Coimisiún na Scrúduithe Stáit
State Examinations Commission

LEAVING CERTIFICATE EXAMINATION 2008

PHYSICS

ORDINARY LEVEL CHIEF EXAMINER'S REPORT

HIGHER LEVEL CHIEF EXAMINER'S REPORT

CONTENTS

1. General Introduction

1.1 The Syllabus

The revised Leaving Certificate Physics syllabus was introduced in 2000 and first examined in 2002. The syllabus contains two separate sections, one for Higher Level and one for Ordinary Level, and incorporates the components pure physics, applications of physics and physics issues of concern to citizens. Pure physics which includes principles, procedures and physics concepts has a 70% weighting, while the remaining 30% is allocated to the other two components. The Higher Level syllabus contains two options which are not on the Ordinary Level syllabus.

1.2 Candidature

Table 1 shows the number of candidates sitting Leaving Certificate Physics in the period 2005-2008.

Year	LC candidates	Taking Physics	Physics candidates	Ordinary Level Candidates	%	Higher Level Candidates	%
2005	54069	14.7%	7944	2436	30.7%	5508	69.3%
2006	50995	14.4%	7335	2134	29.1%	5201	70.9%
2007	50873	14.3%	7251	2028	28.0%	5223	72.0%
2008	**52143**	**13.6%**	**7112**	**2183**	**30.7%**	**4929**	**69.3%**

Table 1: Numbers of Leaving Certificate Physics candidates 2005-2008

2. Ordinary Level

2.1 Introduction

Physics at Ordinary Level is assessed by means of a terminal written examination of three hours duration, marked out of 400 marks.

The paper is divided into two sections – A and B.

- Section A (30%) assesses the experiments listed in the syllabus that are required to be completed by the candidates during their course of study – three questions are to be answered from four given questions (40 marks each).
- Section B (70%) assesses the general syllabus content, including practical work – five questions are to be answered from eight given questions (56 marks each).
- Question 5 consists of ten short items, of which eight items are to be answered.
- Question 12 consists of four parts, of which two parts are to be answered.
- There are no options at Ordinary Level.
- There is no compulsory question on either examination paper.
- Appropriate formulae and data are provided in the relevant questions.

2.2 Performance of Candidates

Table 2 shows the percentages of candidates achieving each grade in the Ordinary Level Physics examination in the period 2005-2008.

Year	Total	A	B	C	ABC	D	E	F	NG	EFNG
2005	2436	17.7	30.0	22.9	70.6	18.1	6.3	3.9	1.2	11.4
2006	2134	13.8	31.9	26.8	72.5	18.2	5.5	3.3	0.5	9.3
2007	2028	13.5	30.3	29.1	72.9	17.3	5.2	3.4	1.1	9.7
2008	**2183**	**15.5**	**31.8**	**26.5**	**73.8**	**17.6**	**6.0**	**2.1**	**0.6**	**8.7**

Table 2: Percentage of candidates achieving each grade in Ordinary Level Physics 2005-2008

Table 3 shows the average percentage mark per question and the response rate in individual questions. The response rate is given as the percentage of candidates attempting each question in each section. . Data in Table 3 are based on a random sample of 240 scripts, approximately 11% of the total Ordinary Level cohort.

Section	Question	Topic	Average % mark	Rank order	Response rate (%)	Rank order
A	1	acceleration	77	1	99	1
	2	speed of sound	48	4	44	4
	3	refractive index	68	2	70	3
	4	diode	67	3	80	2
B	5	general	72	2	99	1
	6	gravitation	56	4	55	6
	7	temperature	56	4	87	3
	8	sound	54	7	72	5
	9	current electricity	55	6	42	7
	10	atomic structure	51	8	29	8
	11	renewable energy	82	1	96	2
	12	general	57	3	77	4

Table 3: Performance of candidates and response rates in Ordinary Level Physics 2008

- At Ordinary Level, most candidates answered the required three out of four questions in Section A, and five out of eight questions in Section B.
- At Ordinary Level, 47% of all candidates attempted more than the required number of questions, while 66 % of the candidates awarded A grades attempted more than the required number of questions.

2.3 Analysis of Candidate Performance

- Examiners noted that the standard of answering was higher in 2008 than in previous years and candidates generally wrote more detailed responses.
- Graphing, experimental work and STS applications appeared to be the candidates' strongest areas, while calculations and relevant units were their weakest.
- There was an increase in the number of candidates using data logging techniques.
- 57% of candidates who achieved an E, F or NG attempted less than the required number of questions.

Section A

Section A was the best answered section and Question 1 was both the most popular and best answered question.

Question 1 **Average mark 77%** **Response rate 99%**

A student carried out an experiment to find the acceleration of a moving trolley. The student measured the velocity of the trolley at different times and plotted a graph which was then used to find its acceleration. The table shows the data recorded…

- Describe, with the aid of a diagram, how the student measured the velocity of the trolley.

  The diagram was well answered. The methods used to measure the velocity of the trolley varied with ticker timer, photogate and data logging methods, in that order, being the most popular. In general, candidates' descriptions were poor as many only described the experiment set-up and failed to mention how the data was taken or used. Some candidates confused velocity and acceleration.

- Using the data in the table, draw a graph on graph paper of the trolley's velocity against time. Put time on the horizontal axis (X-axis).

  The graph was very well drawn and many candidates got full marks.

- Find the slope of your graph and hence determine the acceleration of the trolley.

  Well answered. Common errors in getting the slope included: using the inverse slope equation $\frac{x_2 - x_1}{y_2 - y_1}$ or using (0, 0) as a point for the slope.

Question 2 **Average mark 48%** **Response rate 44%**

You carried out an experiment to find the speed of sound in air, in which you measured the frequency and the wavelength of a sound wave.

