GCE

Physics A

Advanced GCE **7883**

Advanced Subsidiary GCE **3883**

Report on the Units

June 2007

3883/7883/MS/R/07

Oxford Cambridge and RSA Examinations

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Advanced Subsidiary GCE Physics (3883)

REPORTS ON THE UNITS

Forces and Motion (2821) June 2007

General comments

The general impression of the Examiners who marked the paper for this module was that the level of difficulty of the questions was appropriate for the candidates for whom it was intended. The paper consisted of a wide range of questions covering a large proportion of the Specification. The questions and mark scheme allowed those whose responses indicated a good level of understanding to achieve very good marks. At the same time the average candidate was able to demonstrate a pleasing standard.

The candidates produced a very wide range of responses and the majority of questions provided good differentiation. There was an almost complete range of marks but very few scored less than 10 or more than 50. This suggests that the paper contained sufficient material to test the most able candidate. There were a significant number of candidates with a mark of less than 20 and there appeared to be little evidence of the course being thoroughly taught in these cases. Those candidates with less than 20 were often unable to give acceptable definitions, used inappropriate formulae in their calculations and often left complete sections of questions blank. Questions 3 and 4 were the main questions that had sections that were left blank and candidates from some centres seemed completely unprepared for such questions.

The mean mark for candidates in this session was 32.4, which was similar to the mean mark obtained in the June session in 2006 of 31.6. All the questions provided the opportunity for the weaker candidates to score some marks, and each question had at least one part in which the more able candidates were able to show their understanding of the subject. The responses differed widely depending on the Centre. There were many centres whose candidates had clearly been very well prepared but equally there were a number of centres where the candidates had a very poor understanding of the concepts involved. The lack of precision, poor use of English, basic errors in calculations, poor presentation of mathematical analysis and the failure to read the question carefully reduced the marks of many candidates of the full range of abilities. However, the majority of candidates were able to give good answers to some parts of every question.

The first parts of question one allowed a good proportion of the candidates to get off to a good start with the paper. The most able candidates scored highly in all the questions. The written explanations in question six were often of a poor standard by candidates of all abilities. Students did not read the question and gave long inappropriate answers explaining the physics after the parachute had been opened. The length of the paper was considered to be correct with the vast majority of the candidates finishing the paper in the required time. The standard of written communication was generally adequate with many candidates scoring at least one of the marks available for written communication.

Comments on Individual Questions

Question one

Q.1 (a) (i) the majority of candidates scored full marks on this part of the question. Very few gave the reverse answers and only the weak candidates were unable to gain some credit on what was considered an easy start to the paper. Parts (ii) and (iii) were designed to test the understanding of adding vectors along the same line and when there is an angle between the vectors. This part proved to be very good at discriminating. The majority answered part (ii) correctly but only the better candidates were able to complete the analysis of the vector triangle of forces. Many candidates did not use the components they had calculated in the vertical and horizontal directions but went back to the original forces from the diagram. However, they often used

Pythagoras for the triangle that clearly did not contain a right angle. A significant number of candidates added the two forces that were acting in different directions to determine their resultant. Part (iv) was more demanding and only the better candidates scored even one mark. Two marks were seldom given. Very few candidates answered the question that required the magnitude of the resultant of the other forces that were acting. Part (b) was generally well answered. However, a significant number of candidates did not use the total downward force they had been given in part (a) (ii) in order to calculate the pressure. The majority knew the pressure formula but by no means all.

Question two

Q.2 (a) the answers given were often centre dependent. There were many incorrect answers that referred to mass acting or mass being concentrated or balancing at a point. The correct terminology at this level is expected. Weight or gravitational force is expected not ‘gravity’ or where the ‘mass acts’. Candidates often scored marks in parts 1 and 3 of part (b). This question was found to be difficult by many candidates with many unable to take moments from the most suitable pivot in part 2. In part (ii) only the better candidates scored one mark for stating what happened to the forces A and B. Very few could give a satisfactory explanation, involving moments, as to why the forces should change in this way. Parts 2 and (ii) proved good discriminators in this question.

Question three

There were very good scores on this question by the better candidates. However, a significant number failed to obtain any marks leaving sections blank. Some only managed to obtain the last two marks for the potential energy calculation. Part (a) discriminated well at the top end. The weaker candidates were unable to differentiate between the vertical and horizontal motions. Part (a) (i) was well answered by those who recognised which part of the motion had accelerated motion. Many candidates did not appreciate how straightforward (a) (ii) was meant to be and tried to use equations of accelerated motion. Some then did realise that a = 0 and obtained the correct answer. However, many went on to use non accelerated motion to calculate the vertical component in 2. Candidates would benefit from more practise of the treatment of the independent analysis of the horizontal and vertical components in projectile motion. Part (b) was generally well answered. A few answers were seen involving a change in the mass value that was given in kg in the question to g by the candidate and a value given to only one significant figure.

Question four

This question produced good differentiation. The required answer for part (a) was generally given. In part (b) (i) more candidates seem to know the expression for density than in the past. Weaker answers still involved mass / area. Marks were generally lost due to poor presentation of the expressions for volume and then area. Often strings of numbers were given without any identification of the quantity being determined. The calculation in (ii) was good at sorting out the candidates as the weaker candidates found difficulty rearranging the equation. Only the best were able to go on and solve part (iii). Part (iv) was easier and many gave the correct answer despite not being able to complete the calculations in the parts before.

Question five

The performance on this question was generally good with many candidates scoring 9 or 10 marks. Parts (a) and (b) proved generally straightforward. There were again a significant few who failed to square the speed in the kinetic energy formula. The main weakness was in (b) (ii) where the equation for constant acceleration was not used by many candidates. Part (c) proved to be a good discriminator mainly due to candidates not reading the question or giving incomplete answers. There were still many candidates referring to ‘grip’ or ‘traction’ instead of friction and often road conditions were not given at all in their examples. The effect on the braking distance was often not given. The last part had one straight forward mark that the majority of candidates obtained. The second mark was only obtained by the better candidates as the effect on the braking distance of the mass of the vehicle was not clearly explained by the average and below candidates.

Question six

Q.6 Part (a) generated a god range of marks. Very few considered the horizontal component and hence lost the marks that were available for its description. The large majority failed to read the question carefully and did not describe the motion from when she left the plane until the moment she opened her parachute. No credit was given for the many descriptions about the motion from the moment the parachute was opened until she reached the ground. This part was a good discriminator as many of the candidates had been well prepared for the completed journey. They were expected to apply their knowledge and understanding to a part of this journey. However, there were many poor explanations in which the correct terminology was not used. Terms such as acceleration, velocity and force were muddled and force was often equated with acceleration. Part (b) was generally well answered and candidates were usually able to score at least two or three of the marks. Answers that involved increasing the mass were only given credit when the explanation was correct physics.

Candidates generally scored at least one mark for Quality of written communication. Those that lost a mark for spelling had some of the terms they had miss spelt given to them in the question.

Electrons and Photons (2822) June 2007

General comments

In general, the performance of most candidates was Centre-dependent. The majority of Centres had made excellent use of previous examination material and this had a positive effect on the performance of their students. There was marked improvement in the quality of analytical work. Solutions were generally well structured, concise and attention was given to both significant figures and units. However, a significant number of candidates still do not have an awareness of the magnitude of quantities. This was particularly noticeable in the last question where the mass of the lithium ion ranged from 10^{-41} kg to 10^{22} kg.

The quality of written work is still a cause for concern. On many scripts, it was difficult to interpret the responses of the candidates. There were two main causes. The first of which was writing vague statements such as '*Blue light has more energy'* and the second was using invalid comparisons such as '*The frequency of light is below the work function energy of the metal'*. Candidates need to be reminded that being precise, brief and clear are vital qualities for descriptive work in physics. Candidates need to carefully consider their answers before putting pen to paper.

The marks for this paper ranged from zero to sixty. There were fewer candidates scoring very low marks or leaving questions unanswered. The recall of equations and definitions was marginally better. As mentioned in previous reports, the legibility of some candidates' writing was quite poor. It is not just the words that were difficult to decipher, but also numerical steps and the final answers. On some scripts it was impossible to make sense of the scrawl for the powers of ten, especially when negative numbers were involved. The Quality of Written Communication (QWC) was assessed in **Q5**. Most candidates gained two marks for organising their text and correctly spelling most of the words. Most descriptive answers either had no commas or had too many commas sprayed randomly over the page. Almost all candidates finished the paper in the scheduled one hour.

Comments on Individual Questions

Question One

Most candidates gained five or more marks in this opening question.

The vast majority of candidates realised that the direction of the magnetic field would reverse in **(a)(i)**. More than half of the candidates managed to secure a mark for **(a)(ii)** by making clear reference to either the number of field lines increasing or the magnetic field pattern become much more '*compact'*. Some candidates focussed on the strength of the magnetic field, but mentioned nothing at all about the field pattern itself.

The modal mark for **(b)** was two. Candidates who substituted the term '*motion'* for '*force*' were not penalised.

The majority of the candidates found **(c)** fairly accessible. The magnetic flux density *B* and current *I* were often the two correctly identified terms. Examiners allowed *magnetic field strength* for *B*. Approximately half the number of candidates appreciated that *L* was the length of the conductor '*in the magnetic field*'*.* A small number of candidates gave the units tesla, ampere and metres as the answers; and hence gained no marks.

For **(d)**, the battle was between the tesla and the ampere. The tesla turned out to be the most popular distracter. About a third of the candidates underlined the correct answer (ampere).

Question two

There were very few scripts with full marks for **(a)**. Examiners were looking for two features. The first was a graph depicting a finite resistance at a temperature of 0°C. The second was the correct shape of the graph; which could either be a straight line or a curve with increasing *sensitivity*. The most common sketch was a straight line through the origin. Such an answer could only be give one mark. A significant number of candidates resorted to guessing which resulted in totally bizarre lines and curves.

Too many candidates lost marks for vague statements in **(b)(i)**. Terms like resistance, current and voltage were being used without the technical precision necessary at this level. It was impossible to give credit for statements that lacked precision such as '*the voltage increases*' or '*the current is constant in a series circuit'.* A significant proportion of the candidates failed to make it clear that it was the resistance of the thermistor that decreased. Very few candidates realised that the circuit was a potential divider circuit and hence either $\frac{V_1}{V_2} = \frac{R_1}{R_2}$ or

$V_{\text{out}} = \frac{R_2}{R_1 + R_2} V_{\text{in}}$ could have been used to reason why the voltmeter reading increases.

Fortunately, only a very small number of candidates stated that the current was not affected by the changes in the resistance of the thermistor because '*the ammeter was placed before the thermistor'*.

