# A Level

## Physics

Session: 2000 June
Type: Report
Code: 9244

Oxford Cambridge and RSA Examinations

OCR

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A LEVEL

(former Cambridge linear syllabus)

A 9244

# PHYSICS



## REPORT ON COMPONENTS

TAKEN IN JUNE 2000

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# PHYSICS

## GCE Advanced Level 9244

## 9244 Physics Paper 2

### General Comments

Most candidates found the paper straightforward and consequently there were some high marks. Almost all candidates scored more than 30 marks and a majority of candidates scored in the range 50 to 70, with some good papers in the 80s. Candidates were usually able to attempt all the questions with only very few candidates missing out whole questions. The length of the paper was correct with almost all candidates finishing the paper in the allotted time. Candidates generally score well with numerical problems but they must be careful not to round off numerical answers too frequently. In some questions repeated rounding meant that final answers were a long way from the correct value. There is still a problem for some candidates in noticing whether or not their answers are sensible. Candidates should continually be on their guard for nonsensical answers such as the radius of aircraft circle approximately equal to the distance from the earth to the sun, or, in one case, about equal to the wavelength of light. This is really a matter of checking everything as it is done, rather than leaving the checking process to the end of question or to the end of the exam. The standard of English was generally at least adequate and often good.

### Comments on Individual Questions

### Question 1

Part (a) was well answered apart from a few candidates who did not make it clear which way round the ratios were. In part (b), whilst the algebra was usually successfully manipulated very few candidates adequately explained what they were doing. Candidates should have used the space on the paper for a sketch diagram showing the meaning of the terms they were using and then in their proof used some words of explanation. Too many answers were simply a list of equations. Some candidates introduced $A$ for area and $a$ for acceleration (which they later equated to $g$). Another variation was $M$ for mass and $m$ for length (later equated to $h$). Three marks were seldom awarded for part (c). This was frequently because candidates did not work from part (b) but simply quoted Archimedes principle. The commonest misconception was that the upthrust was always equal to the weight of the submerged body. A minority of candidates appeared to imagine that water was some sort of anti-gravity shield.

### Question 2

Many candidates scored full marks on this question but others, unsurprisingly, lost a large proportion of the marks by demonstrating a fundamental lack of understanding of the laws of potential difference and current. It was amazing how many candidates, having 12 V and 5A, used involved methods for finding the total resistance rather than simply dividing by 12/5.

*Answers* p.ds: 12V, 10V, 2V, 12V. Currents: 3A, 2A, 2A, 5A. Power: 36W, 20W, 4W, 60W. Resistances: 4Ω, 5Ω, 1Ω, 2.4Ω

**Question 3**

This question was generally well answered, although some candidates had problems with sines and cosines. A surprising proportion of candidates thought that the acceleration towards the centre was $mv^2/r$ and many candidates worked out the force the long way round rather than using $F = ma$.

*Answers:* (a) $3.92 \times 10^5$ N (b) $4.79 \times 10^5$ N (c) $2.74 \times 10^5$ N (d) 6.86 $ms^{-2}$ (e) 9110 m

**Question 4**

Most candidates grasped the idea of superposition in (a), though many of the results were odd. The answers in part (b) usually showed the right idea but the diagrams were often poor and candidates often did not take enough care to keep the wavelength constant. The calculations in part (c) were frequently correct and a fair proportion of candidates understood, in general terms, what was going on. In part (c)(iii) though, only a few correctly predicted the number of maxima.

*Answer*: (c)(i) 30.8

**Question 5**

The calculations in part (a) were generally correct, though some candidates had the turns ratio the wrong way round.
In part (b) it was common to read sensible statements considering the role of the diode, but the simple proposition that resistors limit current was rarely put forward explicitly, though there were a few sensible statements about the division of potential.

*Answers:* (a)(i) 9.2 V, (ii) 13.0 V

**Question 6**

Correct descriptions of the photoelectric effect – often unnecessarily detailed – were fairly common, though a number of candidates went to great lengths to avoid stating that the material emitting electrons was a metal. It was quite often believed that photons rather than electrons were emitted. In part (b), the second and third definitions were more commonly correct than the first. Candidates usually omitted to state that photons are electromagnetic in nature and / or that they carry energy. Those who had no idea about the rest of the question often gained credit for the calculation in part (c).

*Answer:* (c) $3.38 \times 10^{-19}$ J

**Question 7**

Almost everyone knew that glass was brittle, and most could explain why the graph indicated this. Calculations of the cross-sectional area frequently involved many different formulae. Powers of 10 were an additional problem.
The small-scale of the graph permitted a fairly wide range of justifiable pairs of values for force and extension – a few candidates, however, went beyond the elastic limit. The main error in the calculation was in forgetting to convert mm to m. Most forgot the calculation they had just made when asked to calculate the ultimate tensile stress. Most of those who did realise that they just needed the force and the area chose a small tensile force. Quite a high proportion of students made a reasonable attempt at estimating the work done, though many were out by a factor of $10^3$ because of a unit error. An unwanted factor of a half was also sometimes introduced.

*Answers:* (b)(i) $1.018 \times 10^{-7}$ m, (ii) $6 \times 10^{10}$ Pa, (iii) $1.4 \times 10^{8}$ Pa, (iv) 0.3 J

**Question 8**

In part (a), most candidates had the sense to begin by copying the three relevant statements from the passage. Very few gained any credit for subsection (iii). The initial statement was usually ignored and there was plenty of waffle. Only a couple of students mentioned tension or compression, but a few did gain credit by discussing the implications of the formula for *x*. The calculation in part (b) was often correct. When errors did occur they were usually arithmetical and associated with either or both of the two cubed quantities. Errors in part (c) tended to involve either the wrong choice of formulae or omitting the units in subsection (ii). Part (d) gave the majority little trouble. The interpolation involved in part (e) was often wrongly performed and the factor of $10^6$ regularly forgotten. More worryingly, a number of candidates could not state correctly which was the greater of two numbers.

*Answers:* (b) 667N, (c)(i) 0.0117m (ii) 17 300 Nm, (iii) 0.00383 m, (d) 85.1 kN m, (e)(i) 91 Mpa, (ii) $1.90 \times 10^{-4}$ $m^3$.

## 9244/03 Physics

### General Comments

There were parts of questions that proved to be demanding for most candidates. In general, parts of questions involving short calculations or brief comments were answered much more successfully than questions seeking more discursive answers as in, for example, questions 3 and 5. High-scoring candidates were able to develop coherent and logical arguments, showing a good understanding of basic principles. The most popular questions in Section B were those on Medical Physics, Environmental Physics and Physics of Fluids. Paradoxically, these required candidates to develop arguments and it may be for this reason that the marks for Section B questions were significantly lower than for Section A. There was some evidence for a very superficial level of study of the Options. Candidates appeared to have sufficient time to complete their answers. It was pleasing to note that there were few scripts where candidates had not attempted whole parts of questions.

### Comments on Individual Questions

### Section A

### Question 1

(a) In part (i), almost all candidates gave the required extension, but many emphasised that this is the extension required to set the trolley in motion rather than provide motion with zero acceleration. Part (ii) presented very few problems.

(b) Most candidates used the correct formulae and in parts (i) and (ii), errors were usually confined to confusion of units. There were rather more errors in part (iii), where candidates did not use the result from (ii), but rather equated frictional force to the answer in part (i).

(c) The calculation in part (i) was generally well done but a significant minority wrongly used the spring constant to calculate an acceleration based only on the force produced by the elastic cord, rather than reading the acceleration from the graph. The equations of uniformly accelerated motion were used in a variety of ways in part (ii). Apart from those candidates who tried to use a single equation involving the given additional distance and an initial zero speed, the majority were successful.

(d) Many candidates thought that a linear graph meant that acceleration and extension were proportional. Very few made any comment regarding the intercept. In part (ii), the majority of candidates simply said that the Hooke's law limit had not been exceeded because the graph is linear. Very few provided any real justification for their statements.