- With the aid of a diagram describe the adjustments you carried out during the experiment.

  The diagram and the adjustments were well answered.

- How did you find the frequency of the sound wave?

  This was well answered by some candidates.

- How did you measure the wavelength of the sound wave?

  This was poorly answered in general. The length of the column of air was often taken to be the wavelength. A common error was to confuse the sonometer experiment with the speed of sound experiment.

- How did you calculate the speed of sound in air?

  This was poorly answered. Some candidates used the formula $v = \frac{d}{t}$ instead of $c = f\lambda$.

- Give one precaution you took to get an accurate result.

  This was reasonably well answered by most candidates.

Question 3 **Average mark 68%** **Response rate 70%**

An experiment was carried out to measure the refractive index of a substance.

The experiment was repeated a number of times.

- Draw a labelled diagram of the apparatus that could be used in this experiment.

  Well answered. Most candidates who attempted the question found the refractive index of glass using $n = \frac{\sin i}{\sin r}$, and only a small number of candidates used the apparent/real depth experiment. Other candidates confused the experiment with a demonstration of refraction experiment.

- What measurements were taken during the experiment?

  This was well answered.

- How was the refractive index of the substance calculated?

  This was well answered. Some candidates did not know a formula for refractive index.

- Why was the experiment repeated?

  This was reasonably well answered.

Question 4 **Average mark 67%** **Response rate 80%**

The diagram shows a circuit used to investigate the variation of current with potential difference for a semiconductor diode in forward bias.

- Name the apparatus X. What does it measure?

  This was well answered. Some candidates mixed up the labelling X and Y.

- Name the apparatus Y. What does it do?

  This was well answered. Common errors included stating that Y was a fuse, a semiconductor or a resistor.

- What is the function of the 330 Ω resistor in this circuit?

  This was poorly answered. The function of the 330 Ω resistor was often vaguely stated and was sometimes confused with that of a fuse.

- Using the data in the table, draw a graph on graph paper of the current against the potential difference. Put potential difference on the horizontal axis (X-axis).

  The graph was usually well drawn. Common errors were using incorrect scales and drawing the graph through the origin.

- What does the graph tell you about the variation of current with potential difference for a semiconductor diode?

  Many candidates had difficulty interpreting the graph. It was often misread or not explained properly.

Section B

Question 5 **Average mark 72%** **Response rate 99%**

(*a*) State the principle of conservation of momentum.

This was well answered.

(*b*) A solid block in the shape of a cube of length 120 cm rests on a table. The weight of the block is 25 N. Calculate the pressure it exerts on the table.

This was poorly answered. Candidates had difficulties with the calculations. A common error was to find the volume of the block instead of its area.

(*c*) Which of the following is the unit of energy?

kelvin **watt** **newton** **joule**

This was well answered.

(*d*) What physical quantity is measured in decibels?

This was well answered.

(*e*) A concave lens has a power of 0.1 cm^{-1}. What is the focal length of the lens?

This was well answered. Some candidates had difficulties with the calculation.

(*f*) Give one effect of static electricity?

This was well answered.

(*g*) Give two uses for the instrument shown.

This was well answered.

(*h*) What is the colour of the live wire in an electric cable?

This was well answered. A common error was giving the colour of the live wire as blue.

(*i*) State two properties of X-rays.

This was poorly answered. A common error was to give uses of X-rays instead of their properties.

(*j*) What is nuclear fusion?

This was poorly answered. The answer was often incomplete or confused with fission.

Question 6 **Average mark 56%** **Response rate 55%**

The weight of an object is due to the gravitational force acting on it. Newton investigated the factors which affect this force.

- Define force and give the unit of force.

  The definition was poorly answered. Most candidates knew the unit.

- State Newton's law of universal gravitation.

  This was poorly answered.

- Calculate the acceleration due to gravity on the moon.
  The radius of the moon is 1.7×10^6 m and the mass of the moon is 7×10^{22} kg.

  This was reasonably well answered. Most candidates made a good attempt at calculation *g* on the moon, substituting correctly into the given equation, but some candidates were unable to complete the calculation.

A lunar buggy designed to travel on the surface of the moon had a mass of 2000 kg when built on the earth.

- What is the weight of the buggy on earth?

  This was reasonably well answered.

- What is the mass of the buggy on the moon?

  This was poorly answered. Many candidates did not realise that the mass on the moon was the same as on earth and tried to calculate it.

- What is the weight of the buggy on the moon?

  This was poorly answered.

- A powerful rocket is required to leave the surface of the earth. A less powerful rocket is required to leave the surface of the moon. Explain why.

  This was well answered. Some candidates gave 'no gravity' on the moon as the reason.

Question 7 **Average mark 56%** **Response rate 87%**

The temperature of an object is measured using a thermometer, which is based on the variation of its thermometric property.

- What is meant by temperature?

  This was poorly answered.

- What is the unit of temperature?

  This was well answered.

- Give an example of a thermometric property.

  This was poorly answered.

The rise in temperature of an object depends on the amount of heat transferred to it and on its specific heat capacity.

- What is heat?

  This was reasonably well answered. Many candidates showed a misunderstanding between heat and temperature in their definitions. Some candidates defined heat as a rise in temperature.

- Name three ways in which heat can be transferred.

  This was very well answered.

- Define specific heat capacity.

  This was poorly answered and specific heat capacity was often confused with latent heat.

A saucepan containing 500 g of water at a temperature of 20 °C is left on a 2 kW ring of an electric cooker until it reaches a temperature of 100 °C. All the electrical energy supplied is used to heat the water.

- Calculate the rise in temperature of the water;

  This was well answered.

- Calculate the energy required to heat the water to 100 °C;

  This was poorly answered.

- Calculate the amount of energy the ring supplies every second;

  This was poorly answered.

