2007
Assessment
Report

GENERAL COMMENTS

The number of students who sat for the 2007 Physics examination 2 was 6378. The mean score was 61%, which is similar to the means for the past few years. Students presenting for the examination were well prepared. Fourteen students achieved the maximum score of 90. The vast majority of schools chose 'Sound' as the Detailed study. Although the number choosing 'Synchrotron and its applications' appears to be steady, very few are now doing Photonics.

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

- sketching magnetic fields
- unit conversion; for example, nm to m
- calculations involving powers of 10
- the distinction between the behaviour of bound and free electrons
- the direction of current flow
- the distinction between diffraction as it applies in 'Interactions of light and matter' compared with 'Sound'
- the ability to transform simple equations
- the **gradual** change in diffraction patterns as the λ/w ratio is varied
- the **gradual** change in the amount of internal reflection as the incident angle is varied.

Students and teachers should note the following points in relation to the 2007 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 can not decipher what is written, no marks can be awarded. This applies particularly to multiple-choice questions where one answer is written over another.
- 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.
- In questions that require an explanation, the number of marks generally equates to the number of relevant points that should be made.
- Students should be encouraged to show their working. Credit can often be given for working even if the final 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 in some instances that students had only given the question a cursory glance and then proceeded to answer a question they expected to see.
- 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.

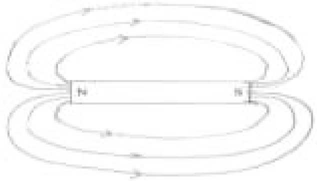
SPECIFIC INFORMATION

Section A – Core
Area of Study 1 – Electric power

Questions 1–3

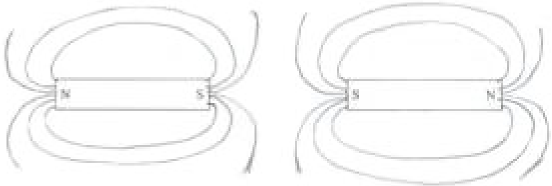
Marks	0	1	2	3	4	5	6	7	Average
%	2	2	4	8	17	26	27	15	5.1

Question 1



Although this was expected to be an easy introductory question, that was not the case. Common mistakes included field lines touching, crossing or joining together at the poles. Sometimes no complete field lines were shown, or the arrows were in the wrong direction.

Question 2



A common error was to not clearly indicate what happens between the poles of the magnets. Apart from this, the same errors as in Question 1 were evident.

Question 3

- Magnitude: 1.6 N
- Direction: up

Students were generally able to calculate the magnitude of the force; however, determining the direction was not as well done. It was often given as down instead of up. This may be a result of students' confusing the direction of Earth's magnetic field.

Questions 4–5

Marks	0	1	2	3	4	5	6	Average
%	7	9	10	11	13	20	30	**4.1**

Question 4
4a.
B – anti-clockwise

4b.
It will rotate anti-clockwise because the current travels from J to K which (using the right hand rule) results in a downward force on this side.

It was surprisingly common for students to discuss current flowing from negative to positive. Quite a few discussed the operation of a commutator, which was irrelevant.

Question 5
The commutator reverses the direction of the current every half turn. This reverses the direction of the forces on each side of the coil and therefore keeps the motor rotating in a constant direction.

It was common for students to omit any discussion of the forces. A disappointing number of students confused the motor with a DC generator.

Questions 6–9

Marks	0	1	2	3	4	5	6	7	8	9	10	11	Average
%	5	1	4	4	3	5	8	6	9	15	7	33	**8.1**

Question 6
5.0×10^{-3} Tesla

The formula $\Phi_B = B \times A$ could be used to find the strength of the magnetic field. Common mistakes included confusing the magnetic field with the magnetic flux or stating the wrong unit. Some students seemed to believe that the number of turns had something to do with the magnetic flux and used $\Phi_B = N \times B \times A$. This would imply that if there were no coils present there would be zero magnetic flux threading that area of space. The magnetic field, and thus the flux through the area, is established by the magnets. Placing a coil, of any number of loops, in the field does not alter the flux (number of magnetic field lines) through the area.

Question 7

$$\text{EMF} = \frac{N\ \Delta\Phi_B}{\Delta t}$$
$$= 30\ \text{V}$$

Students were required to show their working for full marks. Common errors included neglecting the 1000 turns, using the magnetic field instead of the change in flux and taking the time as one-quarter of 0.01.

