water was greater than air, or that the beam meets the interface at an angle of incidence which is greater than the critical angle.

Detailed Study 3 – Sound

Question 1

Marks	0	1	2	3	Average
%	5	8	27	60	**2.5**

The correct terms were **diffraction**, **less** and **increase**.

Question 2

Marks	0	1	2	Average
%	22	0	78	**1.6**

The correct answer was D.

The most common incorrect response, A, possibly resulted from graphical analysis which is often represented as a transverse wave.

Questions 3–4

Marks	0	1	2	3	4	Average
%	7	3	16	13	62	**3.3**

Question 3
0.71 m

Students were required to apply the wave equation to obtain the correct answer. Some students neglected to provide the unit as required.

Question 4
2.5×10^{-6}

Although this question was reasonably well done, a number of students had difficulty with the mathematics involved in the transformation.

Question 5

Marks	0	1	2	Average
%	48	0	52	**1.1**

The best estimate from those available was D.

Some students neglected the log scale while others had trouble with the d^2 factor.

Questions 6–7

Marks	0	1	2	3	4	5	Average
%	14	10	5	22	15	34	**3.3**

Question 6

Sound from the back and front of the speaker is out of phase. The box prevents these meeting and interfering destructively.

A common misconception was that the rearward sound wave was reflected from the back of the box, became in phase and then constructively interfered with the front wave.

Question 7

$$v = f \times \lambda$$

$$\lambda = \frac{340}{200} = 1.7$$

$$L = \frac{\lambda}{2} = \frac{1.7}{2} = 0.85 \text{ m}$$

The wave equation was required to be applied to obtain $\lambda = 1.7$ m.

Question 8

Marks	0	1	2	Average
%	13	14	73	**1.6**

The correct answers were B and D.

Since the pipe was open at both ends, all harmonics were possible.

Question 9

Marks	0	1	2	3	Average
%	34	31	26	9	**1.2**

Sound waves travel along the tube and reflect from the open ends. This causes interference between the two waves, and will produce standing waves (resonance) if the wavelength matches the pipe length.

Many students wrote about the driving frequency matching the natural frequency of the pipe and setting up a standing wave. They were only awarded two marks for this as the question asked for an explanation in terms of the behaviour of the sound waves in the tube.

Question 10

Marks	0	1	2	Average
%	30	0	70	**1.5**

The correct answer was C.

Question 11

Marks	0	1	2	Average
%	23	11	66	**1.5**

In a dynamic microphone, sound waves cause the diaphragm to move. As the attached coils move in the magnetic field, current is induced electromagnetically.