- Calculate the time it will take to heat the water to 100 °C.

  This was poorly answered.

Question 8 **Average mark 54%** **Response rate 72%**

The diagram shows a signal generator connected to two loudspeakers emitting the same note.
A person walks slowly along the line AB.

- What will the person notice?

  This was reasonably well answered. Some candidates mentioned that the volume decreased as one went further from the speakers.

- Why does this effect occur?

  This was reasonably well answered.

- What does this tell us about sound?

  This was reasonably well answered.

- Describe an experiment to demonstrate that sound requires a medium to travel.

  This was well answered. Most candidates described the bell in a bell jar method.

The pitch of a note emitted by the siren of a fast moving ambulance appears to change as it passes a stationary observer.

- Name this phenomenon.

  This was well answered.

- Explain how this phenomenon occurs.

  This was poorly answered and many candidates had difficulty in explaining it.

- Give an application of this phenomenon.

  This was poorly answered. Few candidates gave an application – many gave examples instead
  e.g. a siren.

Question 9 **Average mark 55%** **Response rate 42%**

An electric current flows in a conductor when there is a potential difference between its ends.

- What is an electric current?

  This was well answered.

- Give two effects of an electric current.

  This was poorly answered.

- Name a source of potential difference.

  This was poorly answered.

- Describe an experiment to investigate if a substance is a conductor or an insulator.

  This was well answered.

The two headlights of a truck are connected in parallel to a 24 V supply.

- Draw a circuit diagram to show how the headlights are connected to the supply.

  This was poorly answered. A common mistake was having the bulbs in series.

- What is the advantage of connecting them in parallel?

  This was poorly answered.

- Why should a fuse be included in such a circuit?

  This was well answered.

- The resistance of each headlight is 20 Ω. Calculate the total resistance in the circuit.

  This was poorly answered. Some candidates did not use the given formula and others were not able to manipulate reciprocals.

- Calculate the current flowing in the circuit.

  This was poorly answered and was rarely correct.

Question 10 **Average mark 51%** **Response rate 29%**

- Give two properties of an electron.

  This was well answered.

The diagram shows the arrangement used by Rutherford to investigate the structure of the atom. During the investigation he fired alpha-particles at a thin sheet of gold foil in a vacuum.

- What are alpha-particles?

  This was poorly answered. Candidates did not state what alpha-particles were. Some candidates stated that they were radiation, others mixed up alpha-particles with electrons, protons and atoms.

- Describe what happened to the alpha-particles during the experiment.

  This was well answered.

- What conclusion did Rutherford make about the structure of the atom?

  This was poorly answered.

- How are the electrons arranged in the atom?

  This was poorly answered.

- Name a device used to detect alpha-particles.

  This was poorly answered. A common error was to name the gold leaf electroscope as a device to detect alpha-particles.

- Why was it necessary to carry out this experiment in a vacuum?

  This was poorly answered.

Question 11 **Average mark 82%** **Response rate 96%**

(*a*) State two uses of energy in the home.

This was well answered.

(*b*) Give two ways to reduce energy needs in the home.

This was well answered. A common error was to state that using more renewable energy is a way to reduce energy consumption.

(*c*) List the main sources of renewable energy.

This was well answered.

(*d*) What are the main parts of a solar heating system?

This was well answered.

(*e*) Why does a solar panel need to face south?

This was well answered.

(*f*) What is the function of the backup heater?

This was well answered.

(g) Why are parts of the solar panel painted black?

This was reasonably well answered. Some candidates stated that black 'attracted' heat or 'conducted' heat.

(h) What is the name given to the tendency of water to circulate as it is heated?

This was reasonably well answered. Many candidates gave 'circulation' instead of 'convection'.

Question 12 (overall) **Average mark 57%** **Response rate 77%**

Table 4 shows the average percentage mark and the response rate for each part in Question 12.

Part	Average mark (%)	Rank order	Response rate (%)	Rank order
(*a*)	69	1	56	1
(*b*)	47	4	47	2
(*c*)	67	2	10	4
(*d*)	59	3	34	3

Table 4: Performance of candidates and response rates in Question 12, Ordinary Level Physics

Part (*a*) **Average mark 69%** **Response rate 56%**

- Define (i) velocity, (ii) acceleration.

  This was reasonably well answered; however many candidates had errors in their definitions.

A speedboat starts from rest and reaches a velocity of 20 m s^{-1} in 10 seconds. It continues at this velocity for a further 5 seconds. The speedboat then comes to a stop in the next 4 seconds.

- Draw a velocity-time graph to show the variation of velocity of the boat during its journey.

  This was well answered.

- Use your graph to estimate the velocity of the speedboat after 6 seconds.

  This was well answered.

- Calculate the acceleration of the boat during the first 10 seconds.

  This was poorly answered.

- What was the distance travelled by the boat when it was moving at a constant velocity?

  This was poorly answered. Many candidates used the incorrect time.

Part (*b*) **Average mark 47%** **Response rate 47%**

Sunlight is made up of different colours and invisible radiations.

- How would you show the presence of the different colours in light?

  This was reasonably well answered. Many candidates did not give enough detail, and merely stated 'use a prism'.

- Name two radiations in sunlight that the eye cannot detect.

  This was poorly answered. A common error was to give X-rays and gamma rays.

- Describe how to detect one of these radiations.

  This was poorly answered. Many of the descriptions were vague and lacked sufficient detail.

- Give a use for this radiation.

  This was reasonably well answered. The use was usually consistent with the radiation named above e.g. gamma rays are used for cancer treatment.

Part (*c*) **Average mark 67%** **Response rate 10%**

- What is the photoelectric effect?

  This was reasonably well answered.

A photocell is connected to a sensitive galvanometer as shown in the diagram. When light from the torch falls on the photocell, a current is detected by the galvanometer.