*Answers:* (a) 1.6cm; (b) 0.48 N, $4.3 \times 10^{-2}$ N $cm^{-1}$, $6.9 \times 10^{-2}$ N; (c) 0.49 cm $s^{-1}$, 0.58 s.

**Question 2**

(a) 'Force x distance' was a common definition for work, with no mention of movement or displacement or consideration of the direction of displacement. Definitions of power were more satisfactory in that a ratio was indicated rather than 'work in unit time'.

(b) Most candidates used appropriate formulae and ended with a correct expression for kinetic energy. However, explanation was frequently lacking and it was often not clear why the final expression, calculated as ' work done' was indeed kinetic energy.

(c) In part (i), more than half the candidates failed to determine correctly the base units for power. Additionally, many failed to realise that the base units of all three terms in the given equation must be the same, and unnecessarily attempted to involve the middle term. Substitution into the formula in part (ii) caused very few problems.

(d) All three calculations in this section are straightforward and presented few problems to candidates who understood the basic concepts.

(e) A significant proportion of candidates made a comparison between the values of kinetic energy and work done and most concluded that it would not be worthwhile to store the kinetic energy. However, not many considered why it would not be worthwhile. Factors such as additional weight, the cost of development and production and the efficiency of the storage device were seldom mentioned. A significant minority of candidates stated blindly that it would be worthwhile to store the kinetic energy on the basis that energy conservation is always 'a good thing'

*Answers:* (c) 36.6 kW; (d) $3.46 \times 10^5$ J, 1180 N, 11 MJ.

**Question 3**

(a) Almost all candidates were able to distinguish between progressive and stationary waves as regards energy transfer. In part (ii), many candidates confused amplitude with displacement. There was confusion in part (iii) where candidates used vague terms such as 'out of phase' and 'in phase' where for the stationary wave they really meant zero phase difference.

(b) In part (i), most candidates gave an adequate explanation as to why the wire should vibrate. Usually, resonance was mentioned but few explained clearly that the natural frequency of vibration of the wire varies with the applied tension. In part (ii), most candidates sketched an acceptable wave shape and correctly deduced the corresponding wavelength. The most common error was to give a wave form with a node at its centre.

(c) Those candidates who were successful in this section followed the advice given in the question and stated the laws of electromagnetic induction. Poorer answers frequently made no reference to cutting of flux lines but rather, stated that there would be a change in magnetic flux. Likewise, some candidates merely said that the emf would change direction when the direction of motion changed.

**Question 4**

(a) Many candidates lost marks in this section because they failed to give answers which referred to the graph that they had drawn. Of those who made a reference to the graph, many merely stated that 'the area under the graph represents energy', without giving any justification or indicating which area is involved.

(b) In part (i), most candidates calculated total capacitance but few suggested that the potential difference across each capacitor would be reduced. The most common answer was to suggest that if one capacitor failed, the arrangement would still 'work'. In part (ii), many realised that the force in the two cases would be in opposite directions, but comparatively few went on to discuss the magnitude of the forces. Part (iii) was surprisingly poorly answered with comparatively few clear statements related to ionisation and consequent flow of charge. In part (iv), most candidates correctly calculated the energy dissipated in one flash, but often failed to use the correct residual energy in calculating the p.d. across the capacitors immediately after the flash. Also, many forgot that this p.d. is the p.d across a pair of capacitors, not across an individual capacitor.

(c) Kirchhoff's laws were poorly understood with many failing even to relate correctly the currents at junction D. In part (iii), it was common to find that the directions had not been considered.

*Answers:* (b) 4.6 J, 164 V

**Question 5**

(a) Many answers were verbose and failed to focus on the requirement of the question. Similarly in part (ii), many candidates failed even to mention the first law of thermodynamics. Of those who did attempt to state the law, the majority proceeded to make little or no significant reference to the law in their subsequent explanations. The most common error was the assumption that the internal energy of a gas is determined solely by its temperature. Comparatively few candidates considered any change in potential energy.

(b) In part (i), the assumptions made in the kinetic theory model were quite well known although vague statements such as 'the size of the molecules is negligible' were not uncommon. With few exceptions, the correct formula was given in part (ii) and there were many competent derivations for the average kinetic energy of a molecule. However, there were also many rambling illogical attempts with the required result appearing at the end. In most of these answers there was a failure to eliminate variables or to cancel unequal quantities.

(c) Candidates who had successfully completed section (b) generally found little difficulty with these calculations. Others had considerable difficulty and usually obtained some numerical answers by ignoring symbols which proved hard to quantify. Few realised that, in the final calculation, the temperatures under the specified conditions are directly proportional to the masses of the particles.

Answers: (c) $6.38 \times 10^{-21}$ J, 2760 $ms^{-1}$, 1200K

**Question 6**

(a) Few candidates clearly differentiated between the three terms. Most correctly identified nucleons, but when describing the nucleus, very few offered more than a statement that it is the charged core of an atom. Very few appreciated that a nuclide is a particular type of atom and the majority of candidates seemed to think that the terms nucleus and nuclide are synonymous.

(b) Most candidates correctly identified the particles in the nuclear equation but frequently failed to include energy. Definitions of half-life rarely made it clear that what is being halved is a quantity associated with a particular nuclide, ignoring the fact that the final product may well include radioactive daughters. In part (iii), the relevant formulae were generally well known and the calculations were completed successfully by a large proportion of candidates. The most common error was a failure to convert the energy in MeV to joules. Surprisingly, a significant minority confused decay constant with wavelength, presumably because they are represented by the same symbol.

(c) The calculations presented few problems and it was pleasing to note that the vast majority of candidates correctly used the Avogadro constant to determine the number of molecules per cubic metre of air.

(d) Many candidates attempted to argue that radon must be a valuable addition to the environment. Suggestions included using its radioactive properties to provide either lighting or heating in buildings. In other answers, vague comments referring to 'health hazards' were common. Very few mentioned that inhalation of radon gas could contribute to lung cancer.

*Answers:* (b) $1.2 \times 10^{-29}$ kg, $2.3 \times 10^{-12}$ m; (c) $1.6 \times 10^{4}$, $6.4 \times 10^{-22}$.

**Section B**

**Question 7**

(a) Descriptions of the meaning of both terms was generally quite good.

(b) Most candidates mentioned few factors such as absorption and distortion and the effects of light pollution. Very few mentioned that the remoteness of the galaxy means that radiation received even outside the atmosphere would be of very low intensity.

(c) In part (i), most candidates mentioned, with varying degrees of clarity, the difficulty in obtaining accurate values for the quantities determining the Hubble constant. Since the relevant formula is given, the calculation in part (ii) presented few problems. Many candidates had difficulty in calculating the number density in part (iii). However, in part (iv), most candidates knew about the 'closed' Universe resulting from the circumstances described.

*Answers:* (c) $1.2 \times 10^{-26}$ kg m$^{-3}$, 7 m$^{-3}$

**Question 8**

(a) In part (i), the description of a dislocation rarely went beyond 'an imperfection in the lattice' and similarly, in part (ii), ease of movement was usually attributed to merely 'planes slipping easily over each other'. In both parts, supporting diagrams were useful, but some of these diagrams were crudely drawn. Part (iii) was usually answered adequately.

(b) Explanations of the terms 'strong', 'tough' and 'stiff' were often imprecise and muddled. Although almost all candidates suggested steel for the construction of the cage, few had anything significant to say about the consequences of side impact other than to point out that there are no 'crumple zones'. Very few mentioned that the strong cage would result in larger impulsive forces over a shorter period of time.

**Question 9**

(a) In part (i), most answers did little more than include what was to be explained. The term 'virtual earth' appeared with no mention of the consequences of the large open-loop gain of the op-amp. When deriving the gain of the amplifier circuit, very few included the vital point that the input impedance of the op-amp is very large. In part (ii), most answers included correct signs, but many failed to realise that the output voltage saturates at ±9V.