A pleasing number of candidates either used their knowledge of series circuits or the potential divider equation to determine the resistance of the thermistor in **(b)(ii)**. Candidates were awarded two marks for determining the total resistance (1.67 kΩ) of the circuit. A disturbing number of candidates calculated the current in the circuit by ignoring the thermistor and assuming the potential difference across the 1200 Ω to be 5.0 V. This erroneous physics was given no credit.

Question three

As expected, most candidates picked up the marks for **(a)** and **(b)**. A small number of candidates assumed the component to be a light-emitting diode (LED). Examiners were lenient with this because at least it was a diode. There was no error carried forward from **(a)** to **(b)** if the component was not correctly identified. The most common error was circling the LDR symbol.

The majority of candidates gained two marks in **(c)** for correctly calculating the resistance of the diode at 0.70 V. An astounding number of candidates calculated the resistance of the diode to be 0 Ω when it was not conducting at 0.20 V. There were too many scripts with '$R = 0.20/0 = 0$ Ω'. For many candidates zero resistance was synonymous with no conduction.

Candidates must endeavour to understand what is being asked for in a question before writing on the scripts. In spite of the hint given in **(d)**, a worrying number of candidates made no use of the graph in Fig. 3.1. The e.m.f. of the supply was divided by the circuit current to give an answer of 75 Ω. Far too many candidates assumed this to be the resistance *R* of the resistor and failed to realise that this was the total circuit resistance. Some candidates used the graph to determine the resistance of the diode. A few candidates filled the space with as many equations and numbers as they could. A good number of candidates drew a straight line through the origin in **(e)** but some lost a mark for the incorrect slope.

Question four

This was a high-scoring question with candidates demonstrating good understanding of circuit theory and resistivity.

Most candidates gave correct responses for **(a)**, **(b)** and **(c)**. A small number of candidates wrote '*electromagnetic force'* instead of '*electromotive force'*. The most common incorrect answer for **(b)** was the quantity '*resistance*' instead of its unit the ohm. Examiners were fairly lenient with the marking of **(c)** by ignoring aberrant spellings for the unit of charge.

A good number of candidates gave textbook statement for Kirchhoff's first law in **(d)**. There was the inevitable confusion with the second law. Some candidates made reference to a '*circuit*' rather than a '*point or junction*' in the statement of Kirchhoff's first law. There were fewer vague answers such as: '*current in = current out'*.

Most candidates made a good start with **(e)(i)** by making clear reference to the state of both switches. Candidates were well rehearsed to tackle the resistivity question in **(e)(ii)**. Some candidates failed to convert the length of 15 cm into metres. Others used resistance of either 8.0 Ω or 12 Ω. Most candidates even managed to quote the correct unit for resistivity. Candidates in the lower quartile were convinced that the unit for resistivity was the ohm. The answers to **(e)(iii)** were generally well presented and demonstrated a good understanding of circuits. Almost all candidates found the total resistance of the circuit to be 11 Ω. A small number of candidates could not cope with reciprocals; for example: $\frac{1}{4}+\frac{1}{12}=\frac{2}{16}$. The most common route to the power delivered by the battery was using the equation $P=\frac{V^2}{R}$. In the last section **(e)(iii)**, the ratio of 3 was a fairly common error.

Question five

Many candidates made a good start with **(a)** by quoting '*particle*' and '*wave'* for **(i)** and **(ii)** respectively. Low-scoring candidates made random guesses by using terms from Module 3 (Wave Properties).

The answers to **(b)** varied greatly between Centres. The world of quantum physics remains enigmatic for many candidates. Too many candidates presented rehearsed answers that had little bearing on this specific question. Some candidates wrote details of the experiments they had observed in their classes. Candidates cannot be expected to pick up any marks if they have not answered the question. There was also a lack of planning which led to vague and conflicting statements. However, a good number of candidates did realise that the phenomenon had something to do with photons interacting with surface electrons. High-scoring candidates understood the relevance of the higher frequency of blue light compared with the threshold frequency and appreciated that intensity of the incident radiation did not alter the energy of the photons.

Some candidates struggled with **(c)(i)** and thought the question had something to do with the de Broglie equation. A good number of candidates produced well structured answers. However, some candidates failed to convert the photon energy from electronvolts to joules. There was the inevitable dilemma of what to do with the 1.6×10^{-19} factor. Although the majority of candidates got a mark for **(c)(ii)**, an alarming number guessed the region of the electromagnetic spectrum. The most prevalent incorrect answer was '*ultraviolet light'*.

For most candidates, **(d)** was a formidable task. The majority of candidates could not determine the gradient of the straight line; the factors 10^{-11} and 10^{-4} on the axes were simply ignored. This is a lamentable situation. Determining the mass of lithium ion from the gradient or the de Broglie equation was simply too much for most candidates. Many candidates also could not cope with the $\frac{1}{v}$ axis. A small number of candidates attempted to determine the mass of the lithium ion using the Avogadro constant and molar mass of lithium. Such an approach was not allowed because no use was made of the information provided in the question. On the horizontal axis, the 10^{-4} factor may have been obscured by the grid lines. Centres can rest assured that candidates were not penalised for using 10^{4} instead of 10^{-4} in their calculations.

2823/01 Wave Properties June 2007

General Comments

The general standard of work was similar to last year and the paper provided ample opportunity for candidates to demonstrate their knowledge and understanding of the module content. There was no evidence of candidates being short of time but there was a noticeable increase in the number of very weak scripts which attracted less than 10 marks. It appeared that these students were making no effort to score marks and they would often leave many of the questions completing unanswered.

Comments on Individual Questions

1 This was answered well by the majority of candidates. In part (a) virtually all were able to define frequency but definitions of wavelength were often too vague to score the mark. Popular answers that were not accepted included *"length of a wave"* and *"distance from one peak to another"*. Those who stated *"distance from one peak to the <u>next</u> peak"* secured the mark.

Before we met for our mark-scheme standardisation meeting we became aware that virtually no candidates were able to derive the formula $v=f\lambda$. This was somewhat surprising because this question has been asked before and is clearly stated on the specification. It was decided to reallocate one of the marks to part (c) (ii) for a full explanation of how the distance from a flash of lightning could be determined. Most candidates finished the question well by being able to identify two differences between sound and light waves.

2 Most candidates found this to be a straightforward question and the mean mark was high. The most common errors were to label the critical angle ***C*** between the ray and the surface and to use the wrong value for the refractive index ***n*** when calculating the angle of refraction in the air for an angle of incidence of 30^{o} in the glass. A value of 19^{o} was very common instead of the expected 50^{o} even though in (b) most had correctly shown the ray being refracted <u>away</u> from the normal when leaving the glass block.

3 There were many different shapes drawn for the pulse of light at the end of optic fibre. Most scored the mark by showing that the pulse was now covering a greater time span. The majority could recall *"multipath dispersion"*, explain its meaning and suggest a valid way of reducing it.

4 Many found this to be the most difficult question on the paper. The definition of *'coherence'* was marked quite strictly with the idea of a "constant phase difference" being required. Yet again, candidates seem very weak in explaining what is meant by "path difference" and being unable to state the required value of the path difference for constructive and destructive interference to occur. Most choose to offer explanations involving the more abstract concept of phase difference. Teachers are urged to look closely at the specification requirements and to teach interference phenomena by emphasising the path difference of the waves involved. Virtually all could recall the 'double slit' formula: $\lambda = ax/D$ but many failed to take sufficient notice of the stated units and consequently made substitution errors. Very few candidates were able to predict the appearance of the fringes when a white light source was used. Some scored a relatively easy mark by simply stating that a spectrum would be formed but very few referred to the white central fringe.

5 Most candidates showed some understanding of why there would be hot and cold areas in the microwave oven but very few were able to offer a concise and convincing explanation of how the standing wave was formed. Only about 50% of candidates correctly labelled the positions of two antinodes but significantly more determined the correct value for the wavelength of the microwaves.

PRINCIPAL MODERATOR'S REPORT FOR Physics "A"

2823/02 AND 2826/02, Summer 2007

There has been a slight increase in both the number of centres entering this session and in the number of candidates submitting work.

The vast majority of the work was of a very high standard and very well marked by the centres. Most assessors now fully understand the mark scheme and therefore very few adjustments were needed.

When centres were moderated, the movement is back to zero tolerance and not to the +/- 4 allowed in the original marking. Most moderation therefore involved only 6 or so marks but the very few centres that suffered a major adjustment are urged to attend a training session, either the national meeting for new markers, held in London in December or a more private one that can be arranged closer to the centre, (please contact OCR Training Division for more details).

Many centres offered detailed annotation and mark schemes, care should be taken that they are in line with the specification's scheme. Only one "Centre Authentication Form" is needed to cover all the candidates entered and most centres had correct paperwork. Centres must try to ensure that the work they present is that of individual candidates and not a collective exercise. The marker does sign that this is the candidate's own work, unfortunately downloaded scripts and direct copying still seem to get authenticated.

The use of the 8 marks for Planning and Analysing should be viewed with great caution, this level should be for the very best possible work and not awarded too easily. If a moderator disagrees with the award of 8 marks for these two areas, the maximum permitted tolerance is already used up, only one further disagreement will cause the centre to be adjusted downwards. If the 8 mark is awarded, please annotate clearly why the marker feels that this is exceptional quality. Please remember that the "A Grade" is, generally, at 80% of the available marks.

I beg to offer much the same general advice as in previous years.

Often the work presented at AS shows a great deal of guidance is being offered by the centres, it must be borne in mind that in order to score heavily, it is the student's work that should be considered and not the teacher's. At A2, the level of guidance offered should be kept to a minimum so that the quality of original work offered by the candidate may be considered.

There are still rather too many experiments that do not comfortably match the mark descriptors. If the investigation does not end up giving a straight-line relationship on a graph, the higher descriptors in analysis are very difficult to obtain.

All the descriptors may be assessed on a single piece of work with one graph; there is no need to do investigations involving comparisons that simply offer a series of repeat observations. A really fine piece of work may well be completed in less than 10 or 12 sides.

The major problem with A2 remains the linking of work back to other areas of the specification (bold type in the mark scheme); this must be done to get above level 3. Candidates should be encouraged to make these cross-links clear in their work and where this is done, an annotation from the marker would be of great assistance. A good grade A can be obtained with less than 12 sides of A4. Some centres are still allowing their candidates to produce in excess of 100 sides, this may stem from the fact that the students are so excited by their tasks that they get carried away, but the time would be better spent revising for the theory papers and not producing more than one graph etc. etc.