- Name the parts of the photocell labelled **A** and **B**.

  This was well answered. A common error was to name the parts as a battery and capacitor.

- How can you vary the brightness of the light falling on the photocell?

  This was well answered.

- How does the brightness of the light effect the current?

  This was poorly answered.

- Give a use for a photocell.

  This was poorly answered.

Part (*d*) **Average mark 59%** **Response rate 34%**

- What is electromagnetic induction?

  This was poorly answered.

- A magnet and a coil can be used to produce electricity. How would you demonstrate this?

  This was well answered.

- The electricity produced is a.c. What is meant by a.c.?

  This was very well answered.

2.4 Conclusions

- Examiners noted that many candidates attempted extra questions.
- Candidates demonstrated a good knowledge of the experiments listed in the syllabus. Most candidates scored well in Section A, but the responses of some candidates lacked sufficient detail and many gave vague or incorrect descriptions of the experiments.
- Definitions and laws were answered satisfactorily. While candidates seemed to know the laws, their understanding of applications of the laws was less developed.
- Candidates scored reasonably well in the Science, Technology and Society (STS) aspects of the paper but some candidates did not give applications when required. Examiners noted that the full STS question seemed to be an attractive question for candidates.
- Diagrams were generally used to support written answers, where appropriate. The diagrams were usually well drawn and labeled.
- Units of measurement were sometimes omitted or incorrect.
- Where candidates did poorly, there were three major causes: not answering enough questions, not displaying a clear understanding of physics; and not calculating correctly.
- There was a tendency for candidates to avoid questions on electricity.
- Candidates who performed well showed clear comprehension of:
  - knowledge of the fundamental principles of physics
  - applications of physics to everyday life and technology
  - knowledge, derivation and application of formulae
  - logical thought and problem solving
  - mandatory and demonstration experiments
  - factual items
  - definitions
  - graphing skills.

2.5 Recommendations to Teachers and Students

Recommendations to teachers:

- Teachers should encourage their students to understand the principles of physics using a variety of techniques. These could include, for example:
  - in interactive ways such as using ICT
  - spending more time on the electricity section
  - placing a greater emphasis on practical work
  - linking classroom physics with its applications in everyday life
- Encourage students to engage in physics through experiments and demonstrations. This would further develop students' understanding of scientific method, data handling and presentation of results.
- Provide opportunities for students to experience a wide variety of practical and relevant situations in which they can apply their knowledge of the principles and concepts of physics.
- Encourage students to integrate their knowledge of physics with everyday experiences to enhance their understanding of the STS aspect of the syllabus.

Recommendations to students:

- Students should study all sections of the syllabus and attempt the required number of questions in the examination.
- Students should express their understanding of physics concepts in language that is clear, concise and correct.
- Students should elaborate more in their answers. Examiners have noted a tendency on the part of some candidates to give a minimum of detail in their answers.

3. Higher Level

3.1 Introduction

Physics at Higher Level is assessed by means of a terminal written examination of three hours duration, marked out of 400 marks.

The paper is divided into two sections – A and B.

- Section A (30%) assesses the experiments listed in the syllabus that are required to be completed by the candidates during their course of study. Candidates are required to answer three questions from four given questions (40 marks each).
- Section B (70%) assesses the general syllabus content, including practical work. Candidates are required to answer five questions from eight given questions (56 marks each).
- Question 5 consists of ten short items, of which eight items are to be answered.
- Question 12 consists of four parts, of which two parts are to be answered.
- At Higher Level in 2008, Question 10 examined the two options in the syllabus – Applied Electricity and Particle Physics.
- There is no compulsory question on the examination paper.
- Appropriate data are provided in the relevant questions on the Higher Level paper.

3.2 Performance of Candidates

Table 5 shows the percentages of candidates achieving each grade in the Higher Level Physics examination in the period 2005-2008.

Year	Total	A	B	C	ABC	D	E	F	NG	EFNG
2005	5508	20.4	28.3	22.9	71.6	19.5	5.8	2.6	0.4	8.8
2006	5201	19.6	27.4	23.6	70.6	22.4	5.2	1.7	0.2	7.1
2007	5223	21.6	24.8	26.0	72.4	20.4	5.3	1.8	0.3	7.4
2008	**4929**	**19.9**	**26.5**	**24.4**	**70.8**	**20.6**	**6.2**	**2.0**	**0.4**	**8.6**

Table 5: Percentage of candidates achieving each grade in Higher Level Physics 2005-2008

Table 6 shows the average percentage mark per question and the response rate in individual questions. The response rate is given as the percentage of candidates attempting each question in each section. Data in Table 6 are based on a random sample of 680 scripts, which equates to approximately 14% of the total Higher Level cohort.

Section	**Question**	**Topic**	**average % mark**	**rank order**	**response rate (%)**	**rank order**
A	1	simple pendulum	53.8	4	77.1	3
	2	specific latent heat	57.5	3	94.3	1
	3	wavelength of light	59.0	2	78.2	2
	4	resistance	68.3	1	63.8	4
B	5	general	58.4	1	93.8	1
	6	space station	44.5	5	66.9	4
	7	electric toaster	52.0	2	68.3	3
	8	electromagnetism	42.9	8	37.2	8
	9	The eye	43.6	7	61.9	5
	*10 (*a*)	particle physics	44.3	6	61.3	6
	*10 (*b*)	transistor	31.3	9	2.0	9
	11	Einstein	50.7	3	75.8	2
	12	general	46.8	4	59.4	7

Table 6: Performance of candidates and response rates in Higher Level Physics 2008
* Question 10 had an internal choice between (*a*) and (*b*).