(b) This was answered correctly by most candidates. In part (iii),the symbol for the equivalent single logic gate was frequently poorly drawn and could only be identified by a written statement that it is an EX-NOR.

*Answers:* (a) −1.0V, +9.0 V.

**Question 10**

(a) Many answers included correct statements of the conditions for a ship to float and be stable although a surprising number thought that, for a ship to float, the upthrust has to be greater than its weight. Sketches drawn to illustrate the metacentre were often very crude and of little value.

(b) Most candidates adequately justified the expression in part (i), but frequently it was difficult to distinguish between the symbols $\rho$ and $p$. In part (ii), the derivation of the Bernoulli equation was generally not well done. Many did not use the expressions derived in (i) and there was widespread confusion as to what quantities are constant in magnitude throughout the tube. Cancellations were made without any justification. The majority of candidates gave a correct assumption relating to incompressibility or laminar flow.

(c) In part (i), a quantitative explanation was required, but few attempted this. Many explanations were purely qualitative. Frequently candidates considered the drag at speeds of 100 km $h^{-1}$ and 10 km $h^{-1}$ and a number even found that the drag at 10 km $h^{-1}$ is much greater than that at 100 km $h^{-1}$. In part (ii), most candidates suggested lower power or lower fuel consumption but rarely gave any basis for comparison, such as 'at the same speed'.

**Question 11**

(a) Only brief outlines were required, but many answers were extensive. The use of X-rays, usually for diagnosing broken bones, was described well. Some candidates described a surgical use for the laser, not a diagnostic use. Diagnostic uses were confined either to pulse oximetry or endoscopy.

(b) In part (i), most answers included an adequate explanation of the role of the ciliary muscles but only a minority included a reference to refraction at the air/cornea boundary. In part (ii), there were many clear and correct calculations. It was not necessary to assume a value for the length of the eyeball, but of those who did, most chose a reasonable one.

(c) Intensity level was usually defined correctly, with a reference to threshold intensity. However, in part (ii), most candidates said in some way that loudness is a subjective response but comparatively few explained that intensity level gives an approximate measure of loudness at any particular frequency but that loudness is also frequency dependent.

*Answer:* (b) 3.3D

**Question 12**

(a) Apart from those who confused fission with radioactivity, most gave adequate outlines of the fission process, although there was some lack of precision in the use of terms such as atom, nucleus, nucleon and neutron. In part (ii), very few answers included kinetic energy of fission fragments or neutrons and gamma ray photons. The most common answer was 'heat and light'. In part (iii), the roles of the moderator and the control rods were sometimes confused, but nevertheless there were many good accounts of the function of the moderator.

(b) Candidates who were familiar with the indicator diagram had little difficulty with this section of the question. Many of those who did not understand the cycle were still able to calculate the efficiency correctly.

(c) There were some clear descriptions of named forms of pollution. However, there were many answers unrelated to any type of pollution and in some cases the candidates were expressing their views on unrelated topics.

*Answers:* (b) 200 J, 53 %

**Question 13**

Very few candidates attempted this question but the range of marks awarded was very similar to that for the other option questions.

(a) Statements as to the meaning of a digital signal were clear. However, in (ii), very few candidates could calculate the time interval. Either they calculated the length of a 5-bit number or the time between the starts of samples. Nevertheless, in part (iii), most mentioned time division multiplexing. In part (iv), most answers included reference to the fact that some frequencies would not be recovered, but then no further suggestion as to the effect on the transmitted signal was given.

(b) Candidates were divided into two groups. Either they produced completely correct answers to all parts of this section, or they appeared to have little appreciation as to what is involved.

(c) Most candidates could give at least two aspects of geostationary satellites. The most frequent omission was that the satellite must be in an equatorial orbit.

*Answers:* (a) 53.1μs; (b) 322 dB, -40dB, 4.

## 9244/04 - Physics: Practical

### General Comments

The overall performance of the candidates was much the same as in previous years. The more able candidates were able to demonstrate their practical abilities and achieved high marks. It was pleasing to see a number of very able candidates scoring full marks. The requirements of each question were generally understood by candidates and there was little evidence that they were confused by the terminology of the questions.

Candidate's answers to questions 3 and 4 continue to improve, and it was pleasing to see some of the weaker candidates gaining respectable marks in this part of the examination.

The achievement of candidates continues to be very Centre specific, and it is still the case that a number of Centres have very clear ideas of the requirements of this paper, and are able to prepare their candidates well.

### Comments on Individual Questions

**Question 1**

In this question candidates were required to investigate how the period of oscillation of a V-shaped pendulum changes as the distance between the supports changes. Most candidates were able to set up the apparatus and take six sets of readings of time $t$ for a predetermined number of oscillations and separation $d$ of the supports. Occasionally candidates used a small number of oscillations leading to raw times which were less than ten seconds. It is expected that candidates will allow the pendulum to oscillate for long enough so that the error due to reaction time will not be a significant proportion of the measured time. A number of candidates miscalculated the period and gave frequency instead (i.e. divided the number of oscillations by the average time instead of the inverse). Sometimes candidates did not divide the average time by the number of oscillations and used $t^4$ instead of $T^4$.

Most candidates repeated readings and calculated an average.

Virtually all candidates presented their results in a table. The column heading for $T^4$ was often given as $T^4$/s instead of $T^4/s^4$. Sometimes the unit had been omitted completely.

It is expected that candidates will record the results consistently. This means that all the raw values of a particular quantity should be given to the same number of decimal places, and that this will be consistent with the apparatus from which the measurement has been made. Many candidates gave values of $d$ which were integer values of tens of centimetres (e.g. from 30 to 80). It is expected that these values would be given to the nearest millimetre, since a rule with a millimetre scale is used to obtain the readings (e.g. it is expected that 30.0 cm would be recorded, rather than 30 cm)

Most candidates were able to quote values of $T^4$ to a sensible number of significant figures. Raw values of time were usually given to three or four significant figures, in which case it was expected that the calculated values of $T^4$ would also be given to three or four significant figures. As a general guide, candidates should be aware that a calculated quantity should be given to the same number of significant figures, or one significant figure more than the raw data from which the quantity is derived.

Candidates were instructed to plot a graph of $T^4$ against $d$. Most candidates were able to choose sensible scales so that the plotted points occupied at least half the graph grid in both the $x$ and $y$ directions (an interval of at least six large squares in the $y$ direction and five large squares in the $x$ direction was considered to be a minimum). It is expected that candidates will label the scales with the quantity which is plotted, and that the intervals on the axes will be easy to use. Many candidates made life difficult by choosing scales of 3:10, 6:10 or 8:10 etc.. This often led to misplotted points (as a calculator had to be used to determine where the plot should be placed).

Lines of best fit were usually drawn quite well. It is expected that there will be a good balance of points about the line of best fit. A single clear thin line is expected. Candidates would find it helpful to use clear plastic rules so that points which lie below the line of best fit are not obscured by a rule when the line is drawn.

Candidates were required to determine the gradient of the graph. The most common error made by the candidates was to omit a negative sign with the value. Some candidates used very small triangles resulting in inaccurate values for $\Delta x$ and $\Delta y$. It is expected that candidates will use triangles where the length of the hypotenuse of the triangle is greater than half of the length of the line which has been drawn. A number of candidates misread the scales or used $\Delta x/\Delta y$ instead of $\Delta y/\Delta x$.

Candidates were required to find an intercept. If scales had been chosen so that the plotted points filled most of the page then it was often the case that the origin was not on the graph grid. This resulted in many candidates reading an intercept from a line where $x \neq 0$. Usually an incorrect value for the $y$-intercept was read from the line $x = 30$. In cases where the origin is not shown on the graph candidates would benefit from being advised to substitute values for $x$ and $y$ from a point on the line into the equation of a straight line and to calculate a value for the intercept. The more able candidates had no difficulty in doing this.
Candidates should be advised ***not*** to plot a second graph to determine the $y$-intercept as this will not be credited.