Question 8

12.5 Hz

From the graph, the period of rotation was 80 ms; therefore the frequency was 12.5 Hz. Some students neglected to notice that the scale was milliseconds. Still others could not convert milliseconds to seconds.

Question 9

$$V_{\text{RMS}} = \frac{V_{\text{peak}}}{\sqrt{2}}$$
$$= \frac{80}{\sqrt{2}}$$
$$= 56.6\ \text{V}$$

Some students used the peak–peak voltage instead of the peak voltage.

Question 10

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

C

This question was quite well done.

Questions 11–12

Marks	0	1	2	3	4	5	6	Average
%	11	14	15	15	11	13	22	**3.4**

Question 11

11i.
2.5 A

11ii.
10 V

11iii.
2.0 V

A considerable number of students had difficulty with part ii., which involved voltage in a series circuit.

Question 12

12i.
6.0 W

12ii.
5.0 W

12iii.
5.0 W

It was disconcerting to see how many students gave answers to parts ii. and iii. which were greater than the answer to part i.

Question 13

Marks	0	1	2	3	Average
%	37	7	15	42	**1.7**

The globe will not illuminate (or it will glow momentarily as the DC battery is connected). A transformer requires a changing current in the primary to produce a changing magnetic field which threads the secondary. The resulting changing flux in the secondary produces a voltage.

Some students simply quoted from their note sheet about using transformers to reduce power loss in transmission lines.

Question 14

Marks	0	1	2	Average
%	56	0	44	**0.9**

B. current flows momentarily in the direction Y to S

This question was not well done. Students clearly had difficulty applying Lenz's law.

Question 15

Marks	0	1	2	3	Average
%	33	35	13	19	**1.2**

Students were firstly expected to state Lenz's law. Most were able to do this, although some said it was necessary to oppose the flux instead of the change in flux. It was then necessary to explain that when the switch was closed a magnetic field built up to the left. To oppose this, the induced current must produce a magnetic field to the left.

Very few students were able to explain the application of Lenz's law.

Area of Study 2 – Interactions of light and matter

Questions 1–3

Marks	0	1	2	3	4	5	6	7	Average
%	17	8	11	9	10	10	13	21	**3.9**

Question 1
2.0 eV

This answer could be obtained from the graph. It was best obtained by extrapolating the graph to find the intercept with the vertical axis.

Question 2
1.0 eV

By using the wave equation, 400 nm equates to a frequency of 7.5×10^{14} Hz. Locating this point on the graph then gives the energy of the emitted electrons as approximately 1.0 eV.

Question 3
The experimental evidence supported the particle theory. The wave theory predicts that photoelectrons would be emitted at any frequency if the intensity was sufficient. In the particle theory, the energy of the photons is related to the frequency, not the intensity, so there would be no electrons emitted below the threshold frequency.

Many students had difficulty relating the theory of the photoelectric effect to the actual context of this particular question.

Questions 4–5

Marks	0	1	2	3	4	Average
%	16	12	22	26	24	**2.4**

Question 4
2.0×10^3 m s^{-1} (or 1985 m s^{-1})

The relationship $\lambda = \frac{h}{mv}$ gave the speed of the neutrons. Common difficulties included transposing the equation to get *v* and deciding which version of Planck's constant to use.

Question 5
There would be a diffraction pattern because the wavelength is of the same order of magnitude as the interatomic spacing.

Many students confused the diffraction requirements from the Detailed study 'Sound' with what is necessary to form a useful diffraction pattern in this topic.

Question 6

Marks	0	1	2	Average
%	53	0	47	**1.0**

B

The wider the slit the narrower the pattern, so the answer was B. It was disappointing that fewer than half of the students were able to apply the simple relationship required to determine the answer. This may be related to the apparent confusion over diffraction patterns mentioned in the previous question.