- In Section A, 15% of the candidates answered an additional question. About 3% of candidates did not answer the required number of questions.
- In section B, 50% of the candidates attempted an additional question and 3% did not answer the required number of questions.

3.3 Analysis of Candidate Performance

Section A

- The most popular question was Question 2, followed by Question 1 and Question 3 which shared almost equal popularity. Question 4 was the least popular in this section but had the highest average mark awarded, 68.3%.
- The experiments were generally well-known and the appropriate apparatus, techniques and precautions were included.
- Examiners noted that there was some indication that not all candidates had practical experience of the simple pendulum experiment in Question 1 and of measuring the wavelength of light in Question 3. An explanation of how the first order images were identified in Question 3 proved difficult for a significant number of candidates.
- Candidates displayed a good knowledge of graphing techniques and consequently scored highly. A minority chose wrong scales which made plotting of points and calculation of slope difficult.
- There was very little reference to data logging techniques.

Question 1 **Average mark 54%** **Response rate 77%**

A student investigated the relationship between the period and the length of a simple pendulum. The student measured the length *l* of the pendulum. The pendulum was then allowed to swing through a small angle and the time *t* for 30 oscillations was measured.

This procedure was repeated for different values of the length of the pendulum.

The student recorded the following data...

- Why did the student measure the time for 30 oscillations instead of measuring the time for one?

  This was very well answered. Common answers included ‘average’ and ‘more accurate’.

- How did the student ensure that the length of the pendulum remained constant when the pendulum was swinging?

  This was well answered, with ‘split cork’ being most popular. Occasionally, answers were vague and included responses such as ‘heavy bob’, ‘angle less than 5^{o}’.

- Using the recorded data draw a suitable graph to show the relationship between the period and the length of a simple pendulum.

This was well answered, but the relationship investigated was not always the correct one and graphs were drawn using a number of combinations, e.g. *l* versus *T*. A common error involved not dividing by 30 (oscillations).

- What is this relationship?

  This was well answered when the correct graph was drawn.

- Use your graph to calculate the acceleration due to gravity.

  The method for obtaining value for the slope was satisfactory but the subsequent application of the slope value to the correct formula proved difficult for many candidates. Some candidates confused the formula with the 'free-fall method'.

Question 2 **Average mark 58%** **Response rate 94%**

In an experiment to measure the specific latent heat of fusion of ice, warm water was placed in a copper calorimeter. Dried, melting ice was added to the warm water and the following data was recorded…

- Explain why warm water was used.

  This was well answered. Some candidates gave somewhat vague answers with reference made to 'energy balance'.

- Why was dried, melting ice used?

  The use of 'dried ice' was adequately explained but a significant number of candidates omitted an explanation for the 'melting ice'.

- Describe how the mass of the ice was found.

  This was well answered by most candidates. A minority of candidates suggested the direct weighing of the ice.

- What should be the approximate room temperature to minimise experimental error?

  This was poorly answered. Many candidates' answers were based on guesswork. A lack of clear understanding was apparent and a common answer was 15 ^{o}C, halfway between 0 ^{o}C and 30 ^{o}C. Other candidates suggested 22 ^{o}C or 23 ^{o}C as their room temperature.

- Calculate the energy lost by the calorimeter and the warm water.

This was well answered. Many candidates did not give a direct answer to this question but proceeded to get the final answer as required in (ii). Incorrect units were common.

- Calculate the specific latent heat of fusion of ice.

  This was well answered. Occasionally, $(mc\Delta\theta)_{ice}$ was omitted and $\Delta\theta = 20.3\ ^{o}C$ was used.

Question 3 **Average mark 59%** **Response rate 78%**

In an experiment to measure the wavelength of monochromatic light, a diffraction pattern was produced using a diffraction grating with 500 lines per mm. The angle between the first order images was measured. This was repeated for the second and the third order images.
The table shows the recorded data…

- Draw a labelled diagram of the apparatus used in the experiment.

  This was well answered. The spectrometer method was far more popular than the laser method. Common errors involved labelling the light source as a ray box and omitting the grating.

- Explain how the first order images were identified.

  Many candidates had difficulty in expressing their answer.

- Describe how the angle between the first order images was measured.

  Examiners noted that responses to this item were rather vague. Many candidates assumed that the scale read zero at the straight through position. Many measured θ rather than 2θ.

- Use the data to calculate the wavelength of the monochromatic light.

  The formula was well known. A common error involved the use of 2θ rather than the correct value of θ.

Question 4 **Average mark 68%** **Response rate 64%**

A student investigated the variation of the resistance R of a metallic conductor with its temperature θ. The student recorded the following data…

- Describe, with the aid of a labelled diagram, how the data was obtained.

  This was generally well answered. A minority of candidates confused the experiment with Ohm's law or Joule's laws. Other candidates included a battery in series with the ohmmeter.

- Draw a suitable graph to show the relationship between the resistance of the metal conductor and its temperature.

  This was well done by the majority of candidates, with many achieving full marks.

- Estimate the resistance of the metal conductor at a temperature of –20 ^{o}C

  This was well answered. Many candidates drew a second graph in order to include negative values and extrapolated correctly.

- Estimate the change in resistance for a temperature increase of 80 oC

  This was reasonably well answered. A minority of candidates gave the R value at 160 ^{o}C.
  A significant number of candidates gave an answer with no evidence of using graph.

- Explain why the relationship between the resistance of a metallic conductor and its temperature is linear.

  The vast majority of candidates made a successful attempt at this item.

Section B

- Question 5 examined topics covering the entire syllabus and scored the highest average mark (58.4%) in this section and proved to be the most popular with a response rate of 93.8%.
- Question 10(*b*) had the lowest average mark (31.3%) and was also the least popular question, with a response rate of 2.0%.

Question 5 **Average mark 58%** **Response rate 94%**

(*a*) State the law of flotation.