In part **(c) (iii)** candidates were instructed to use their answers from part **(ii)** to find values for $g$ and $k$. Many of the weaker candidates found this section very difficult and were not able to re-arrange the given equation into the form $y = mx + c$. A number of candidates attempted to substitute pairs of values for $T^4$ and $d$ from the table of results into the equation and solve the resulting equations simultaneously. Sadly this almost always resulted in pages of confused algebra and wasted much time. It was expected that candidates would equate their gradient value with $-8\pi^4L/g^2$ to obtain a value for the acceleration of free fall. Candidates who did manage to expand the brackets in the expression often omitted the negative sign and equated their gradient with $8\pi^4L/g^2$.

The unit of $g$ was usually given correctly, but the unit of $k$ was often omitted.

In the last part of the question, candidates were required to state why the given equation may not be suitable for describing the behaviour of a fairground ride shown in Fig. 1.2.
Although a number of sensible suggestions were given (e.g. 'large resistive forces due to air resistance' or 'the weight of the heavy steel cables needs to be taken into account'), many candidates felt that the mass of the riders would make a difference, even though the equation did not contain a term involving mass. Candidates who wrote down a selection of correct and incorrect responses (leaving the Examiners to decide which responses were right and which were wrong) were not given credit in this section.

**Question 2**

In this question, candidates were required to investigate how the current through a milliammeter varies as the resistance of a resistor (connected in parallel with the meter) is changed.

Most candidates were able to set up the circuit without help. Occasionally, Supervisors had to help candidates by making a small change to the circuit in order to make the circuit function properly, in which case a one mark deduction was applied. A small number of very weak candidates had the circuit set up for them by the Supervisor. In this case a two mark penalty was incurred.

Most candidates were able to take six sets of readings for current $I$ and resistance $R$ and present their results in a table. Candidates were told to include values of $1/I$ and $1/R$ in the table. Many candidates either omitted the unit of these quantities, or gave an incorrect unit. Sometimes it was unclear as to what was actually intended. For example the heading $1/R/$ was sometimes given, which was not accepted. It would be helpful if candidates could be encouraged to use an index notation which is not ambiguous (e.g. $R^{-1}/\Omega^{-1}$).

One mark was reserved for 'quality of results' which was judged by the scatter of points about the line of best fit. Candidates who had done the experiment carefully and read the meter correctly were able to score this mark. A number of candidates who rounded down when calculating values of $1/I$ and $1/R$ did not score the mark because the rounding down led to increased scatter of points on the graph, so quality could not be judged.

Candidates were asked to justify the number of significant figures which they had given for $1/I$. The weaker candidates gave vague responses such as 'I have given $1/I$ to three significant figures for accuracy' or incorrect responses such as 'I have given $1/I$ to two significant figures because I am going to plot a graph'. There continues to be confusion between decimal places and significant figures. All that is required is a simple statement which relates the number of significant figures given in the value of $I$ to the number of significant figures in the value of $1/I$. For example, the statement 'I have given the values of $1/I$ to three significant figures because the raw values of $I$ are to three significant figures' would get full credit.

Candidates were asked to plot a graph of $1/I$ against $1/R$. Generally this was done quite well. Candidates who had used values of $1/I$ in units of $A^{-1}$ simplified matters for themselves, as these values were in a typical range from 10 - 60 $A^{-1}$ which made life easier. Candidates working in $mA^{-1}$ had to deal with small numbers and generally made more errors. Awkward scales on the axes of the graph again resulted in points being misplotted and gradients miscalculated. Finding an intercept on the graph in this question was more straightforward than in question one, as it was easier for candidates to include the origin on the graph grid since the range of values for $1/I$ and $1/R$ did not produce compressed scales if both the $x$ and $y$ axes were started from zero.

Most candidates were able to equate $c$ with the $y$-intercept, although some candidates omitted the unit ($mA^{-1}$ or $A^{-1}$).

Most candidates were able to record a value for the e.m.f. of the power supply using the circuit shown in Fig. 2.2. Many of the weaker candidates did not understand how to use the gradient of the graph and the value of $E$ to find a value for the effective resistance $s$ of the milliammeter. Usually values were substituted into the equation which had been given. It was expected that candidates would equate the gradient of the graph with *rs/E* to arrive at a value for *s*. Mistakes which had been made earlier in the working (e.g. a power of ten error in the conversion of units) often led to a value for *s* which was a thousand times too small. Errors of this kind were only penalised once (in the final value for *s*).

**Question 3**

In this question, candidates were given a 'scene-setting' section (as in previous papers). Some of the weaker candidates were not able to distinguish between the context of the situation (i.e. the effect on sea levels of a rise in the average temperature of the Earth) and what was required in the investigation. Candidates were asked to describe an experiment to investigate how the volume of a given amount of water changes with temperature and to use the apparatus shown in Fig. 2.1.

Candidates should be encouraged to draw a well-labelled diagram of their proposed arrangement of the apparatus. A well-drawn diagram could score half the marks which were available in this question.

It was expected that candidates would heat a flask filled with water and measure the rise in the level of the water in the capillary tube as the temperature increased. The main error made by the weaker candidates was to use a flask which was only partially filled with water, which meant that any expansion would be due primarily to the expansion of the air in the flask and not the water. Some candidates used a flask filled with ice cubes. Many descriptions involved using the microscope with a scale to measure the change of the water level in the wide part of the flask and not the change in the level of the water in the capillary tube.

Candidates were asked to explain how they would measure the initial volume of water accurately. Weaker candidates were only able to gain partial credit in this section by stating that they would use a measuring cylinder. This was not considered to be particularly accurate. It was expected that candidates would use a weighing method (since candidates were told that the density of water at the starting temperature is known).

One mark was available for the candidates who suggested using a water bath to heat the water in the flask. Weaker candidates tended to use a Bunsen burner to heat the flask directly, which was not considered to be an appropriate method.

One mark was available for showing how the temperature of the water in the flask would be measured. Weaker candidates often drew a diagram showing a thermometer placed inside the capillary tubing, or showing the wires of a thermocouple passing down the inside of the tube. Some thermometers were shown protruding from the side of the flask. All that was required was a sensible approach (e.g. a thermometer shown in the water bath, or placed in a second hole in the bung at the top of the flask).

To measure the increase in volume candidates needed to suggest a method of finding the diameter of the capillary tube (i.e. using the microscope with scale) and multiplying the rise in the water level by the cross-sectional area of the tube. Many candidates suggested using a micrometer screw gauge or vernier calipers to measure the diameter which was considered to be unworkable and not rewarded. A small number of candidates suggested measuring a length of mercury in the tube and described a method of finding the cross-sectional area based on knowledge of the density of mercury and the mass of mercury in the tube. This was quite acceptable.

Many of the weaker candidates thought that the mass of the flask and contents changed as the water was heated, and described methods which involved heating and weighing. Answers of this kind did not score very well.

Some candidates are still wasting time by giving a detailed treatment of what the results of their experiment might be. Since the candidates do not have access to the apparatus they cannot 'know' what the outcome will be and therefore no credit can be given. Candidates should be discouraged from doing work of this kind.

Two marks were available for what was considered to be 'good or relevant further detail'. It was possible to score both of these marks on a well-drawn and labelled diagram.
Examples of some of the points made by candidates which were rewarded are as follows:

A flask shown fully submerged in a water bath;
Any mention of problems due to the expansion of the flask during heating;
Measurement of the diameter of the capillary tube in several places;
Use of a large flask so that the expansion of water will be greater;
Use of a small bore capillary tube so that the movement of the water up the tube will be greater;
Statement that water is a poor conductor of heat, so the flask must be left for a long period of time to come to thermal equilibrium;
Use coloured water so that the level of water in the capillary tube can be seen more easily;
Take a range of values of temperature and change in water level;
Don't heat the water close to boiling point because of problems with steam;
Measure the rise of the water level in the capillary tube using a microscope or vernier calipers;
'Swirl' the flask/stir the water in the water bath to achieve a uniform temperature.