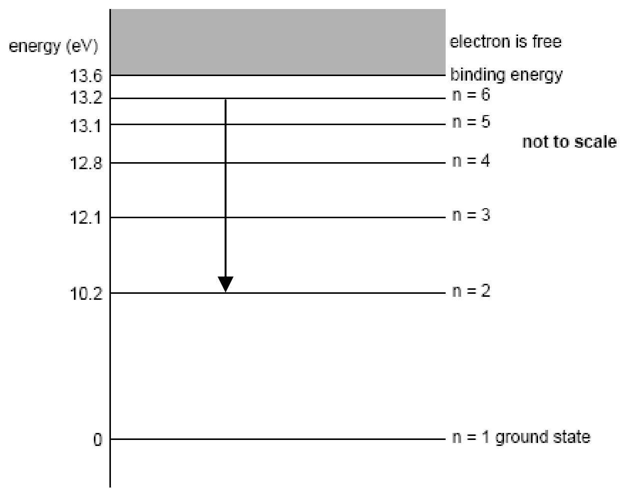
Questions 7–9

Marks	0	1	2	3	4	5	6	7	8	Average
%	22	4	6	14	5	17	9	8	14	**4.1**

Question 7
2.86 eV

This answer could be obtained by using $E = \frac{hc}{\lambda}$. Some students were confused about which Planck constant to use, while others forgot to convert nanometres to metres. Some appeared to have tried to use the energy level diagram.

Question 8



Students were required to draw an arrow from the n = 6 to the n = 2 lines. Some had the arrow going up instead of down; others had an arrow head on both ends.

Question 9
The dark lines exist because photons are absorbed which correspond to the energy levels in hydrogen. This indicates the presence of hydrogen.

It was very common for students to attempt to explain the dark lines in terms of destructive interference.

Questions 10–11

Marks	0	1	2	3	4	Average
%	46	18	14	10	12	**1.3**

Question 10
10i.
Continuous (or broad)

10ii.
Discrete (or individual lines)

This question was poorly done, with common answers being 'incoherent' and 'coherent' or 'emission' and 'absorption'.

Question 11
11i.
Thermal motion of free electrons

11ii.
Energy transition of bound electrons

This question was poorly done, with students unable to distinguish between the behaviour of free and bound electrons. They often simply referred to excited electrons.

Section B – Detailed studies

Detailed Study 1 – Synchrotron and its applications

Question 1

Marks	0	1	2	3	Average
%	12	18	30	40	**2.1**

The three correct statements were 'accelerates electrons from the linac', 'travel around curved segments' and 'electric fields in the straight segments'.

Questions 2–3

Marks	0	1	2	3	4	Average
%	25	6	13	9	46	**2.6**

Question 2
2.65×10^7 m s^{-1}

The formula $\frac{1}{2}mv^2 = eV$ gave the correct speed.

Question 3
0.24 m

The relationship $r = \frac{mv}{eB}$ could be used to determine the radius.

Question 4

Marks	0	1	2	Average
%	60	0	40	**0.8**

B. The electrons would be deflected outwards from the ring.

This question caused considerable difficulty.

Question 5

Marks	0	1	2	3	Average
%	26	8	19	47	**2.0**

- Magnitude: 2.0×10^{-16} N
- Direction: down

The majority of students were able to apply the relationship $F = e \times v \times B$ to calculate the force.

Question 6

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

C. a beam of electromagnetic radiation

Questions 7–8

Marks	0	1	2	3	4	Average
%	30	7	12	15	37	**2.4**

Question 7

10.4 keV

The formula $E = \frac{hc}{\lambda}$ could be used to find the energy. Note that the question required the answer to be given in keV.

Question 8

0.2 nm

Applying $n\lambda = 2d\sin\theta$ for the first maximum gave the spacing. Some students neglected to convert the wavelength to metres.

Question 9

Marks	0	1	2	Average
%	63	0	37	**0.8**

D. 37° and 64.4°

Surprisingly only just over one-third of students got this correct.

Question 10

Marks	0	1	2	Average
%	34	0	66	**1.4**

D. The scattered X-rays have a longer wavelength that the incident X-rays.

This question was well done.

Question 11

Marks	0	1	2	3	Average
%	63	16	12	9	**0.8**

A beam line has a range of wavelengths. By using a suitable crystal where the separation of the layers is known, particular wavelengths will be scattered at certain angles. By selecting angles carefully, very specific wavelengths can be obtained.

Many students did not attempt this question. Some students made reference to the Bragg equation but were unable to explain how this related to the question.

Detailed Study 2 – Photonics

Question 1

Marks	0	1	2	3	Average
%	25	19	27	29	**1.7**

The three correct statements were ‘population inversion’, ‘photons’ and ‘the same’.