This was generally well answered. Common errors included the use of mass instead of weight and stating Archimedes' Principle.

(*b*) The head of a thumbtack has an area of 500 mm^2. Its point has an area of 0.3 mm^2. The pressure exerted at the head of the thumbtack is 12 Pa. What is the pressure exerted at the point of the thumbtack?

This was well answered. Some candidates had difficulties with the units.

(*c*) What is the relationship between the frequency of a vibrating stretched string and its length?

This was well answered with many candidates giving extended answers.

(*d*) Why does diffraction **not** occur when light passes through a window?

This was often poorly answered. Typically, the definition of diffraction was given without relating it to the window. Some candidates confused diffraction with refraction.

(*e*) Why is a fluorescent tube an efficient source of light?

This was well answered with most candidates contrasting it to the filament lamp. Some candidates did not know what a fluorescent tube was.

(*f*) What is the force exerted on an electron when it is in an electric field of strength 5 N C^{-1}?

The formula was well known and the majority of candidates achieved full marks.

(*g*) What are the charge carriers when an electric current (i) passes through a semiconductor; (ii) passes through an electrolyte?

This was poorly answered with many candidates giving electrons only for the semiconductor.
Many candidates incorrectly associated electrons with an electrolyte and not ions.

(*h*) Give two ways of deflecting a beam of electrons.

Most candidates gave at least one. Many candidates gave 'charged plates'.

(*i*) Name an instrument used to detect radioactivity.
What is the principle of operation of this instrument?

Most candidates gave the GM tube and most also gave ionisation as the principle of operation.

(*j*) The existence of the neutrino was proposed in 1930 but it was not detected until 1956. Give two reasons why it is difficult to detect a neutrino.

This was well answered. Most candidates gave 'uncharged and very small mass'.

or

Draw a diagram to show how a galvanometer can be converted into a voltmeter.

This was very rarely attempted.

Question 6 **Average mark 45%** **Response rate 67%**

- State Newton's law of universal gravitation.

  This was well answered. Formula plus notation were commonly given.

- The international space station (ISS) moves in a orbit around the equator at a height of 400 km. What type of force is required to keep the ISS in orbit?

  This was well answered.

- What is the direction of this force?

  This was well answered.

- Calculate the acceleration due to gravity at a point 400 km above the surface of the earth.

  General procedure was correct, but a common error was the omission of the 400 km.

- An astronaut in the ISS appears weightless. Explain why.

  This was poorly answered with many candidates stating incorrectly that there was little or no force of gravity.

- Derive the relationship between the period of the ISS, the radius of its orbit and the mass of the earth.

  This was well answered, and most candidates obtained full marks.

- Calculate the period of an orbit of the ISS.

  Many candidates failed to get the correct final answer due to errors with T^2, R^3 and 400 km.

- After an orbit, the ISS will be above a different point on the earth's surface. Explain why.

  This was poorly answered with a majority of candidates incorrectly giving 'different speeds'.

- How many times does an astronaut on the ISS see the sun rise in a 24 hour period?

  Many candidates who correctly evaluated the period did not subsequently link it to the number of sunrises observed.

Question 7 **Average mark 52%** **Response rate 68%**

- Define resistivity and give its unit of measurement.

  This was reasonably well answered. Formula and notation were frequently given. The unit of measurement was often given incorrectly as 'ohm per metre'.

- An electric toaster heats bread by convection and radiation. What is the difference between convection and radiation as a means of heat transfer?

  Most candidates give the definitions for convection and radiation, rather than giving a specific difference.

A toaster has a power rating of 1050 W when it is connected to the mains supply. Its heating coil is made of nichrome and it has a resistance of 12 Ω. The coil is 40 m long and it has a circular cross-section of diameter 2.2 mm.

- Calculate the resistivity of nichrome;

  This was well answered. Errors arose due to problems with units, calculation of area, and the use of diameter instead of radius.

- Calculate the heat generated by the toaster in 2 minutes if it has an efficiency of 96%.

  This was well answered.

- The toaster has exposed metal parts. How is the risk of electrocution minimised?

  This was well answered with the majority of candidates giving 'earthing'. Some candidates made reference to insulation and to fuses.

- When the toaster is on, the coil emits red light. Explain, in terms of movement of electrons, why light is emitted when a metal is heated.

  This was poorly answered. Many candidates introduced the concept of thermionic emission. Others gave rather vague answers such as 'the increased K.E of electrons created friction which increased resistance which in turn produced heat'.

Question 8 **Average mark 43%** **Response rate 37%**

- What is electromagnetic induction?

  This was not well answered even by candidates who knew the two laws. Common errors included use of current rather than emf and the omission of a coil/conductor.

- State the laws of electromagnetic induction.

  Laws were well known and accurately stated. A minority of candidates omitted reference to direction in Lenz's law.

A bar magnet is attached to a string and allowed to swing as shown in the diagram. A copper sheet is then placed underneath the magnet.

- Explain why the amplitude of the swings decreases rapidly.

  This was very poorly answered. Some candidates claimed that copper was magnetic. Few candidates mentioned induced currents or generation of a magnetic field.

- What is the main energy conversion that takes place as the magnet slows down?

  This was poorly answered with most candidates stating 'kinetic to potential energy'. A few candidates referred to 'magnetic energy'.

A metal loop of wire in the shape of a square of side 5 cm enters a magnetic field of flux density 8 T. The loop is perpendicular to the field and is travelling at a speed of 5 m s^{-1}.

- How long does it take the loop to completely enter the field?

  This was well answered.

- What is the magnetic flux cutting the loop when it is completely in the magnetic field?

  This was well answered.

- What is the average emf induced in the loop as it enters the magnetic field?

  This was well answered.