**Question 4**

In this question, candidates were asked to design an experiment to investigate how the amplitude of the reflected sound from a particular surface depends upon the frequency of the incident sound. Candidates were instructed to draw a diagram showing their proposed arrangement of the apparatus. Candidates should be encouraged to give as much detail as they can on this diagram. A well drawn diagram could score four out of the eight marks available in this question.

Generally, question 4 was not done as well as question 3. Some candidates attempted to use the equipment listed in question 3 when they selected apparatus for the investigation. Candidates are expected to state what equipment they would use (e.g. signal generator + speaker; microphone + CRO). A number of candidates suggested using a signal generator without a speaker (or a speaker without a signal generator) to produce the sound waves, whilst other candidates were vague in the choice of equipment; 'detectors' and 'sensors' were common. It was expected that candidates would suggest a workable arrangement of the apparatus (i.e. a source of sound directing waves at an angle on to a board and a sensor of some kind facing the board at the same angle to receive the reflected waves. A few candidates described a transmission experiment whilst others used standing waves (and just gave details of an experiment which they had done in the laboratory). The other main error made by candidates was to suggest the use of tuning forks as the source of sound. This was not accepted, since the amplitude of the incident waves decreases with time. A small number of weaker candidates suggested using violins.

Credit was given for a method of preventing the sound from reaching the microphone directly. This usually involved placing a sheet of 'sound absorbing material' between the speaker and the microphone. A few candidates used long tubes to direct the sound waves. Some candidates suggested placing the loudspeaker in a box made of the material under test.

One mark was available for candidates who described how the amplitude of the waves could be measured. Many vague answers were seen, such as 'use the CRO to measure the amplitude' without stating how this would be done. Many of the more able candidates scored this mark on the diagram (showing which distance would be measured on the oscilloscope screen).

Most candidates had the right idea as regards the procedure to be followed (i.e. measure a frequency and an amplitude; change the frequency and measure the new amplitude). A few of the weaker candidates attempted to use the formula '$v = f\lambda$' to find the frequency of the incident waves (i.e. using a known value for the speed of sound and a wavelength obtained from the trace on the oscilloscope screen (?)).

One mark was available for candidates who realised that the distances should remain constant during the experiment. A large number of candidates did not mention this fact.

As in the previous question, two marks were reserved for what was considered to be 'good/further detail' which was relevant to the design of the experiment. Examples of candidate's suggestions which gained credit are as follows:

Use the same absorbing material each time (explicitly stated);
Method of measuring the frequency of the sound using a CRO;
Problems with the frequency response of the microphone;
Problems with the frequency response of the loudspeaker;
Calibrate the signal generator using the CRO;
Surround the apparatus with sound absorbing material to avoid reflections from other surfaces;
Use incident waves of the same amplitude for each different frequency

## 9244/05 - Physics: Practical

### General Comments

The general standard of work produced by the candidates was much the same as in previous years. There was a wide spread of marks with the most able candidates demonstrating their practical abilities and achieving high marks. It was pleasing to see a number of candidates attaining the paper maximum.

The requirements of each question were generally understood by the candidates, and no one question was answered particularly well or particularly poorly. It was pleasing to see candidates' answers to questions three and four continuing to improve. Many of the weaker candidates were able then to make creditable efforts with these design questions.

The achievements of candidates continues to be very centre specific. Candidates from relatively few centres all do very well, whilst candidates from other centres perform less well.

### Question 1

In this question candidates were required to investigate how the period of oscillation of a metre rule suspended by an inverted V-shape thread depends on the perpendicular distance between the rule and the support. Most candidates were able to set up the apparatus without help and obtain six sets of readings for t and h. A number of weaker candidates timed a small number of oscillations (or one oscillation) which led to the raw values of time being very small. It is expected that candidates will allow the rule to oscillate for long enough so that the error due to reaction time will not be unduly large. Candidates were instructed to calculate values for $T^2h$ and $h^2$ using their results. A number of candidates calculated $Th$ or $Th^2$ instead of $T^2h$ and a few found $t^2h$.

Most candidates repeated readings and calculated an average.

Virtually all candidates presented the results in a table. The column headings for $T^2h$ and/or $h^2$ often did not contain a unit.

It is expected that candidates will record the results consistently. This means that all the raw values of a particular quantity should be recorded to the same number of decimal places and that this will be consistent with the apparatus from which the measurement has been made. A number of weaker candidates gave values of $h$ which were integer values of tens of centimetres. It is expected that these values would be given to the nearest millimetre, since a rule with a millimetre scale is used to obtain the readings. (e.g. it is expected that 70.0 cm would be given instead of 70 cm)

Most candidates were able to give values of $h^2$ to a sensible number of significant figures. Raw values of $h$ were usually given to three significant figures and so it is expected that the values of $h^2$ would be given to three significant figures also. As a general guide, candidates should be aware that a calculated quantity should be given to the same number of significant figures, or one significant figure more than the raw data from which the quantity is derived.

Candidates were instructed to plot a graph of $T^2h$ against $h^2$. Most candidates were able to choose sensible scales that were easy to work with (e.g. 2:10 or 5:10) It is expected that the scales will be such that the plotted points occupy at least half the graph grid in both the x and y directions. Some of the weaker candidates are still using scales where the plotted points occupy only a small portion of the graph grid.

Lines of best fit were usually drawn well. A single clear line is expected. Candidates may find it helpful to use clear plastic rules so that the points below the line can be seen when the line is drawn. Candidates who had done the experiment carefully and obtained little or no scatter usually scored this mark as the line was easy to draw.

Candidates were required to find the gradient of the line. Usually this was done quite well. Common errors included misreading the scales and finding $\Delta x/\Delta y$ instead of $\Delta y/\Delta x$. A number of weaker candidates used very small triangles when determining the gradient. It is expected that candidates will use triangles where the length of the hypotenuse of the triangle is greater than half the length of the line which has been drawn.

Candidates were required to find an intercept. This could be read directly from the graph in most cases although some candidates made life difficult by choosing a point on the line and substituting the co-ordinates of this point into the equation of a straight line and then went on the calculate a value for the intercept. This was an unnecessarily complicated method as the intercept could almost always be found directly.

In (c)(iii) candidates were instructed to use their answers from (ii) to find values for *g* and *k*. Many of the weaker candidates were unable to attempt this section. Others tried to substitute values from the table of results into the equation and solve the resulting equations simultaneously. This led to much confused algebra and wasted time. A number of candidates who were able to equate the gradient of the line with $4\pi^2/g$ and the intercept with $4\pi^2k^2/g$ did not use these ideas and attempted a substitution method.

The unit of *g* was usually given correctly but the unit of *k* was often omitted.

In the last part of the question, candidates were required to state why the given equation may not be suitable for describing the behaviour of the fairground ride show in fig 1.3. Although a number of sensible suggestions were given (such as 'the ship is powered by a motor' or 'the weight of the metal rods needs to be taken into account') many candidates felt that the mass of the riders would make a difference, even though the equation did not contain a term involving mass. Candidates who wrote down a selection of correct and incorrect responses (leaving the Examiners to decide which responses were right and which were wrong) were not given credit in this section.

**Question 2**

In this question candidates were required to investigate how the potential difference across a resistor varies as the resistance of the resistor is changed.

Most candidates were able to set up the circuit without help. Occasionally Supervisors had to make small changes to circuits in order to make the circuit function properly, in which case a one mark deduction was made. A small number of weak candidates had to have the circuit constructed for them. In this case a two mark deduction was made.

Most candidates were able to take six sets of readings for the potential difference *V* and resistance *R* and present the results in a table. Candidates were instructed to include values of 1/*V* and 1/*R* in the table. Many of the weaker candidates omitted the units of 1/*V* or 1/*R* (or both). Some candidates gave ambiguous column headings (e.g. 1/*R*/Ω) which was not accepted. Candidates may find it helpful to be encouraged to use index notation.
(e.g. $R^{-1}/\ \Omega^{-1}$).