Planning

Attention should be paid to the progressive increase in scientific knowledge and understanding as the basis of the mark descriptors. There should be a variety of external sources referred to in the text. The use of “Wikipedia” is increasing; however students rarely do students acknowledge what authority this source has for the statements made. Anyone can add a page so it is difficult to exhibit the same trust that one might give a recognised encyclopaedia or a university source.

A preliminary experiment should be just that not a double run of the main investigation.

An area often missed is the detailed discussion on the choice of equipment to be used (in terms of precision and reliability). This will severely hinder progress to the higher descriptors.

Implementing

All results should be recorded to the degree of precision available from the apparatus eg to 1mm with a metre rule, and they should be consistent. All observations should be repeated and tabulated properly with units. Care should be taken that we are only looking at direct observations in this section and any inconsistencies in derived figures should be assessed at A7a.

Analysing

It is difficult to progress in this section with anything other than the analysis of a straight-line relationship. Very few candidates take the statistical route though these descriptors and the measurement of a gradient or intercept is more usual. The use of small triangles when taking a gradient is to be discouraged due to the large uncertainty that this would introduce. Only one gradient is needed to assess the mark.

Where ICT is used, strict attention should be paid to the significant figure problems that may be introduced and to the correct labelling of axes. The use of software that will not produce a good trend line is to be discouraged, many candidates are still producing simple “dot to dot” lines.

Centres should be careful in the use of significant figures in producing the candidate’s final answer. In particular, uncertainties are sometimes quoted to a greater number of significant figures than the actual result. Again, the use of good scientific knowledge and understanding is at the root of these descriptors.

Evaluating

The numerical evaluation of uncertainties is required and then the combination of these uncertainties into the final values to give, where possible, an “x +/- y” result. Uncertainties can rarely be quoted to a high number of significant figures and if left produce rather silly looking answers.

Comparison with a recognised value is of use to assess reliability but is not what this section is about. The difference between the book value and the student’s value if not the error. The level of work involved needs only to be similar to that found in the appendix of “ Physics 1”

Once the uncertainties of observations or procedures have been looked at, improvements should be suggested to increase the reliability of the investigation. This should really be attempted in some detail rather than the simple addition of a computer without the description of how it might be used and to what level the improvement might be.

2823/03: Practical Examination 1

General Comments

The general standard of the work done by candidates was again similar to previous years. Candidates still find the analysis section in question one and the evaluation section in question two the most difficult parts of the paper.

Some Centres experienced difficulties in obtaining the necessary apparatus for question 2; however all centres did have appropriate equipment in time for the practical examination.

Candidates appeared to complete the paper within the necessary time allocation and most candidates were able to complete question one and two without help from the supervisor. Sadly there were a small number of Centres where inappropriate help was given. Usually this was in giving the candidates the formula to work out resistance or to assist candidates in the analysis section. It is essential that Supervisors read the instructions carefully.

Candidates should be encouraged to show all the steps clearly when carrying out calculations. In addition candidates should be encouraged to include greater detail in their answers to descriptive type questions, giving reasons where necessary.

Plans are still centre specific. Centres are reminded that the planning sheet should be signed by both the candidate on page two and the teacher on the front page. Sadly some candidates were reported for having too similar plans.

Comments on Individual Questions

Plan

Candidates were required to plan an experiment using a light dependent resistor (LDR) to investigate how the intensity of light emitted by a lamp varies with wavelength.

The majority of the plans were about an appropriate length. Parts **(a)** to **(g)** on the planning sheet are designed to focus candidates' attention to relevant areas where marks will be awarded. Candidates should be encouraged to give a response to each section with reasoning. This summer part **(d)** asked for the range and precision of any instruments that would be used and part **(e)** asked for the factors that needed to be controlled – plans often omitted these parts.

Candidates were expected to draw a workable diagram of the apparatus which included a method of identifying individual wavelengths; this latter part was often missed out. It was also expected that candidates should draw a correct circuit diagram using appropriate symbols. Candidates were also expected to explain their procedure. Some weak candidates suggested wrong experiments such as varying the lamp used. Good candidates explicitly stated that the LDR would be illuminated for a specific wavelength and a measurement would be made from the LDR circuit. Good candidates then added that the procedure would be repeated for a number of different wavelengths.

Most candidates scored marks for suggesting that the experiment should be performed in a darkened room and explaining how the wavelength of light would be determined. Many candidates were vague in their explanation of how a measure of intensity can be obtained from the LDR. A bald equation did not gain this mark.

Candidates often did not suggest factors that needed to be controlled. In this experiment the obvious two factors were that the output of the lamp needed to be kept <u>constant</u> and the distance between the lamp and LDR needed to be kept <u>constant</u>. Additional detail marks could have been scored for the method for achieving the control of the factors.

Many candidates did not suggest the range and precision of any measuring instruments used. There was one mark available for a relevant safety precaution. Again too often examiners just see a list of standard laboratory safety rules rather than an explanation as to why a safety precaution is required in this particular experiment.

There were three marks available for extra detail eg
typical resistance of LDR,
method of determining measuring instruments range and precision
evidence and use of preliminary investigation,
method of maintaining power of lamp constant
discussion of determination of wavelength
discussion of transmission, reflection and absorption of filter.

In the notes for guidance for the plan it is stated that candidates should list clearly the sources that have been used. Two marks were available for evidence of the sources of the researched material. Detailed references should have page or chapter numbers or be internet pages. Two or more detailed references score two marks. Two or more vague references scored one mark.

Most of the more able candidates were able to score two marks for the quality of written communication which were awarded for the organisation and sentence construction of the Plan.

1 This question asked candidates to investigate how the potential difference across part of a circuit depends on the resistance of the circuit.

Candidates were initially asked to set up the circuit and measure the readings on an ammeter and voltmeter. A few candidates needed help; a maximum of two marks were penalised if help was given. It is very helpful where Supervisors write in detail the actual help given. Candidates were then asked to calculate values of $1/R$ and $1/V$. The latter caused few problems. Often the wrong formula for resistance was used and a few supervisors gave inappropriate help at this stage.

The justification of significant figures was poorly answered. Good candidates successfully related the number of significant figures in $1/R$ to the <u>number of significant figures</u> in I and V. Answers that referred to accuracy, decimal places and graph plotting did not score. Some candidates referred to the calculated value of R.

Results tables were generally well presented. The majority of candidates labelled the columns with both a quantity and the appropriate unit for I and V; however the units for $1/R$ and $1/V$ were often wrong or missing. It is expected that there should be a distinguishing mark between the quantity and the unit. It is expected that all raw data should be included in a table of results. All the raw data should be given consistently.

Graphical work was generally done well. Weaker candidates often used either less than half of the graph grid for their points. Points were usually plotted accurately to the nearest half square. Often mis-plotted points were very obviously wrong; candidates should be encouraged to check points like this as they finish plotting graphs. The majority of candidates drew their line of best-fit with a fair balance of points.

It is expected that the gradient should be calculated from points on their best-fit line which are at least half the length of their line apart. Weaker candidates often lost marks either by using triangles that were too small or by working out $\Delta x/\Delta y$. Good candidates clearly indicate the points that they have used and show their calculation. The *y*-intercept was usually correctly read from the *y*-axis. Where candidates could not read off the *y*-intercept, it is expected that they should substitute a point on their line into the equation $y = mx + c$.

In part **(g)** candidates were asked to determine values for *E* and *P*. Again weak candidates do not follow the question which tells them to use their answers for determining the gradient and *y*-intercept. Failure to use these values prevented candidates gaining four marks. Good candidates equated the *y*-intercept to $1/E$ and the gradient to P/E. A large number of candidates gave the appropriate unit for *P* as the watt!

Part **(h)** asked candidates to explain whether their results indicated a random error. Large numbers of candidates failed to refer to their results often just describing errors which might have occurred in their practical work or differences in their values of *E*. Examiners expected the scatter of points on their graph would help candidates explain the random error. Candidates were expected to give an appropriate conclusion.

Part **(i)** asked candidates to determine the percentage difference between two values of *E*. A common error was that candidates just divided one value by the other without finding the difference. Good answers clearly demonstrated the method used to calculate the percentage difference.

2 In this question candidates were required to investigate the rise of water in a capillary tube and then write an evaluation of the procedure.

In part **(b) (ii)** most candidates recorded the rise of water correctly. It was expected that the height would be measured to the nearest millimetre.

The determination of the percentage uncertainty was better on this paper with most candidates using the correct ratio. Many candidates did not use an appropriate absolute uncertainty in *h*.

The majority of candidates gained a larger height for the smaller diameter capillary tube.

In part **(e)** candidates were asked whether their results supported the relationship that *h* is inversely proportional to *d*, explaining their reasoning clearly. No marks were awarded without reasoning. Weak candidates were either very vague with their reasoning or confused inverse proportionality with direct proportionality. Good candidates calculated a constant of proportionality. It is expected that candidates will then draw a conclusion based on their results.

Part **(f)** asked candidates to suggest how the internal diameter of the capillary tube could be measured. It was expected that a travelling microscope would be used. The second mark was gained for taking repeat readings and averaging the results.

(g) Weak candidates are still evaluating experiments by describing the procedure they followed. Some candidates wrote very little of substance. Good candidates scored well by describing relevant problems and suggesting specific ways to overcome them. Vague suggestions without explanation did not gain credit. In particular human error without explanation did not score.

Credit worthy problems:
Difficultly in seeing liquid in the tube,
discussion of parallax or meniscus problems,
discussion of difficulties with measuring *h*, eg tube and ruler moving
water droplets or dirt within the tube will affect *h*
two readings of *h* and *d* are not enough to verify the suggestion.

Credit worthy solutions:
Using dye,
method to avoid parallax, clamping the capillary tube and rule, marking scales on the capillary tube, use of a travelling microscope
dry and clean the capillary tube before use,
use many different diameters or tube <u>and</u> plot a graph relating *h* v *d*.

Two marks were available for spelling, punctuation and grammar in this part. These marks were not scored as well this year as in previous years. Often weak candidates did not use capital letters at the start of sentences and there were many spelling errors.

2824: Forces, Fields and Energy (Written Examination)

General Comments

Candidates are very familiar with the layout and style of the question paper which has remained unchanged. Strong candidates appeared to have ample time to complete all the questions, writing a very full answer to the last question. Less than five percent of candidates failed to attempt at least half of Q7. Many middle of the range candidates scored widely different marks on different questions, showing significant knowledge of some topics and little of others. The most successfully answered questions by all candidates were Q1, Q3 and Q5. The question which proved most difficult for many was the ideal gas question, Q2, where weaker candidates spent much time attempting unnecessary calculations instead of following the guidance in the stem of the question. Some candidates also used elaborate methods in two sections of Q4, taking much time to complete. In the questions written in the form 'show that…' candidates were much improved in showing all the steps in any calculations.