Question 9 **Average mark 44%** **Response rate 62%**

- What is meant by refraction of light?

  This was well answered.

- State Snell's law of refraction.

  This was fairly well answered. Many candidates simply gave formula but omitted the notation.

An eye contains a lens system and a retina, which is 2.0 cm from the lens system. The lens system consists of the cornea, which acts as a fixed lens of power 38 m^{-1}, and a variable internal lens just behind the cornea. The maximum power of the eye is 64 m^{-1}.

- Calculate how near an object can be placed in front of the eye and still be in focus;

  This was poorly answered. A significant number of candidates obtained the f value for maximum power and did not proceed.

- Calculate the maximum power of the internal lens.

  This was well answered.

- Light is refracted as it enters the cornea from air as shown in the diagram. Calculate the refractive index of the cornea.

  This was very well answered.

- Draw a diagram to show the path of a ray of light as it passes from water of refractive index 1.33 into the cornea.

  This was poorly answered. Having obtained a correct value for n, many candidates still drew a diagram showing a pronounced refraction.

A swimmer cannot see properly when she opens her eyes underwater. When underwater:

- Why does the cornea not act as a lens?

  Few candidates gained full marks.

- What is the maximum power of the eye?

  This was well answered.

- Why do objects appear blurred?

  This was poorly answered and candidate responses were vague.

- Explain how wearing goggles allows objects to be seen clearly.

  This was poorly answered. A number of candidates stated that the goggles functioned as a lens.

Question 10 (a) **Average mark 44%** **Response rate 61%**

Baryons and mesons are made up of quarks and experience the four fundamental forces of nature.

- List the four fundamental forces and state the range of each one.

  This was well answered. A minority of candidates gave incorrect ranges.

- Name the three positively charged quarks.

  This was well answered. 'Strange' was sometimes given instead of 'charm'.

- What is the difference in the quark composition of a baryon and a meson?

  This was well answered.

- What is the quark composition of the proton?

  This was very well answered.

In a circular accelerator, two protons, each with a kinetic energy of 1 GeV, travelling in opposite directions, collide. After the collision two protons and three pions are emitted.

- What is the net charge of the three pions? Justify your answer.

  Responses were generally fair. A variety of incorrect answers given, e.g. +2, '3 times the charge of a proton',

  'Justify your answer' was poorly answered due to earlier incorrect responses.

- Calculate the combined kinetic energy of the particles after the collision;

  This was poorly answered with many candidates using $E = ½\, mv^2$ rather than $E = mc^2$.

- Calculate the maximum number of pions that could have been created during the collision.

  Due to the knock-on effect of part (i), this item was often poorly answered. Many candidates confused mass with energy and joule with the electron volt.

Question 10 (*b*) **Average mark 31%** **Response rate 2%**

The transistor was one of the most important inventions of the twentieth century.

- Draw the basic structure of a bi-polar transistor.

  This was well answered.

- Name the three currents flowing in a transistor. State the relationship between them.

  This was well answered.

The diagram shows the circuit of a voltage amplifier.

- What is the purpose of the bias resistor?

  This was poorly answered. Many candidates experienced difficulty in stating the purpose. Some candidates claimed that it had a protective function.

- What is the purpose of the load resistor?

  This was frequently incorrect and responses were poorly phrased.

A varying voltage is applied to the amplifier.

- Draw a sketch of the input and output voltages, using the same axes and scales.

  This was well answered. Some candidates did not have the output voltage inverted.

A NOT gate is a voltage inverter.

- Draw a circuit diagram to show how a transistor can be used as a voltage inverter.

  Most candidates drew a variation of the given circuit diagram and scored highly.

- Give the truth table of a NOT gate.

  This was very well answered.

Question 11 **Average mark 51%** **Response rate 76%**

- The SI unit [of temperature] is named in honour of Lord Kelvin.
  What is the temperature of the boiling point of water in kelvin?

  This was well answered.

- Define the newton, the unit of force.

  This was reasonably well answered. Common errors included: formula without notation, acceleration as m s^{-1}.

- A force of 9 kN is applied to a golf ball by a golf club. The ball and club are in contact for 0.6 ms. Using Newton's laws of motion, calculate the change in momentum of the ball.

  This was reasonably well answered. Units given were often incorrect.

- Name three different electromagnetic radiations.

  This was well answered. A common error by candidates was stating 'alpha, beta and gamma'.

- What is the photoelectric effect?

  This was very well answered. Many candidates omitted the word 'surface'.

- Why was the quantum theory of light revolutionary?

  Many candidates failed to adhere to light and used irrelevant material from the passage.

- High-energy radiation of frequency 3.3×10^{14} Hz is used in medicine.
  What is the energy of a photon of this radiation?

  This was well answered.

- 100 MJ of energy are released in a nuclear reaction. Calculate the loss of mass during the reaction.

  This was well answered. A minority of candidates failed to square the *c* value.

Question 12 (overall) **Average mark 47%** **Response rate 59%**

Table 7 shows the average percentage mark and the response rate for each part in Question 12.

Part	Average mark (%)	Rank order	Response rate (%)	Rank order
(*a*)	54.3	3	56.8	2
(*b*)	60.4	1	80.3	1
(*c*)	55.7	2	39.2	3
(*d*)	44.3	4	35.9	4

Table 7: Performance of candidates and response rates in Question 12, Higher Level Physics

In this question, 3% of candidates answered all four parts, while 18% attempted three parts and 2% attempted only one part.

Question 12 (*a*) **Average mark 54%** **Response rate 57%**

- State the principle of conservation of energy.

  This was very well answered.

In a pole-vaulting competition an athlete, whose centre of gravity is 1.1 m above the ground, sprints from rest and reaches a maximum velocity of 9.2 m s^{-1} after 3.0 seconds. He maintains this velocity for 2.0 seconds before jumping.