One mark was reserved for the 'quality of results'. This was judged by the scatter of points about the line of best fit. Candidates who had done the experiment carefully and read the meter correctly were able to score this mark. A number of candidates who misread the scale or rounded down when calculating 1/*V* or 1/*R* did not score the mark since there was too much scatter of points about the line of best fit.

Candidates were asked to justify the number of significant figures which they had given for 1/*V*. The weaker candidates gave vague responses such as 'I have given 1/*V* to three significant figures because I am going to plot a graph' or 'I have given 1/*V* to four significant figures because it increases accuracy'. Many candidates were confused between significant figures and decimal places. It is expected that candidates will relate the number of significant figures in the values of 1/*V* to the number of significant figures in the raw values of *V*. A simple statement such as 'I have given 1/*V* to three significant figures because *V* is given to three significant figures' would get full credit.

Candidates were asked to plot a graph of 1/*V* against 1/*R*. Weaker candidates used compressed scales where the plotted points occupied less than half the graph grid in the *x* or *y* direction (or both). Many logarithmic scales were seen where every two large squares (for example) showed an increase by a factor of a power of ten. These non-linear scales led to difficulties with plotting of points and determination of gradient, and graphs of this kind generally did not score well. Candidates would benefit from being encouraged to use simple linear scales. Many candidates read the *y*-intercept correctly and went on to equate *c* with this value. Often the unit of *c* ($V^{-1}$) was omitted.

Many of the more able candidates equated the gradient of the line with *r/E* and obtained a sensible value for the e.m.f. of the cell. Weaker candidates attempted to substitute values from the table of results into the given equation in order to calculate a value for *E*.

Regrettably, candidates from a small number of centres experienced some difficulties reading the voltmeter when the resistor P was removed from the circuit (the reading was slightly greater than full scale deflection if the values suggested in the Supervisor's Instructions had been used). In all cases of this kind, the examiners were lenient in what was accepted. If candidates estimated the reading, or stated what they would have done with the reading if they had been able to obtain one, then full credit (1 mark) was possible. Some candidates became muddled and stated that $R=0$ when resistor P was removed. In these cases subsequent working was not credited.

**Question 3**

In this question, candidates were given a 'scene-setting' situation (as in previous papers) many weaker candidates were not able to distinguish between what was wanted (i.e. a description of a laboratory experiment to investigate how the current passing between two electrodes in humid air varied with the potential difference between the electrodes) and the lighting in the sauna.

Quite a number of scripts were seen where candidates attempted to describe what the results of their experiment might be. Candidates are not expected to know that humid air does not conduct very well, since they have not actually carried out the investigation and therefore no marks can be awarded for any work of this kind. Candidates would benefit from being encouraged to concentrate on the design aspects of the question and not on what the results 'might be'.

It was expected that candidates would use the tank, fill it with steam from the boiler and measure the current flowing between two electrodes situated in the tank when various potential differences (up to a few hundred volts) were applied to the electrodes. A well-drawn diagram could score half the marks which were available in this question.

A list of apparatus was given. Candidates are expected to select the necessary pieces of equipment from this list to carry out the investigation. Not all of the apparatus is to be used. Candidates would benefit from being aware of this fact. Many weaker candidates suggested using the vacuum pump to remove all of the air from the tank at the beginning of the investigation. Other attempted to use the vacuum pump to control the humidity of the air.

Many weaker candidates drew a circuit diagram (including an H.T. supply) inside the tank. Others did not include a meter to measure current, or attempted to use the oscilloscope in series with the power supply to measure current. A surprising number of voltmeters were shown in series with the power supply. A number of circuit diagrams were seen which included a hygrometer and / or a signal generator.

Several candidates carried out the experiment in a sauna instead of a laboratory. Candidates would benefit from being encouraged to describe a laboratory experiment in questions of this kind. A surprisingly large number of candidates did not describe an experiment of the type which was asked for in the question. It was common to see descriptions where the humidity was changed and current was measured instead of using constant humidity and varying potential difference and current.

Two marks were available for sensible suggestions relating to safety. A variety of answers were accepted (e.g. wear heatproof gloves or safety goggles; switch off the power supply before opening the lid of the tank; insulate the wires inside the tank with rubber etc). Many candidates gave responses which were too simplistic, such as, 'don't touch the boiler because it is hot' and 'care must be taken when dealing with water and electricity because they don't mix' were common.

Further detail marks were also available. Sensible and relevant suggestions were rewarded. Examples of some of these are as follows:

Use a constant separation of electrodes;
Support the electrodes on insulating stands;
Keep the air temperature constant;
Method of attempting to achieve constant humidity;
Use a drainhole at the bottom of the tank.

Other valid suggestions were credited.

**Question 4**

In this question candidates were asked to design an experiment to investigate how the amplitude of transmitted sound through a material depends on the density of the material. As in all previous questions candidates should be encouraged to draw a detailed, labelled diagram of their proposed arrangement of apparatus.

As in previous papers, this question was not done as well as question 3. It was expected that candidates would suggest using a signal generator connected to a loudspeaker to generate sound waves. These waves would then pass through a sample of material and be detected by a microphone and CRO (or noise meter). Many candidates either drew a loudspeaker (with no signal generator) or drew a signal generator (with no loudspeaker). Quite a few diagrams were seen where a low voltage power supply unit had been connected to a loudspeaker.

The general idea presented no difficulties to candidates who had seen demonstrations, or done experiments with sound waves during their Physics course. However, it was apparent that a significant number of candidates had little idea of the type of equipment which should be used, and many vague responses were seen. Sound 'emitters' and detectors' were common.

One mark was available for the candidates who realised that a source → board → receiver arrangement needed some method of preventing sound from reaching the receiver directly. Credit was given for placing the speaker in a box made out of the material in question, or for surrounding the apparatus with sound absorbing material.

One mark was available for the candidates who were able to describe how the amplitude of the waves would be measured. Many vague answers were seen, such as 'use the CRO to measure the amplitude' with no mention of how this might be done. Some reference to the amplitude of the wave seen on the screen of the CRO was required (a labelled diagram of a wave of the CRO was the easiest way for candidates to score this mark).

Candidates were directed to make some comments about the control of variables in their experiments. The weaker candidates often omitted this entirely in their answers. Two marks were available which could be scored in a number of ways. Some of these were:

Maintain a constant distance between the speaker and the microphone;
Use a material of a constant thickness;
Use samples of constant surface area;
Use incident waves of the same amplitude / power / loudness / intensity / frequency.

Further detail marks were available (as in previous papers). Credit was given for a wide variety of sensible suggestions. The most common suggestions were to perform the experiment in a quiet room, and for some method of ensuring that the incident waves had the same amplitude for each material tested.

## 9244/07 Physics: Extended Investigation

### General Comments

This option is one in the practical assessment group contributing to the A Level award. As such, it is internally marked and externally moderated. In general, the level of annotation was good, but a number of Centres still show a reluctance to make comments on scripts. The comments not only benefit candidates but – according to the code of practice – are required to assist the Moderators in their duties. It is quite in order to use 'Post-It' sticky labels, if there is a wish to return to the candidate a pristine copy. Overall the standard of marking has improved, with only a small minority having to be changed at moderation. This relative imbalance between the satisfactory and the minor room for improvement, should be borne in mind when reading the highlighted areas which need attention.

### Comments on Particular Skills

### Skill A

A1: Application

There should be two approaches and the varying approaches need more justification. Too often there was just modification of the same procedure; there should be two separate experiments with two separate outcomes.

A2: Definition

Often the hypothesis was not developed, basic physics not being used appropriately. In fact prediction (along GCSE lines) was often equated with hypothesis.

A3: Variables

Sometimes there were limited discrete variables (preferably they should be continuous). The use of discrete variables can lead to penalisation in B4, and also perhaps in C1.

A4: Organisation

General improvement has been maintained – with only a few past tenses proffered.

A5: Apparatus

This created very little problem – apart from the case where approval had been given by the Board – but the Centre had not delivered the apparatus.