Questions 2–3

Marks	0	1	2	3	4	5	Average
%	43	7	4	10	13	23	**2.3**

Question 2

The LED requires sufficient voltage across the diode to raise the electrons to the higher allowable energy state. Electrons then return to the lower state emitting photons.

Students generally either received full marks for this question or could not answer the question at all.

Question 3

4.7×10^{-7} m or 470 nm

Students were required to realise that the photon energy will equal that of the electron transition, 2.64 eV. Transposing the equation $E = \frac{hc}{\lambda}$ and substituting gave the wavelength. Some students were confused about which Planck constant to use. Others had difficulty with transposition or dealing with powers of 10.

Question 4

Marks	0	1	2	Average
%	47	0	53	**1.1**

	Red LED	Voltage across LED	Current through A
A.	Light emitted	Less than 2.64 V	Greater than 500 mA

Questions 5–6

Marks	0	1	2	3	4	Average
%	18	0	31	0	52	**2.7**

Question 5

D. 78°

D gave the best estimate of the critical angle. This question was well done.

Question 6

B. 30°

This question was poorly done. Perhaps the geometry involved caused some difficulty for students.

Questions 7–8

Marks	0	1	2	3	4	Average
%	36	8	9	13	35	**2.2**

Question 7
The LED emits a range of wavelengths. Since different wavelengths travel at different speeds, the signal will be spread over time.

Question 8
Since the laser emits a much smaller range of wavelengths than the LED, there will be a smaller range of speeds and thus less dispersion.

Some students wrote about the intensity of the laser, which was irrelevant.

Question 9

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

C. Rayleigh scattering

This question was quite well done.

Questions 10–11

Marks	0	1	2	3	4	5	Average
%	32	7	14	10	12	25	**2.6**

Question 10
The infrared would be best because the total attenuation was less at this wavelength.

Question 11
When the beam is distorted, the angle at which the beam meets the core-cladding boundary will change. This will vary the amount of internal reflection along the fibre and thus change the intensity of the beam which reaches the detector.

Detailed Study 3 – Sound

Question 1

Marks	0	1	2	3	Average
%	8	15	26	50	**2.3**

The three correct statements were ‘out of phase with’, ‘interfere destructively’ and ‘intensity’.

Questions 2–4

Marks	0	1	2	3	4	5	6	Average
%	14	5	11	7	14	16	32	**3.9**

Question 2
3.4 m

The wave equation $v = f \times \lambda$ could be used to calculate the wavelength. A common error was to misinterpret the question as a tube resonating at the first harmonic.

Question 3
170 Hz

For open-closed tubes, the first resonance is at $L = \frac{\lambda}{4}$, so $\lambda = 4\text{ L} = 4 \times 0.5 = 2.0$ m. Hence, $f = \frac{v}{h} = \frac{340}{2} = 170$ Hz.

Question 4
Students were required to indicate that the sound would be louder. This could have been explained either as the formation of a standing wave, as constructive interference of reflecting waves or as the natural frequency of vibration of the air column matching the incoming frequency.

Question 5

Marks	0	1	2	Average
%	32	0	68	**1.4**

D. 510 Hz

Questions 6–9

Marks	0	1	2	3	4	5	6	7	8	9	10	Average
%	5	4	5	6	5	7	8	10	11	18	21	**6.9**

Question 6
Sound waves cause the diaphragm to move. The diaphragm is connected to a coil in a magnetic field. The relative movement of these causes a change in flux which induces a current by electromagnetic induction.

Question 7
The microphone is suitable because it has a linear response over the frequency range of the singer.

This question was poorly answered. Very few students referred to the linear (or flat) response of the microphone. Many made reference to it as a speaker, perhaps straight from their note sheet.

Question 8
1.0×10^{-6} W m^{-2}

Substitution into the formula for sound level gave the intensity. Some students used derived formulas to give the sound intensity, but often got confused with the calculation.

Question 9
9a.
The 200 Hz signal

9b.
To reach Y the sound will have to be diffracted. The amount of diffraction depends on the ratio λ / w. Since the 200 Hz has the longer wavelength it will diffract more.

Some students neglected to mention the λ / w ratio.

Questions 10–11

Marks	0	1	2	3	4	Average
%	24	0	29	0	47	**2.5**

Question 10
C. 8:1

The question was reasonably well done.

Question 11
B. 54 dB

This question was quite well done.