Comments on Individual Questions

1 **(a)** In general this question was well done. Most candidates were able to show the new expression clearly. In part (ii) most drew a graph accurately by plotting several points.

(b) The two most common mistakes were in (ii) using $E = \frac{1}{2}m(5-4)^2$ to give 1.1 J and in (iii) using a time in hours instead of seconds. Otherwise this part was done well. Nearly all candidates were able to handle logarithms correctly.

2 **(a)** In the derivation of the revised formula for the equation of state few showed a fully reasoned argument. Candidates often confused themselves and the examiner by failing to distinguish their symbols for pressure and density and for molar mass and total mass of gas. Most started with density but then often ignored the number of moles, n, or assumed it to be 1. However a reasonable number did use $\rho = \frac{nM}{V}$.

(b) Only a minority of candidates knew what to do here, and even fewer were successful in their attempt to justify the exponential nature of the curve. Some were unhappy about an exponential decay that did not involve time so the *h axis* was often referred to as the *t axis*. Those who took readings from the graph concluded that halving the pressure meant a doubling of height, not a constant fraction of pressure in equal increments of height. Some attempted to show that dp/dh was proportional to p (or unfortunately h), but this proved too difficult for all who followed that particular route.

(c) Few candidates presented a solution using ratios but those who did usually gained full credit. Most students calculated the mass in order to find the density, that is, used a full expression for pressure including R, T and M, to achieve the correct new density.

(d) A significant minority left the temperature in celsius and scored no marks A correct solution here often followed on from a good answer in part (c). However there were many slip-ups involving the use of the pressure in part (c), 35 kPa, instead of 30 kPa as required here.

3 **(a)** The drawing of field lines was extremely varied. In many cases very little care was given to make the pattern symmetrical and with lines starting and stopping normally to the surfaces of the spheres. Calculations in part (ii) were generally well done but a few used the 53 factor for the charge on the iodine ion. Other marks were lost through careless application of arithmetic.

(b) There was a tendency for candidates to write down statements of the laws of motion with no real attempt to apply them to the situation described. Attempts to apply the principle of conservation of linear momentum missed the point of the question. Most candidates could quote the definition of simple harmonic motion. Better candidates were able to link acceleration and displacement if not amplitude, but often the magnitudes given in the question were ignored.

(c) The graph and subsequent explanation concerning resonance were usually well done. Some of the sketches, although of the correct period, were far from sinusoidal in shape.

4 **(a)** The gravitational field line was usually given correctly. There was no penalty if the line went below the surface of the planet, but it had to reach the planet.

(b) A large number of responses for the gravitational field at the surface used r instead of R in part(i). In parts (ii) and (iii) the more common correct answers involved a full calculation involving the mass of the planet. Rarely were one line answers using ratios given. In part (iv) common wrong answers involved averaging the 40 together with the 2.5 and 1.6 N kg^{-1}.

(c) Most candidates got part way through the calculation and gained some credit. There were many correct answers but some methods were very lengthy, losing the candidates valuable time. There were many possibilities of mistakes on the way.

5 **(a)** The definition of momentum and its application to an explosion were generally done well. More candidates than one might have anticipated were unable to cross multiply their initial statement to achieve an answer in the form requested.

(b) This question discriminated well with most candidates working through successfully as far as part (iii). In part (iv) a large majority used 45kg instead of 50kg giving a slightly wrong answer, which was then glossed over. This scored the candidate zero. However the mark in part (v) was usually scored. Answers to part (vi) were also good even by those who had got lost earlier in the calculation. Most made a good attempt at drawing the displacement time graph, often scoring at least two marks out of the three.

6 **(a)** This first part was answered poorly. Any reference to nuclei was rare, and for many the terms nuclei and nuclide are the same. Very few could go further than stating that λ is the decay constant.

(b) This part was however answered well, including the calculations in parts (iii) and (iv).

(c) The change of phase and the requirement for specific latent heat were often correctly given as one reason. Some talked about a mass loss and a small minority thought $E=-mc^2$ was relevant. A few gained the third marking point, the second reason, by mentioning either the change in value of specific heat capacity from water to steam or the possibility of energy dissipation to the surroundings.

7 (a) Candidates who read the question carefully were at a considerable advantage. Having started from the appropriate field definitions, their responses had a coherent structure imposed upon them. Those who launched in with a series of unconnected statements invariably missed the point. Most could define the three fields and realise that gravity is only an attractive phenomenon. Many talked about the inverse square relationship, but failed to mention point masses or charges. Many answers were rambling, using a lot of space to explain a single often irrelevant point rather than follow the suggested pattern involving similarities and differences. Few described field lines or the concept of action at a distance. Very few explored the very different vector nature of a magnetic field to the other two.

(b) Candidates usually had a rote understanding of the laws of electromagnetic induction, but found the basic definitions of *flux* and *flux linkage* difficult to explain. There is always much confusion between *cutting lines of flux* and *flux linkage*. The concept of *flux linkage*, let alone *rate of change of flux linkage* is apparently understood by very few. Only a handful could relate Lenz's Law to conservation of energy. Most discussed opposing forces or used similar statements.

The quality of presentation and the standard of writing varied considerably, from excellent to very poor. Better candidates showed sound elements of planning by structuring each new idea as a separate paragraph, with much success and pleasure from the examiners.

June 2007 Examination

2825/01: Cosmology

General Comments

The entry for this paper was similar in quantity and quality to June 2006. Marks on the paper ranged from 6 to 85 out of 90, the average being in excess of 50, and many candidates displayed a good knowledge of Cosmology across the entire paper. Answers were generally expressed well, but there is some evidence that in a small minority of cases poor handwriting or presentation of diagrams is making it difficult for some candidates to communicate their ideas clearly.

The overall standard of mathematics was improved compared to recent years and candidates were able to calculate gradients and give correct units.
Candidates were required to calculate factors of 10^n in questions 3 and 5. It was not uncommon, where calculators were used, for an error with a factor of 10 to be made. Candidates are, it seems, entering 10 x 10^n and getting 10^{n+1}.
In question 1 the formula for the circumference of a circle sometimes lacked the factor 2π and weaker candidates had problems manipulating the logarithms in question 2.

Comments on Individual Questions

1 **(a)** The idea of retrograde motion was well understood and diagrams were used by many to help in their explanations. Some candidates erroneously stated that the planets move backwards, rather than *appear* to change direction when observed relative to the stars. It is a small but nonetheless important distinction in this context.

(b) Many answers scored one of the two marks available by discussing either the different periods of planets or the idea of one planet overtaking another, but not both. Otherwise, answers were expressed well.

(c) **(i)** About half of candidates scored full marks on this question. Errors were usually arithmetical, made in the body of the calculation or from an incomplete equation for the circumference of a circle. In some cases, more than one type of error occurred.

(c) **(ii)** This referred back to the result of c.i and a good number of candidates were able to discuss the difficulty that the high speed expected of the Earth could not be detected in Copernican times, this being something of a difficulty in pre-Newtonian times.

2 **(a)** Apparent magnitude was well known by many candidates. The change in value of apparent magnitude was explained carefully in part ii where examiners were looking for the idea that its value would decrease or become more negative when Vega moved closer and appeared brighter. The calculation in part iii produced the usual range of responses. Some candidates confused apparent and absolute magnitude; others dropped the minus sign in the middle of the calculation; logs to the base e were used occasionally but probably the most common error was to bring the factor of 10 outside the logarithm too soon.

(b) The energy generating processes within a Main Sequence star were well explained. Some candidates gained credit by quoting the full p-p reactions, although these are not a specific requirement of the syllabus. The most common slip was to refer to hydrogen *atoms* within the core.

(c) The first two sections of this part were answered well, with errors limited to arithmetic errors in calculation or the omission of g in finding the weight. The ratio provided few difficulties but a number of candidates either got it the wrong way up or left it as two numbers and lost a mark for not working out the final figure. The last part proved more difficult and fewer candidates appreciated that having the fusion reactions limited to the core of a star gave a human being a greater power per unit mass.

3 **(a)** Many candidates gave full answers to this part which were very often amplified by sketch drawings. Credit could be gained by giving a small diagram but it was a requirement that some labelling was included, sufficient to make its meaning clear.

(b) The calculation of distance was relatively straightforward, stemming straight from the definition of the parsec. It was completed successfully by the majority of candidates, the most common errors being to include factors of 3600 or to use trigonometric functions such as tangent or cosine.

The conversion of parsecs to metres was done well and errors from part i were allowed forward without further penalty.

(c) The points of distance and velocity were successfully plotted by most candidates and the best straight line drawn. A number of candidates still use pen for this exercise and risk having difficulties making changes to simple errors.

The gradient was found by nearly all candidates, but a significant minority lost a mark by completely omitting the powers of ten from their calculation. The inverse of the gradient together with the accompanying units were correctly stated by most candidates.

The significance of k as the Hubble constant and 1/k as the age of the Universe was known by many although some interchanged the quantities and a few candidates did not make it clear in their answers to which constant they were referring.

(d) This part was well known by many candidates, who could also quote typical stellar distances for which the use of parallax as a means of measurement is appropriate.

4 **(a)** Diagrams of a spiral galaxy viewed side-on came in a variety of forms, but examiners were expecting to see spiral arms at least as long as the central bulge, which was not always the case. Few candidates could identify galaxy B as being elliptical.

(b) The H-R diagram was well known and only the weakest candidates made serious errors labelling the axes correctly. It was expected to have the y axis as Absolute Magnitude and to include some indication of the temperature scale direction.

(c) This produced a range of answers. The most common misconception was that smaller stars, having less hydrogen to burn, would spend a shorter time on the main sequence.

5 **(a)** The term isotropic was frequently explained poorly, candidates omitting to bring in its directional nature. The accompanying idea of an homogenous Universe was better understood and seems to be easier to explain.

(b) The calculation of volume was done well and candidates had little difficulty working in cubic parsecs. The following explanation in part ii proved harder and about half of candidates determined that the Universe would be more dense, thus resulting in a big crunch.

6 **(a)** The features of stellar spectra were well described by a majority of candidates, but the explanations of emission spectra were generally clearer and fuller than those for absorption spectra. A number of candidates failed to point out that each element has a unique set of spectral lines which can be used to establish its presence in stars. Candidates could also gain credit by referring to the red shift of spectra and the spectral broadening effects.