A6: Procedures

In most cases, plans were realistic, especially when continuous variables were involved.

### Skill B

B1, B2, B3: Carrying Out; Safety; Manipulative Skills.

Too often Teacher Observation Sheets are missing and some which were produced, contained general comments which were not specific enough to the task, thereby leading to insufficient justification for the marks awarded.

B4: Observations

Raw data still continues to be absent. When discrete variables are used, several examples of 5 values (or less) were reported. Centres are reminded that at least 6 values are required, even more, overall where a 'turning point' may be involved.

B5: Recording Observations

This has improved. Although a few units are absent, Centres should be reminded that some printing procedures produce the wrong case i.e. upper case for lower case, in for example KG for kg. In addition, computer notation such as 3.0E05 is inappropriate.

B6: Precision / accuracy

Again it must be emphasised that this refers to the original and not the processed data. Validation by repetition is nearly always relevant and appropriate significant figures should be reviewed. At A (and AS) level forces of 1,2,3,4...N and currents of 1,2,3,4....A should be reassessed.

**Skill C**



C1: Processing

Nearly all produced at least one hand-drawn graph. It should be noted that some IT package software – perhaps aimed at the business community – sometimes led to inappropriate physics use – e.g. the line of best fit may not in itself, be the final arbiter.

C2: Reliability

The candidates tend not to be very good at assessing the quality of their own data.

C3: Modification

Some suggested modifications were trivial.

C4: Interpretation

There were too many qualitative discussions for A level. Self-induced difficulties are created when discrete variables are chosen.

C5: Conclusion

Emphasis is on a single clear statement, which is essentially concise.

C6: Communication

Many excellent examples were seen.

There has been an increasing tendency to utilise IT packages of varying complexity and appropriateness. Predominantly, the outcome is pleasing and leads to excellent presentation and conclusion. However, Centres should be aware that many are aimed at business presentation and may contain features which lead to inexactitudes. It must be explained that the Extended Investigation is based on Physics principles and their application, so packages must be used accordingly.

The attention of Centres is also drawn to the publication which is available from OCR viz:

'The Assessment of Experimental Skills and Investigations in AS / A level Physics'
A Handbook for Teachers

**9244/09, Physics: Experimental Skills**

**Introduction**

Separate Skills Assessment is one route to assessing coursework; another, equivalent route is by an Extended Investigation and Experimental skills can also be assessed by a Practical Examination. The moderation of Centres entering Candidates for Separate Skills on both modular and linear syllabuses, for A level and AS, was carried out at the same time, and to the same standards. Hence, the practical work of all candidates for module 4839, module 4848 component 2 and syllabus 9244 Paper 9 together with any Physics parts of the work of candidates for module 4848 component 2 and module 4844 component 1, was moderated together. There was a total of over 400 centres, with an average of 8.7 candidates in each Centre. 85% of the candidates, representing 70% of the Centre entries, were entered for modular A level (module 4839/01), with 24% of the Centre entries, but only 5% of the candidates, for modular AS (module 4847/02).

**Skills and Assessment**

For Experimental Skills, there are three skills, each with six sub-skills, and the assessment of each of these has a maximum of two marks; the maximum overall score is thirty-six. Assessments are made from a number of experiments, typically five or six for each candidate, each contributing a mark for one or more sub-skill. Hence the final score for any particular candidates is the sum of the best marks from each sub-skill. There is, therefore a pick and mix of sub-skill, and high marks can be expected, and were common; indeed, before moderation, 21% of candidates had been awarded thirty-six. The Moderators noted that, in a majority of Centres, parts of each sub-skill were assessed many more times than the minimum number required, on occasions spread throughout the course, with the best of several marks for each sub-skill contributing to the final score. Centres should ensure that the best example of each sub-skill is chosen for each candidate. It should be noted that, in any particular experiment, it is not necessary to assess all the sub-skills of a skill. A limited range of different sub-skills is generally combined for each experiment.

**Experiments**

It is clear that interesting practical work is being carried out by candidates, and some work of a high standard was seen by the Moderators. However, it appears that this still applies to only a limited number of Centres, although a slight improvement was noticeable this year. It may well be that the process of assessment, rather than Physics, continues to influence the tasks set by teachers; it is hoped that practical work other than for assessment does take place.

Tasks used for assessment should be carried out individually, and it is expected that Centres will be able to confirm that al experiments contributing to final scores are candidates' own unaided work. It should be ensured that A level standard if maintained; the Moderators noted some experiments more suited to GCSE. If experiments are too simple, candidates are not given the opportunity to display a full range of practical skills. On the other hand, tasks should not be over-ambitious; the Moderators found occasional examples of complicated experiments with several aims, which resulted in very lengthy experimental accounts. The information given to candidates needs careful thought; instructions that are too prescriptive could invalidate the assessment of some sub-skills. The Moderators were again aware of a number of cases in which a great deal of theory was involved in an experiment, and this was often unnecessary. Teachers should not feel constrained to exemplar material for their assessed experiments. Fewer experiments than in the past used questions taken directly from past Practical Examination Papers, or investigations described in text books; these tend not to be appropriate as they are generally too prescriptive, although such tasks can be modified, with the assessment of a limited range of sub-skills in mind, to create suitable experiments.

Tasks should be set to match particular criteria. The Marking Schemes should show how the criteria are applied to each experiment; these should make clear what is required for each sub-skill, with the award of two marks being realistic and appropriate at this level, without attempting to stretch the limits. There were many examples of a score of two marks for a sub-skill being awarded to work which did not fulfil all the requirements for that sub-skill. It is not helpful for candidates to write their accounts using headings of the sub-skills, since this is likely to make the work to compartmentalised.

Centres are encouraged to read and take note of the Moderator's Report to the Centre; a minority appears not to do so, since similar comments are made in successive years. Reference should also be made to the Handbook for Teachers, which includes an Amplification of the Criteria for each of the sub-skills.

**Documentation**

The Moderators were pleased to receive all the paperwork from many Centres, according to the published Instructions. However, this was not always the case, and omissions hindered the moderation process; Moderators cannot be expected to search through a poorly organised package of work to find appropriate documentation.

The sample of work required for moderation depends on the number of candidates in the Centre; the selection for the 10% of the Centres that entered more than twenty candidates was made by OCR, while the work of all candidates in the other, smaller Centres needs to be submitted. It is helpful if the work for each candidate is collected together. There should also be all relevant Instruction sheets or Worksheets, the detailed Marking Schemes used by teachers and Teacher Observation Sheets, showing details of the necessary observations of the candidates made during experiments. These should be accompanied by the Moderator's copy of the completed computer mark sheet, MS1 or its EDI equivalent, the Centre Record Sheet and the Student Record Cards, with the eighteen best marks clearly highlighted. The procedure for Internal Moderation should be described on the Submission Sheet. The administration can be completed only after the sample for moderation has been established. Only those experiments contributing to the final score of the candidates in the sample should be sent in and not experimental work which does not count; a Candidate Mark Sheet should be attached to each experiment, showing only those marks which contribute to the final score. It must be ensured that all the work is marked, and that there is full annotation, in the body of the work, of each sub-skill assessed, at the point where the evidence is recorded and the mark is awarded, together with the mark and any brief appropriate comment. A small number of Centres submitted work which did not show any marking or annotation.

**Moderation**

During moderation, the Moderators endeavour to ensure that the quality of practical work awarded any particular mark in one Centre is the same as that in any other Centre. The criteria are fixed, and therefore the standards for particular marks will remain the same from year to year. Since marks are initially produced by sub-skill, moderation is also by sub-skill. If the standard of work submitted is not satisfactory, then adjustments are proposed; these provisional adjustments, by sub-skill are accumulated, to give an overall picture of the Centre. Although there were some mark increases, most adjustments were mark deductions, and there were several cases of these being fairly large.