- Draw a velocity-time graph to illustrate the athlete's horizontal motion.

  This was very well answered and all candidates drew straight lines for the two stages.

- Use your graph to calculate the distance travelled by the athlete before jumping.

  This was well answered by those candidates who got the area under the curve. Other methods proved less successful with many candidates applying a formula for accelerated motion and treating the entire horizontal displacement of the athlete as a single phase.

- What is the maximum height above the ground that the athlete can raise his centre of gravity?

  This was reasonably well answered. Common errors included not incorporating the 1.1 m in the final answer. Some candidates subtracted the 1.1 m. Many candidates used the equations of motion but confused u and v and were inconsistent in assigning direction to the vectors involved.

Question 12 (*b*) **Average mark 60%** **Response rate 80%**

- On what does (i) the quality, (ii) the loudness, of a musical note depend?

  Both parts were well answered.

- What is the Doppler effect?

  This was generally well known, though a few candidates omitted reference to relative motion between the source and the observer.

A rally car travelling at 55 m s^{-1} approaches a stationary observer. As the car passes, its engine is emitting a note with a pitch of 1520 Hz.

- What is the change in pitch observed as the car moves away?

  Most candidates knew the correct formula, but some confusion arose when applying it to the given situation. Some candidates did not find the appropriate difference.

- Give an application of the Doppler effect.

  This was well answered and reference to 'speed traps' was the most common. Some candidates incorrectly mentioned sonar, sirens, ambulances, and many candidates gave an effect rather than an application.

Question 12 (*c*) **Average mark 56%** **Response rate 39%**

In 1939 Lise Meitner discovered that the uranium isotope U–238 undergoes fission when struck by a slow neutron. Barium–139 and krypton–97 nuclei are emitted along with three neutrons.

- Write a nuclear reaction to represent the reaction.

  This was reasonably well answered. Some candidates confused atomic numbers with mass numbers.

- In a nuclear fission reactor, neutrons are slowed down after being emitted.
  Why are the neutrons slowed down?

  Responses to this question were generally fair but some candidates gave vague answers.

- How are they slowed down?

  This was well answered. A common incorrect answer was 'use control rods'.

- Fission reactors are being suggested as a partial solution to Ireland's energy needs. Give one positive and one negative environmental impact of fission reactors.

  This was reasonably well answered. While candidates usually gave a correct negative impact, a positive environmental impact was often inappropriate – cheap, plentiful fuel, large quantities of energy, etc.

Question 12 (*d*) **Average mark 44%** **Response rate 36%**

- Define capacitance.

  This was well answered. Formula plus notation were frequently given.

- Describe how an electroscope can be charged by induction.

  This was fairly well answered with an equal mix between candidates using a purely descriptive approach and those using a correct sequence of diagrams.

  Errors encountered included reference to conduction rather than induction, and some confusion regarding the removal of the charged rod and the earth link.

- How would you demonstrate that the capacitance of a parallel plate capacitor depends on the distance between its plates?

  Examiners noted that candidates who used a multimeter method generally fared better than those who used an electroscope. Common errors involving the electroscope included incorrect arrangement of apparatus, and permanent connection of a H.T. source to the plates. Some candidates neglected to refer to the charging of the plates.

  Observation/conclusion of the demonstration was poorly stated.

  A minority of candidates attempted a theoretical approach by interpreting the appropriate formula.

3.4 Conclusions

- Many candidates attempted extra questions.
- Candidates showed a good knowledge of the experiments listed in the syllabus. Most candidates scored well in Section A, but the responses of a few candidates lacked sufficient detail. Some incorrect descriptions of the experiments were noted.
- Definitions and laws were answered satisfactorily. While candidates seemed to know the laws, their understanding of applications of the laws was sometimes poor.
- Candidates scored reasonably well in the Science, Technology and Society (STS) aspects of the paper but some candidates did not give applications when required. The full STS question seemed to be an attractive question for candidates, and candidates scored well on this question.
- Diagrams were generally used to support written answers, where appropriate. The diagrams were usually well drawn and labelled and candidates used them to complement their explanations/descriptions.
- Units of measurement were often omitted or incorrect.
- Very few candidates used data logging methods in section A.
- Where candidates did poorly, there were three major causes: not answering enough questions, not displaying a clear understanding of physics; and not calculating correctly.
- Examiners noted that candidates tended to avoid questions on electricity.
- A significant majority of candidates chose to answer the question on particle physics rather than the question on applied electricity.
- Candidates who performed well showed clear comprehension of:
  - knowledge of the fundamental principles of physics
  - applications of physics to everyday life and technology
  - knowledge, derivation and application of formulae
  - logical thought and problem solving
  - mandatory and demonstration experiments
  - factual items
  - definitions
  - graphing skills.

3.5 Recommendations to Teachers and Students

Recommendations to teachers:

- Teachers should encourage their students to understand the principles of physics using a variety of techniques. These could include, for example:
  - in interactive ways such as using ICT
  - spending more time on the electricity section
  - placing a greater emphasis on practical work
  - linking classroom physics with its applications in everyday life
- Encourage students to engage in physics through experiments and demonstrations. This would further develop students' understanding of scientific method, data handling and presentation of results.
- Provide opportunities for students to experience a wide variety of practical and relevant situations in which they can apply their knowledge of the principles and concepts of physics.
- Encourage students to integrate their knowledge of physics with everyday experiences to enhance their understanding of the STS aspect of the syllabus.

Recommendations to students:

- Students should study all sections of the syllabus and attempt the required number of questions in the examination.
- Students should express their understanding of physics concepts in language that is clear, concise and correct.
- Students should elaborate more in their answers. Examiners have noted a tendency on the part of some candidates to give a minimum of detail in their answers.