(b) This question proved more difficult than expected. The relative transmission of electromagnetic radiation through the Earth's atmosphere has been asked in previous papers, in the form of a graph but not all candidates expressed themselves well when attempting to explain the differences in written form. It was not uncommon for the sketch graphs given to contradict the written answer in some way and candidates should be careful to make their meaning clear.

7 **(a)** A thought experiment showing the effect of gravity upon time was described well by about half of all candidates. Examiners were looking for a specific accelerating frame of reference, a statement of the principle of equivalence and a conclusion about the relationship between gravitational field strength and time. This would have gained 3 marks. The other 2 marks were available from the details of the experiment, the measurements taken and the results. The most common example given was of an accelerating rocket containing an observer and two flashing lamps, but full marks were obtainable from other correct experiments, including the 'Harvard tower'. Some candidates would have gained more credit by labelling diagrams and setting out their answers in a slightly more orderly fashion.

(b) The concept of precession was understood by many candidates but the diagrams were generally disappointing. In part ii of the question it was not enough simply to say that Mercury was closest to the Sun: in a question on General Relativity candidates should expect to make some mention of the gravitation field being strongest. For the last part of this question, most candidates ascribed the difference in rate of precession to perturbations from other planets and only a minority referred correctly to the need for Einstein's General Theory of Relativity.

8 Most candidates made a good attempt at this question. The working was shown for the numerical parts at the beginning and there was little evidence that time was a problem in completing this question or the paper as a whole.

(a) The spring constant was found correctly by most candidates. The omission of g resulted in the loss of credit and full working was expected and usually provided.

In part ii it was not uncommon for the factor of 4 to be omitted and the number of arithmetic errors was higher than expected.

(b) The resistance of the rod and power generated within it were found in most instances. Only the weakest candidates had trouble quoting Ohm's law and there were very few arithmetic errors. Candidates could use specific heat capacity to calculate the energy supplied with little difficulty. Again, there were few arithmetic errors but some examples of adding 273 to the temperature difference were seen.

The majority of candidates could find the time of heating but a few used an incorrect relationship for power, energy and time or made an error manipulating the equation.

(c) The first 2 marks on this part of the question were available for discussing conduction in the rod; conduction through the contact; convection in the air; radiation losses or heat loss by water-cooling. Candidates found it difficult to be specific and many answers were poorly explained. Few candidates realised that a longer heating time would result in greater heat losses for the last mark.

(d) Many candidates correctly quoted the equation for resistivity and explained the change in resistance in part i. In the second part candidates usually discussed the change in mass or the change in power delivered but rarely combined both. In parts I and ii a quantitative answer was required in order to gain full marks and candidates found this the most challenging part of the paper. In the final part of the question it was sufficient to realise that a thicker spring would have a greater spring constant and so the frequency would be greater.

2825/02: Health Physics

General Comments

It was noticeable that a general weakness in the population that sat this paper is in the ability to communicate in writing, ideas in a concise and unambiguous way. Much of the numerical work was sound. The same weaker candidates fell into the pitfalls of not explaining their work and failing to pick up part marks when their answers were wrong.

Comments on Individual Questions

1 **(a)** This question caused a number of candidates some problem. The most common mistake was to confuse cosine with sine. A significant minority made no reference to distance in their calculation and so scored no marks.

(b) There were many vague answers which frequently made reference to 'keeping the back straight', rather than 'vertical' etc. Many responses lacked reference to the two calculations in **(a)** and so lost marks. Less than 25% discussed the moving of the line of action of the force towards the pivot, its consequential effect on the moment and therefore the reduction in F.
(a) (i) 2400 N (ii) 950 N

2 **(a)** Many responses scored well here. A few candidates discussed MRI. It was not uncommon to see an explanation of the production of X-rays, which did not gain any credit.

(b) Most candidates were able to appreciate the hazards of unnecessary exposure to ionising radiation as well as the cost in time and money to the health service.

3 **(a)** This part was well answered. Only a few candidates failed to recall the frequency range of an average adult and the value for the threshold intensity.

(b) **(i)** A number of candidates are entering 10^{-12} as $10\ exp^{-12}$ in their calculators and are getting a threshold intensity of 10^{-11} Wm^{-2}. Another common error was to put the intensity as 65 and to calculate the corresponding intensity level. A few candidates left the answer as $10^{-5.5}$ and failed to convert it into standard form.

(ii) This question showed that a large proportion of candidates are familiar with the graph and can answer simple recall questions about it well, but many don't really understand it. Many candidates seemed to believe that if a sound falls outside the curve, it can be heard very loudly or clearly and a few thought it would cause discomfort.
(b)(i) 3.2×10^{-6} Wm^{-2}

4 **(a)** This was straight forward recall. Many candidates gained full marks. A significant number of candidates failed to start as directed by describing the conditions in the eye when focussing on a point at infinity. There was then a problem when describing the change or accommodation of the eye as they simply described the lens as being 'fat' or 'of large power' and made no reference to how it changed.

(b) Most candidates were able to calculate the power and state its unit.

(c) This question required candidates to acknowledge that most refraction takes place at the front surface of the cornea. Many candidates failed to state this. Most, however, were able to say that there would be some vision.

(d) **(i)** The four pieces of information in the introduction to this question caused some candidates to just multiply numbers in a haphazard way with no written explanation. To answer this question, candidates must start at the cells and work out the value for 85% of the photons. Most candidates were unable to then go on to work out what 100% of the photons would be, given a value for 85%.

(ii) About a third of candidates were unable to recall the AS physics equations $c=f\lambda$ and $E=hf$.
(b)(i) 4.0 unit: D (d)(i) 1.8 x 10^{5} (ii) 8.9 x 10^{-14} W

5 **(a)** There were many good responses to this question. The most common omission was that of the backing medium required to damp the vibrations. However it was still possible to score the full 5 marks as there were more than five marking points.

(b) **(i)** While this question was straight forward, a number of candidates worked through it without taking a value from the graph. The most common omission was that of dividing the time interval by two, as it represented the period that the ultrasound was travelling through the medium and back.

(ii) Many candidates found it difficult to put into words what they wanted to say. Many said that the first peak on the graph would be very large instead of making it clear that there would be a large peak before the two peaks on Fig.5.1. It was quite common to find that the explanation for the large reflection was *due to the acoustic impedance of the air and skin*.
(b)(i) 8.1 cm

6 **(a)** Most candidates were able to communicate that ionising radiation kills cells. Many failed to get the second mark which was available for a qualifying statement.

(b) This was poorly answered. Many candidates used the 200 keV photon energy to answer (i). Most candidates only scored the unit mark for this part of the question.

(c) **(i)** The most common error here was to omit the *k* in *keV* when substituting into the absorbed dose equation.

(ii) Very few candidates made reference to either *bone* in their answer or the information in the table.

(iii) This was generally well answered.

7 **(a)** **(i)** This was usually well answered.

(ii) The most common error was to omit the factor of 4.

(b) The four calculations in this section were successfully answered by most candidates.

(c) This was not answered well. The question asked for two ways in which *energy was lost* from the rod. It was common to find answers that had no reference to *conduction, convection* or *radiation*. Where these words were used, candidates frequently failed to describe where the conduction was occurring etc.,

(d) Candidates would be advised to note that where numerical values are given in a question, quantitative reasoning is expected in an answer. Very few candidates offered this.

REPORT FOR PUBLICATION TO CENTRES: 2825/03 MATERIALS JUNE 2007

Last June's report pointed to a general improvement as compared with the performance in previous June papers. That standard has been maintained. None of the questions on this paper threw up particular areas of difficulty for large numbers of candidates, as has happened in the past, so that marks overall were higher.

The work of the best candidates was impressive; many achieving maximum or near maximum marks on several questions. They showed almost total recall of learnt material, obvious ability to present material logically and succinctly in their explanations, and few errors in numerical work.

However, in the middle and lower sections of the performance range, it was evident that an assumption had been made that a topic not previously examined would not now feature in the paper. This led to a substantial sacrifice of marks for the description of an experiment, referred to later in this report, which should have been straightforward. Fortunately, for all candidates, the calculations on this paper were accessible to all, requiring for the most part the recall and transposition of simple formulae and careful substitution. Many candidates made up for deficiencies in other areas with accurate numerical work. Once again there were minimal mark deductions for unit errors in substitution.

There was some evidence from scripts that a small number of candidates ran out of time to complete the paper. Reference to poor handwriting has been made previously in these reports. This was again a relevant feature for a few candidates, resulting in the unnecessary loss of marks. These candidates however could not be pinpointed as those needing to hurry to complete the paper.

On the whole, the quality of candidates' work was encouraging, with the positive aspects of their performance outweighing the negative.

1 This question gave almost all candidates a favourable introduction to the paper, with many gaining full marks or the loss of a minimal number. The common errors, if made, were:

- In (a), in the repulsion area of the graph, showing the line curving towards the force axis;
- In (b)(ii), adding, rather than subtracting, their numerical value of the resultant force from the given attractive force.
- In (c)(i), using a wrong force in the product of force and number of atoms in the cross-section.

(a) The answers zero and infinity were expected, but candidates who gave answers which suggested some tendency to these values were rewarded. Numerical answers were not accepted.

(b) (i) Many of the candidates' answers revealed serious misconceptions about the nature of a superconducting material. The major misconception is that a superconductor is itself magnetic. The following are examples of candidates' ideas as to how a superconducting material may be used to obtain a very strong magnetic field. 'Place the superconductor in a strong magnetic field.'

'Pass a large current through a solenoid wound around a superconducting core.' 'The dipoles in a superconductor are easily aligned.' 'The material is soft and can be magnetised and demagnetised easily.' Comparatively few answers could be given full marks.

(ii) Mention of minimal heat generation could be rewarded, but few candidates could make a further suggestion.

(c) Almost all gained the marks for the calculation in (i). Only a small minority seemed to appreciate the requirement of (ii). Considerably more could give the answer 'current = zero' in (iii).

2 **(a)** **(i)** covered fairly familiar ground and most answers were acceptable.

(ii) required sketches showing **1** a random arrangement of domains; **2** the growth of favourably oriented domains; and **3** the alignment of domains in the direction of *B*. Most candidates gained 3 or 4 marks, although those who represented domains by arrows alone could only gain the first mark.

(b) **(i)** A reasonable tolerance was allowed in the counting of squares in the loops. There was a 1 mark penalty for each square count outside the allowed limit, but a compensation mark was given if it was clear that a candidate was indeed attempting to find a ratio of areas.