Skill A required the most adjustment, with only 44% of Centres needing no adjustment; the average provisional adjustment, across all centres was a deduction of 1.1 marks. For Skill B, 65% of centres needed no adjustment, and the average provisional adjustment was a deduction of 0.5 marks, while for Skill C the equivalent figures were 56% and 0.6 marks. Overall, 25% of Centres needed no adjustment at all and the average proposed deduction across all Centres was 2.1 marks. After deciding what adjustment was appropriate for a Centre the Moderators then had to consider the tolerance. Only adjustments outside the tolerance are applied. The final result of moderation was that the marks of 79% of Centres were not adjusted, and the average deduction actually made, when averaged across all centres was slightly less than 0.9 marks.

**Skill A**

Skill A is the Planning of investigations, and not all tasks were appropriate for this; the Moderators were concerned to note the relatively large number which were not suitable. Tasks should not be trivial and standard A level experiments are inappropriate. While a task to determine a constant of proportionality or a power could be relevant, an experiment to determine the value of a particular constant, especially if it is in the syllabus, is likely to be more appropriate for Skill B and/or Skill C than Skill A. Tasks requiring a verification are likely to be inappropriate for Skill A. Relevant theory can be given, and the task should be open-ended, so that it is possible to approach it in different ways; all the criteria can then be assessed. If the account for a planning experiment is word processed by the candidate, it could suggest that such planning was not completed before carrying out the experiment, or was not completed under test conditions, thus making it invalid for assessment. It is not possible to assess sub-skill B1 on the same task as Skill A, since the planning of an investigation is incompatible with the following of instructions provided.

- For A1, there should be a choice between alternative methods, or different techniques of measurement, within the task; the approaches should be considered by the candidate on paper, before selecting the one to use in the experiment. A choice between variables is not appropriate. The Moderators were concerned that the requirement for A1 was not being correctly interpreted in a significant number of Centres; if only one approach is considered, then no marks can be awarded.

- For A2, the task should be analysed and a correct development, from basic Physics principles and with experimentation in mind, should be shown; this is more than just considering theory.

- A3 should include a statement of those variables that are to be kept constant, as well as those which are to be varied; this is the concept of a 'fair test'.

- The plan, in A4, of the steps which it is intended to follow, should clearly be outlined, in writing and in the future tense, in a logical progression; a report of what was done is not appropriate since it does not necessarily mean that well-ordered steps were planned in advance.

- For A5, the apparatus should be chosen so that the variables can be measured, and also the constants can be monitored; where relevant, reasons for the selection should be included.

- For the assessment of A6, the task should be carried out, and the experimental account written; modifications can be made by the candidate as the experiment progresses. The effectiveness of the plan should then be judged by the candidate, in writing, as part of the account.

**Skill B**

Skill B involves the gathering of experimental data. When assessing sub-skills B1, B2 and B3 there will be little or no evidence in the candidate's work. For moderation, there is the need for a written record; a Teacher Observation Sheet, or check list, should therefore be used, to support the awarding of the marks for B1, B2 and B3. The moderators were concerned to find that there are still centres which do not submit such sheets; it was felt that, in future, such omissions would be likely to disadvantage candidates at the Centre.

- Instruction will have been supplied, and therefore B1 cannot be assessed with Skill A. The requirements should not be trivial, and the details of the observations made are needed for moderation.

- For B2, the task should be appropriate, with relevant safety features to permit assessment. The Moderators noted a large number of tasks used to assess B2 in which safety aspects were too trivial; this could have resulted in a provisional adjustment of a deduction of one or two marks. Centres are encouraged to consider carefully the tasks on which safety is assessed.

- Similarly, for B3, the task should be appropriate and not trivial, with a record of observations to support the assessment.

- In B4, the emphasis is on the appropriateness of the number of readings, their range and its coverage. Giving the number, or range, of readings in the instructions invalidates the assessment of B4.

- The assessment of B5 involves the clear recording of all readings in a neat single table, with scientific convention followed; the *quantity* / unit format, and appropriate symbols, should be used, as recommended by the ASE. If the format for the tabulation is given in the instructions, then B5 cannot be assessed.

- B6 covers appropriate and consistent, significant figures in the raw data, together with the validation of results, which is usually by repetition; the repeated readings, or other checking of data, should be shown, generally in the table, or occasionally elsewhere in the account.

**Skill C**

Skill C is the interpretation of data, and making conclusions.

- For C1, an appropriate and correct process should be evident, and this is generally considered at this level, to include a graph; the graph should, correctly and neatly, display all the conventional features if the maximum mark is to be awarded. The use of computer-generated graphs should be avoided here, so that candidates can display their full range of skills in plotting graphs, and also, for C4, in making deductions from them.

- C2 includes the use of appropriate significant figures in the processed data, with students reviewing their own experiment by considering features of their measuring and processing techniques. A detailed error analysis is not necessary, but, if carried out correctly is an appropriate way to consider reliability. Unfortunately, the Moderators noted, once again, a number of cases in which candidates considered a discrepancy from an expected value, or attempted unsuccessfully, to combine uncertainties without demonstrating any relevant understanding; such calculations were often unrealistic or used where not appropriate, thus showing a failure to appreciate the underlying Physics.

- In C3, there should be a critical evaluation, or discussion, of the experiment actually carried out, by considering the procedures used and any problems encountered; possible and realistic solutions to at least some of the problems should be offered, together with a discussion of the consequence of the proposed modification. Merely suggesting a more sensitive measuring instrument is not sufficient. Neither the carrying out of suggested modifications, nor any suggestions for further investigations are required. If the procedure cannot be improved, then some discussion, to justify not changing is expected.

- C4 covers the treatment of results, and will generally follow C1, often involving deductions from a graph; these should be made with appropriate accuracy, and the interpretation should refer to the Aim of the experiment.

- For the assessment of C5, there should be a valid conclusion, correctly calculated from the processed data, and this should be expressed as a clear and concise statement, consistent with the data obtained.

- In C6, the whole piece of work is judged; it should be well organised and clearly presented, with a good standard of English.

**CAMBRIDGE LINEAR A LEVEL PHYSICS 9244**
**JUNE 2000 ASSESSMENT SESSION**

**Component Threshold Marks**

| Component | Maximum Mark | A | B | C | D | E | N | U |
|---|---|---|---|---|---|---|---|---|
| 1 | 30 | 25 | 22 | 19 | 17 | 15 | 13 | 0 |
| 2 | 90 | 73 | 67 | 59 | 51 | 44 | 37 | 0 |
| 3 | 110 | 73 | 62 | 52 | 43 | 34 | 25 | 0 |
| 4 | 50 | 39 | 36 | 31 | 27 | 23 | 19 | 0 |
| 5 | 50 | 39 | 36 | 32 | 28 | 24 | 20 | 0 |
| 7 | 36 | 32 | 29 | 26 | 23 | 20 | 17 | 0 |
| 9 | 36 | 34 | 31 | 28 | 25 | 22 | 19 | 0 |

**Overall Threshold marks**

| Option (components) | Maximum Mark | A | B | C | D | E | N | U |
|---|---|---|---|---|---|---|---|---|
| A (1, 2, 3, 4) | 310 | 226 | 206 | 180 | 155 | 130 | 105 | 0 |
| B (1, 2, 3, 5) | 310 | 229 | 207 | 182 | 157 | 132 | 107 | 0 |
| C (1, 2, 3, 7) | 310 | 236 | 212 | 186 | 160 | 134 | 108 | 0 |
| D (1, 2, 3, 9) | 310 | 239 | 215 | 189 | 163 | 137 | 111 | 0 |
| H (1, 2, 3, 89) | 310 | 239 | 215 | 189 | 163 | 137 | 111 | 0 |

The cumulative percentage and number of candidates achieving each grade was as follows:

| Grade | A | B | C | D | E | N | U |
|---|---|---|---|---|---|---|---|
| Cumulative percentage | 24.2 | 41.7 | 56.9 | 72.0 | 83.1 | 91.4 | 100 |
| Number of candidates | 220 | 380 | 518 | 656 | 757 | 833 | 884 |