(ii) A large majority of candidates were successful with this calculation. Failure to multiply the 0.030 J of heat generated per cycle by 50, and by 60, each incurred a 1 mark penalty

(iii) To gain 2 marks, candidates were required to state or infer hysteresis and to explain its origin. Many omitted the explanation or gave an inadequate one. The few who stated that heat was generated in the copper coil were only rewarded if they included mention of its transfer to the ring.

3 **(a)** **(i)** Perhaps the fact that this was a 'show that …' calculation enabled a very large majority of candidates to gain both marks.

(ii) Most candidates correctly wrote about energy bands and the energy gap, but penalties were applied for failure to link this with the given energy and wavelength data.

(b) This required, for the first time in a paper of this option, the circuit for and the description of an experiment to find *h*. Circuits often omitted a means of varying the voltage applied to the LED or the correct placement of a voltmeter. There was frequent confusion with an experiment involving an LDR. Many answers involved reading an ammeter and a voltmeter and a calculation of power from the readings. Determination of the result from values obtained was absent or muddled. The marks gained covered the full range from zero to the maximum, with only a few gaining the latter.

4 **(a)** A majority gained both marks; very few scored zero.

(b) Although only a small minority gained maximum marks, most candidates could cope with the main ideas. Most candidates know broadly how free electrons behave but many are confused about the meaning of r.m.s. speed and believe that all electrons drift with the same velocity when there is a current.

(c) Candidates in general scored well with the calculation. It was encouraging that many of the candidates with lower marks overall gained all 4 marks here.

5 **(a)** Surprisingly many only sketched a field outside the solenoid, and could only gain 1 mark for the directional aspect of the field.

(b) The simplistic answer ‘perpendicular to the field’ was acceptable and usually given.

(c) **(i)** Except for occasional lapses over powers of 10, maximum marks were frequently gained.

(ii) Any sensible references to the Earth’s field were rewarded, but candidates gaining this mark were few in number.

Nuclear an Particles Physics (2825/04)
Principal Examiner's Report, July 2007

General Comments

This paper revealed the usual range of competence in the answers. Excellent performances were returned by a minority of able, well prepared candidates but a small minority showed little evidence that they had actually taken the course at all. Poor handwriting hampered some candidates to the extent of making their answers unintelligible. Candidates should also be encouraged to use sketches to illustrate their answers. Where sketches were asked for, many candidates failed to take sufficient care over their drawing and lost marks accordingly. This applied particularly to Q.2(b)(iv) and Q.5(d). Poor expression and inability to construct a reasoned answer also resulted in loss of marks by some candidates, especially in Q.4 and Q.5(a). A more serious concern was the failure, particularly in Q.4 of candidates to address the question asked, resulting in most cases in almost certain loss of credit.

As last year there was some reluctance to use standard form, especially in answers; perhaps in part this reflects a shortcoming of some modern scientific calculators. Candidates should realise that standard form is a shorthand which actually makes the business of handling very large or very small numbers easier and less prone to error. It was also a cause for concern that some candidates stated answers which were clearly absurd but they failed either to check for the error or to even comment on the answer.

As a general point, candidates should realise that the figures in data of 1.66×10^{-27} kg and 1.67×10^{-27} kg are not interchangeable. The former relates to the conversion between kg and u while the latter is a particular mass namely that of the proton. On this paper use of the wrong figure was not penalised but in some situations it would be.

Comments on Individual Questions

1 **(a)** **(i)** Candidates were expected to calculate the gradient of the r3 vs. A graph in the usual way and most were able to achieve this. A few candidates failed to use the powers of ten and so lost this single mark. A few failed to notice the request to deduce the gradient ie find its value, and simply stated that it is equal to some function of r or r_0. Some candidates failed to score here because of mistakes in reading from the graph axes.

(ii) It was expected that candidates would use the formula $r^3 = r_0^3 A$ to deduce that the gradient is equal to r_0^3 and so calculate a value for r_0. Many were able to do this but others either did not know the formula or failed to manipulate it successfully.

(b) Most candidates made a good attempt at finding the density of the carbon nucleus, albeit in a variety of ways. It was expected that candidates would substitute the value for r_0 into the formula for the volume of a sphere, and then divide this into the nuclear mass to find the density. Many succeeded in achieving a correct answer for this though errors involving omission or wrong inclusion of the nucleon number (12) were also common. A surprisingly large number of candidates took their value of r^3 directly from the point on the graph where A = 12. Needless to say this did not give a very precise value but candidates were often careful enough to be able to arrive at an answer within the allowed range. The process of taking cubes or cube roots caused problems in some cases and some candidates substituted for the volume of the nucleus by taking its radius to be 12 r_0 and then cubing this. Even more seriously, a few candidates left the mass of the carbon atom as 12 (kg) ie they did not remember that this is only its mass in u.

(c) (i) Nearly all candidates were able to calculate the ratio of the density of the carbon nucleus to the density of diamond though many by this stage had carried forward several errors! As usual, a correct deduction of an answer from an erroneous previous value did not lead to any further loss of marks.

(ii) Candidates were less successful in explaining why this value is so high. They were expected to realise that most of a carbon atom is empty space and that the mass of the atom is virtually the same as the mass of the nucleus inside it so that the density of the atom will be much lower than the density of the nucleus. Credit was often lost because candidates failed to relate the situation in the atom to the mass and volume ie to the disparity of densities. Some candidates attributed it to the space *between* the atoms in diamond or commented irrelevantly on the fact that the bonds in diamond are strong. Many realised that most of the atom is empty space but failed to refer to the mass at all.

2 (a) (i) Candidates were expected to state that a thermal neutron is one whose energy is similar to that of the atoms or molecules through which it is passing, or simply to say that it has low kinetic energy. Some candidates scored by specifying its k.e. quantitatively in terms of eV. Others lost the mark by stating that it has energy due to its temperature, forgetting that temperature is a concept which cannot apply to a single particle.

(ii) Although (as implied in the question) thermal neutrons trigger the fission of a U-235 nucleus, the important point to make was that only thermal neutrons have a high probability of being absorbed by a U-235 nucleus. Many candidates made the former point but omitted the latter. A few thought that a fast-moving nucleus would pass right through the U-235 nucleus.

(b) (i) Most candidates were able correctly to plot the 3 points on the graph of binding energy per nucleon against nucleon number.

(ii) It was expected that candidates would sketch a line through all the plotted points, make the line peak somewhere to the left of the bromine point and then head towards zero. Some attempted to show the peaks which occur at nucleon numbers of 4, 8 etc. but these were neither rewarded or penalised. The main causes of loss of credit were either to sketch a line which did not pass through all the points and/or to make the line peak at the bromine point.

(iii) This was an absolutely standard calculation of the energy released from a U-235 nucleus during fission and most candidates were able to score full credit. Of others who attempted this part a few (less than in earlier years) failed to multiply the energy per nucleon by the nucleon number and so scored partial credit if they did the otherwise appropriate addition and subtraction.

(iv) Candidates were expected to sketch a graph of relative yield vs. nucleon number which had two peaks of equal height which were sensibly symmetrical. The trough between the peaks was expected to be close to 118 (ie half the nucleon number of U-236). Many were able to do this successfully though a few sketched lines which started from the origin and went either straight or were curved without any turning point. It is perhaps worth pointing out that in cases like this where the quality of a hand-sketched line is an issue, candidates can compensate for any lack of artistic dexterity by stating that (in this case) the curve is intended to be symmetrical.

(v) Many candidates lost marks here by failing to address the actual question which asked them to mark, on the *previous* graph the regions where most of the fission products lie. Many attempted to mark the regions on the graph which they had just drawn - a pointless exercise since they do no more than state what is already apparent from the graph itself. To score fully they needed to show two regions each of which included one of the fission products and to label each region **F**. Some candidates showed only one region and failed to score. Others marked the **F** in two places but failed to show them as regions of the graph.

(c) **(i)** In order to confirm that 120 collisions were necessary to slow down the neutrons from a fission reaction to the stated speed it was necessary to multiply the original speed by 0.93 raised to the power of 120. A high proportion of candidates were able to do this. Of those who failed to score fully, most either left the section blank or applied some erroneous calculation eg they found the loss of speed at the first collision and then subtracted 120 times this amount in an attempt to confirm the final speed. Some gave the correct expression but then failed to show that they had worked it out by merely stating the answer given.

(ii) In this part candidates were asked to explain why the loss of speed in a given (head-on) collision was greater than the value of 7% given earlier. Many realised that the difference was due to the fact that the figure of 7% was an average value of many collisions, most of which were not head-on. Of those who failed to score, many stated that the earlier figure was 'only an average', without stating what it was an average of.

3 **(a)** Candidates were asked to explain the importance of gravity in making fusion reactions possible inside the Sun and were expected to state that gravity pulls the plasma together, so increasing its density and increasing the probability of collisions among the nuclei. Credit was lost by candidates who made statements such as 'it contains the material in the Sun' without specifying what material was being referred to. Some spoke of 'gas' being held together or 'atoms', 'molecules', or 'particles'. Still others stated that gravity increases the pressure inside the Sun, failing to recognise that pressure is a macroscopic phenomenon not relevant to the interactions among nuclei.

(b) This was in part a synoptic question which expected candidates to remember that the area under a force-distance graph represents an amount of energy or work done - in this case the work done in bringing a proton from infinity to the point x_0. It is also the minimum energy which an incident proton (or pair of protons) need if fusion is to take place between them. Many candidates failed to score because they answered entirely in terms of force, omitting any mention of work or energy. Typical answers were to state that the graph describes the nature of the force at the x_0 point or to state that 'it shows the region where there is repulsion between the nuclei'.

(c) Most candidates were able to do the straightforward calculation of the kinetic energy of two nuclei inside the Sun at a given temperature. The few who failed to score usually forgot to double the amount for two nuclei.

(d) Candidates were expected to realise that the kinetic energy which they had just calculated was only an average value and that nuclei have a range of kinetic energies. Thus, although their average is much less than the minimum energy for fusion, at any given moment there will always be a small number which will in fact have enough energy to fuse. A significant proportion of candidates had a good idea of what was going on but failed (for example) to state that nuclei have a range of kinetic energies. Nevertheless a few able candidates were able to demonstrate their full understanding of the situation by sketching a graph of the Maxwellian distribution. Some stated that there is a range of *temperatures* in the Sun and the one given is only an average temperature. Many attributed the phenomenon to the fact that not all of the collisions were head-on, even though the question specifically excluded all others. Others referred to 'successful' collisions without making clear that this referred to collisions which resulted in fusion.

(e) Candidates were asked to use data about the nuclear masses of hydrogen and deuterium to find the energy generated in a given reaction in which two hydrogen nuclei fuse to a deuterium nucleus. They should have found the mass defect (preferably in atomic mass units) and then converted this to kg and, using the relativity equation, calculated the energy in joule. Some used the remembered figure of 931 MeV u^{-1} to arrive at the same answer. Many were successful in this; of those who were not, some forgot to double the mass of the hydrogen nucleus (because there were two), some omitted the relativity calculation, some failed to convert u to kg, some converted to joule before calculating the mass/energy defect and encountered dauntingly complicated figures which they then failed to handle correctly. Some candidates simply ignored significant figures before they had calculated the mass defect and so found that the only mass defect was the mass of the electron itself.

(f) Many candidates realised that the positron would encounter an electron and the two would mutually annihilate, releasing energy, though the spelling of 'annihilation' had some interesting variations! The answers which failed to score included the idea that the positrons somehow initiated further fusions (or fissions) by meeting a nucleus.

4 This question was poorly answered by the majority of candidates. Instead of discussing the similarities and differences between the cyclotron and the synchrotron as requested, these candidates simply told the examiner everything they knew about the cyclotron and then repeated the exercise for the synchrotron, leaving the examiner to pick out the similarities and differences for him/herself. The result was that in many cases what would have won credit in response to a straight descriptive question failed to do so because only half of the point had been made. Candidates who scored best addressed their answer directly as requested and dealt with the two machines together throughout.

Beyond this there was a worrying lack of understanding of the underlying principles. Many candidates seem to think that an electric *current* is needed to set up an electric field, thus revealing that they have failed to understand the concept of potential difference at all. This is particularly disturbing on a A2 paper, sat by candidates who have studied the subject for 2 years beyond GCSE. This problem was compounded on some cases by an equally disconcerting confusion between electric and magnetic fields and their role in the acceleration of charged particles. Indeed some candidates, presumably unsure which they were describing, referred to 'electromagnetic fields'.

As in previous years many candidates revealed an ignorance of the realities of high energy physics in that many gave the speed of light as a limitation on the speed which a synchrotron can impart, failing to realise that most particles in most accelerating machines are travelling at almost the speed of light nearly all the time. In this situation it is *energy* which is being imparted and there is no limit to this at all.

Apart from these fundamental weaknesses, many candidates had clearly confused the synchrotron with the linear accelerator because they described electrodes which increased in length as the charged particles progressed through them. Others wrote about poloidal and toroidal magnetic fields, so revealing a confusion with the JET experimental fusion reactor.

There was a common misconception too that whilst the cyclotron can accelerate heavier particles such as the proton, the synchrotron can only accelerate lighter particles like the electron. Although the latter has been the case in the past, the projected Large Hadron Collider will accelerate larger particles. The reason for using it to accelerate only electrons and positrons in the past has been that colliding hadrons (each consisting of 3 quarks) creates a huge mass of data which has been virtually impossible to process. In the case of the LHC the situation will be managed by the use of a worldwide 'computer grid' in order to handle the vast volume of data generated.

5 **(a)** Candidates were asked to deduce, from a stated ratio of lead atoms to uranium atoms, the ratio of uranium atoms left to uranium atoms initially in the rock sample being dated. Unusually there was no standard formula to which candidates could resort and the question required them simply to appreciate that if there were half as many lead atoms present (ie decayed uranium atoms) as uranium atoms left, then one third of the original uranium atoms must have decayed, so two thirds was left. Many candidates realised that the total number of lead atoms plus uranium atoms must equal the number of uranium atoms present originally and so were then able to explain the point in question. Those who made unsuccessful attempts usually either tried to use a standard formula such as the exponential decay equation or tried to relate the ratios to the nucleon numbers 238 and 206. Some lost marks by their inability to construct a reasoned answer.

(b) Most candidates were able to calculate a value for the decay constant of the reaction and were awarded some credit. A minority then went on to use this value in the decay equation to find the age of the rock. Those who failed to do this were probably unable to substitute the initial and final mass of uranium, failing to realise that only the ratio is needed and this is given in the question as two thirds. A few candidates simply calculated two thirds of the half-life and failed to score. A small minority of candidates calculated the decay constant in s^{-1} instead of y^{-1} which lengthened the calculation considerably. Nevertheless error-free calculations were able to score full credit.

(c) Many candidates were able to calculate the number of atoms in the U-238 sample. Most achieved this by finding how many moles of U-238 were present and multiplying this by the Avogadro number. Some calculated it by the equally valid method of finding the mass of a U-238 atom and dividing the result into 5.0 g.

(d) Candidates were asked to sketch on the same graph axes the way in which the number of U-238 and Pb-206 atoms varied with time. This is an area which has been touched on several times in previous years' examinations and well prepared candidates had no difficulty in sketching an exponential decay for U-238 and an exponential increase, approaching the value of N_0 for the Pb-206. The third mark was effectively a quality of drawing mark since the two graphs have to be mirror images of each other. Many candidates were able correctly to show the decay of U-238 but some had difficulty in representing the increasing number of Pb-206 atoms. A few candidates lost credit by failing to label their graphs or by careless sketching; particular weaknesses were failure to show convincingly that the U-238 was *approaching* zero but not reaching it in finite time. Others neglected to show that the number of Pb-206 atoms approaches (but does not exceed) the value N_0.

6 Well-prepared candidates were able to score high, even full marks on this question. Of the minority who scored poorly, probably a high proportion had not covered, or at least had not revised, this topic.

(a) (i) Nearly all candidates were able to state that electrons and positrons are leptons though a few candidates thought they were mesons.

(ii) Nearly all candidates were able to name another member of the group, such as the neutrino.

(b) (i) Likewise practically all candidates knew the quark composition of the neutron.

(ii) The majority of candidates were able to state the charge, baryon number and strangeness of the up and down quarks.

(iii) Similarly most, though not all, could write down the charge, baryon number and strangeness of the neutron.

(c) Candidates were asked to deduce whether the given reaction might be possible. The data given hinted at a solution in terms of a quark analysis, ie seeing whether the quarks balanced on either side of the equation. Most, however preferred to analyse the suggested reaction in terms of the charge, baryon number and strangeness. This approach was not encouraged in the question because candidates are not required to know the values of charge, baryon number and strangeness of the strange quark. However, many candidates did and were able to score full credit. A few lost partial credit by a sign error in the strangeness of the antiquark but still scored most of the marks. Many knew that the reaction could not take place but were unable to justify their conclusion, leaving it to the examiner to construct the argument for him/herself.

7 Answers to this question divided into two parts; Parts (a) and (b) were mainly quantitative and were successfully answered by many candidates. Parts (c) and (d) required some verbal reasoning and answers were less satisfactory.

(a) (i) Most candidates were able to deduce the spring constant by dividing the load by the compression. Of those who were unsuccessful, some tried to apply the equation shown but were unable to continue because they did not know the frequency of oscillation. A few applied the correct equation but forgot to multiply the 5000 kg mass by g in order to find its weight

(ii) This time it was necessary to apply the equation given in order to calculate the natural frequency of the mass supported by the four springs. Although many candidates did succeed in this, others failed to allow for the fact that because the load is supported by four springs, each spring effectively supports only a quarter of the mass. A surprisingly high proportion of candidates made calculator errors on this part.

(b) (i) Most candidates were able to apply the usual Ohm's law equation to find the resistance of the rod but it was surprising that some of these A2 candidates were unable to quote correctly the Ohm's law equation.

(ii) Most candidates calculated the power generated as the product of the current and the potential difference. A minority used one of the alternative equations such as $P = V2 / R$ with equal success.

(iii) Most candidates were able to use the usual expression to calculate the energy required to heat the rod from 20oC to 1000oC. A few revealed a surprising incomprehension by adding 273 to the temperature difference before multiplying it by the mass and the specific heat capacity, and so failed to score.

(iv) Most of the successful candidates then correctly divided this energy by the power dissipation to deduce the time required for the heating process. A few lost these marks by dividing the power by the energy.

(c) This question really consisted of two parts. In the first part candidates were asked to discuss two ways in which energy was lost from the rod and many were able to refer to conduction through the contacts or the air, convection, radiation or to point out that heat is lost to the water. The second part required the candidate to understand that the increase in total energy supplied shown on the graph was the result of energy losses which increased with heating time. Many found this difficult and answers such as 'heat is lost in overcoming resistance' were not uncommon. Some candidates stated that the energy supplied is proportional to the time, presumably thinking that the graph showed how the energy generated inside the heated rod varied with the heating time.

(d) **(i)** Candidates were expected to realise that when the radius of the rod is doubled the cross sectional area will increase by a factor of four and so the resistance will decrease to a quarter of its initial value. Some candidates scored one of the two available marks by making a qualitative statement such as 'the resistance decreases because the cross sectional area increases'. Sadly some candidates omitted any mention of cross-sectional area at all, referring instead to 'more room' in the metal or there being 'more atoms to deal with'. There was also false reasoning such as 'R } 1/A so R increases'.

(ii) In this part candidates needed to understand that two variables were changing. The mass increased by a factor of four, so the heat needed was four times greater; but also the current through the rod has increased by a factor of two, giving rise to a four times greater power generation. As a result the heating time is unchanged. Few were able to reach this conclusion but a minority did deal satisfactorily with one of the two variables, stating, for example, that the mass had increased by four times and so concluding that the heating time would be four times longer ie failing to realise that the power was changing at all.

(iii) This part required candidates to use the frequency formula given in the question and to realise that the thicker rod would be stiffer and so would have a higher value of k, the spring constant. This meant that the frequency of oscillation must be greater. Many candidates stated that the thicker rod would increase the mass of the system, forgetting that m in the formula is in fact the mass of the load. They then concluded that the frequency would decrease.

A2 PHYSICS OPTION 2825/05

TELECOMMUNICATIONS

June 2007

The fall in the number of candidates taking Telecommunications seems to have been arrested although it continues to be the least popular of the five options. In this summer's paper, while most candidates were able to tackle almost every question, there was one topic in which very few excelled; indeed, only one or two out of more than a hundred and twenty scored anywhere near full marks for it. Question 4, which examined their knowledge and understanding of op-amp circuits, clearly revealed that most candidates have little feel for analogue electronics.

1 **(a)** Surprisingly, only about two thirds of the candidates recognised the frequency spectrum as that of an amplitude modulated transmission.

(b) Only about half candidates correctly explained that the signal being broadcast was a 5kHz pure tone, or sine wave, and thus would have no appeal to any potential listeners to the broadcast.

(c) Most candidates correctly stated that the bandwidth in Fig.1.1 was 10 kHz.

(d) About half of the candidates correctly stated that the waveband of the transmission was Low Frequency ranging from 30kHz to 300kHz. (Quite a significant number stated a range that did not include the 45 to 55 kHz given).

(e) Only a minority of candidates scored full marks for their sketch graph of the radio signal as a function of time. For any symmetrical AM waveform, they would have scored one mark and for a calculation of the carrier period (1/50k = 20μs) and the audio period (1/5k = 200μs) they would have scored two more marks.

(f) Surprisingly, many candidates who mistakenly answered part (a) as "frequency modulation", now correctly sketched this part with a carrier centred on 50kHz together with two symmetrical sideband continuums.

2 **(a)** The majority of candidates failed to answer this question satisfactorily and produced very woolly statements as to the meaning of signal-to-noise ratio. For example, many wrote to the effect that it was "how the signal is compared to the noise" or "the difference between the signal and the noise" or "how the signal is in relation to the noise" with no attempt made to qualify their "signal" as current, voltage or power. The answer sought was simply that it is the ratio of signal power to noise power. However, the majority of candidates did know that it decreased with length along the fibre.

(b) The majority of candidates made a decent attempt at the decibel calculations. They had to show that the signal power out of the fibre was 151μW, then show the attenuation in the cable was 20.8dB before calculating the signal power input to the cable to be 18mW.

(c) A significant number of candidates incorrectly stated that there would be an LED at the input to the fibre (some hedged their bets and wrote "LED or laser" but they were denied the available mark). It is necessary to use a laser because only these devices can launch sufficient power into the 65km of cable.

(d) While a few candidates were penalised for their too woolly explanations of an analogue and digital signal, most scored the two available marks. In their explanations of the advantages of digital signal transfer over analogue, however, a large number of candidates revealed considerable confusion over these two forms. Many gave the impression that analogue transfer of TV signals was not possible but this is simply not the case; until relatively recently it was a standard method by which many TV companies transferred signals. For example, many stated that digital signals can be multiplexed as if analogue signals could not be (not so) that digital signals do not suffer from noise (they do) that digital bandwidth is greater (it is not) that digital transfer is faster (it's the same light in the same fibre) or that digital transfer is better (this was the point of the question).

3 **(a)** Most candidates (although some, surprisingly, failed even to answer it) scored the available mark for a reasonable indication of the position of the North Pole on the diagram of the geostationary satellite.

(b) Almost all candidates scored both marks for a sensible explanation of why satellites carry both solar panels and batteries.

(c) The majority of candidates correctly calculated the efficiency of the solar panels to be 15%.

(d) It was rare to see this question completely unanswered and most candidates scored some marks for it. Indeed, it was pleasing to note that about half of them correctly calculated the power received by the satellite dish as 5.67×10^{-10} W.

(e) In explaining how the TV signals get from the TV station to the viewer's satellite dish, most candidates scored one mark for writing that the TV station transmits to the satellite which then retransmits it back to Earth. Several candidates wrote to the effect that the satellite simply acts as a reflector in the sky, like a mirror, and this was a surprise. Many had carrier frequencies in the low frequency waveband and this was another surprise.

(f) While the majority of candidates scored both the available marks for explaining the advantages of satellite TV broadcasting (and the examiners were prepared to accept any two of seven different points), quite a few simply had no idea why this system has come to be so widely used today.

4 **(a)** This entire question was very poorly answered and clearly candidates' experience of op-amp circuits is very limited. Very few candidates scored all the available marks for an op-amp circuit with a correctly drawn amplifier (inverting or non-inverting and several ended up with a Schmitt trigger), a correctly wired microphone, an LED with a series resistor connected to the output and a permanent bias on for the LED (a summing amplifier or the cathode to -15V line or the anode to the +15V line). The maximum gain of the circuit (depending on how the LED is biased) could be between 250 and 500 and a series resistor should have been calculated for the LED to be between about 1kΩ to 3kΩ. Explanations of how the circuit functioned were very poor indeed.

(b) Similarly, very few candidates scored full marks for a decent receiver circuit; a photodiode or an LDR should have been drawn in a potential divider from which a capacitor can remove the permanently on bias of the light level, then the capacitor should feed an amplifier which in turn should drive the loudspeaker.

5 This question should have been a gift to the well-prepared candidate and while many clearly were, a large number were not. The examiners expected no more than that surface waves are below 3MHz and follow the curvature of the Earth by diffraction, Sky waves are between 3MHz and 30MHz and make multiple reflections between the ionosphere and the Earth and Space waves are greater than 30MHz and propagate by line-of-sight.

6 **(a)** A significant proportion of candidates failed to spot that to calculate the spring constant k, all they had to use was, $mg = ke$. In their calculation of frequency of oscillation, most candidates forgot to divide the 5000kg mass by 4 and thus arrived at an incorrect answer of 2.47Hz instead of 4.93Hz.

(b) Almost all the candidates correctly calculated the resistance of the rod to be 4.17mΩ and showed the power generated to be 600kW. Most then continued to calculate correctly the energy required to be 6.17×10^6 J and the minimum heating time to be 10.3s.

(c) Very few candidates were awarded full marks for their discussion of heat losses from the rod and most made rather obvious statements such as "the rod loses heat to the air". To score marks they were expected to mention the physics of heat loss in non woolly statements and to finish by explaining that the trend in the graph is due to the fact that the longer it is heated the greater will be the energy lost so the greater will be the energy supplied.

(d) Again, very few candidates scored well in this part and most relied on poor physics and specious reasoning. The correct answers are that the resistance will decrease to a quarter because the cross sectional area has increased 4 times. The power will increase by 4 times but then so will the mass, so the time of heating will stay more or less constant. The spring constant k will increase so the natural frequency will increase (the majority of candidates confused the increase in mass of the spring itself with the constant mass being set into oscillation).

GCE Advanced Level A
June 2007

Unifying Concepts in Physics Paper 2826/01

Examiner's report

General Comments

The paper and mark scheme were written this year with an attempt to increase the standard deviation. It was felt that too narrow a spread of marks meant that some candidates who made a careless mistake were too harshly penalised. The discrimination on this year's paper was much improved. Many candidates were able to score over 50 but weak candidates struggled to reach 20. A problem that arose this year was an unusual one. It is sometimes difficult to keep the pagination of a paper sensible, without a turn over in the middle of a question, and to allow enough space for questions to be answered. This year there was an encouraging sign that many candidates did look at their answers, and often realised that something had gone wrong. In this case they often squashed up their re-working into a very small space. Examiners had many apologies from candidates written on the paper. Oddly enough, this is a good sign. Candidates did not suffer. Examiners spent extra time sorting out the work because it was not the candidates fault that the work was squashed and much crossed out. Candidates could have requested a separate sheet of paper to insert in their booklet or they could have done the substitute question on pp.10 or 11.

Computer marking is the reason for some pages being left blank but it is not being used for this paper. There were the usual glut of nonsensical answers, some of which are given below. A general problem is that too many candidates will not use <u>words</u> in their mathematical answers. They just string together number after number, using equals signs at random and often not meaning equals at all – just "I am going on to the next stage". Sloppiness is still a problem with many candidates and poor handwriting handicaps a minority of candidates. There is a general feeling that many candidates are not getting enough practice at using their knowledge.

Virtually all the candidates completed the paper in the allotted time.

Comments on Individual Questions

1 This question worked well in that good candidates were able to suggest all or most situations but weak candidates made many mistakes. In (a) the use of the word speed rather than velocity was too common and in (b)(i) it fortunate for many that it was possible to get the mark without stating constant speed. Answers for (b)(ii) and (c) were often described as 'in simple harmonic motion' or 'a mass oscillating on a spring', but the point at which these conditions pertain needed stating. It is a far too common perception of candidates that any object at rest still has an acceleration of *g*. (d) caused problems for many by not thinking about resultant force being zero, but a torque or a couple acting on the body.

2 **(a)** The words 'excess' and 'average' were ignored by many candidates. Some who did calculate excess temperatures then did not use them when reading times from the graph. Here was a particular place where words written down would have eliminated many mistakes. Something like this would not take long to do.

temperature	temperature excess		½ temperature excess	final temperature time
95	80	40	55	22 – 0 = 22
75	60	30	45	31.4 – 8.6 =2.6

The logarithmic calculation in (b) on the other hand was done well, despite the fact that many candidates were using incorrect numbers from (a). Too many were unaware that the unit had to tie in with their own answer. Parts (c) and (d) caused little trouble to the better candidates but it was amazing to see how many candidates thought that *T* in the specific heat equation was time rather than temperature. A number also thought that the temperature *difference* was (72 + 273) K.

3 In part (a) too many candidates gave an answer to the question “Why are power stations near coal mines”. There was plenty of latitude in (b) for different answers and most candidates scored well. However, because too many trivial answers were given here it was decided to allocate only three marks for (b). The other mark was moved to 5(c). Despite all the care taken by the nuclear industry to get its message across about nuclear waste, it seemed that about a quarter of candidates thought that nuclear waste was dumped in the sea as a matter of course. It was interesting to note that many candidates could answer part (d), where the structuring was rigid, but a much smaller percentage of candidates could answer (e). Where candidates did make mistakes in (d) it was usually by getting the 4000 V and 7000 V the wrong way round. Weaker candidates are much too fond of stringing together any voltage and any current to get the power where it is required. Words again would help, as in ‘voltage across leads = current through leads x p.d. across leads’. In (e), lots of candidates started with 800 A instead of working out the new current, 632 A, by considering the power loss in the cables.

4 In the explanation of ionisation some mention of electrons was expected. In part (b) there were a considerable number of power of ten errors and many candidates ignored the speed of light completely. These candidates just used □instead of *f.* One suggested photon had an energy of 8.36 x 10^{14} J. The mark scheme for part (c) demanded the clear statement that because the wavelength of UV is less than the wavelength of light, its photons had the greater energy and then for candidates to go on to conservation of energy type answers. Many candidates only got 1 or zero for their answers. Most knew the equation for (d) and the unit but many lost one or two marks by getting the distance conversion into metres and/or missed the factor of 2.

5 Mistakes abounded in this easy first part. Almost all could get 118 000 J of p.e. at the top, but then many, many candidates gave 118 000 J as the k.e. when the jumper was said to be ‘stopping for the first time’ at the bottom, instead of realising that at that stage all the energy has become elastic potential energy. It is questions like this which make it clear to examiners that too many candidates do not think about their answers at all. Those who made this particular mistake and did stop and think, were able to cross out their initial answer and put the correct one underneath. Answers that did go wrong almost always broke the principle of conservation of energy. The sum of the energies in each column must be equal – someone who never checks anything would not look for this either. The careless brigade carried on with (b). A length is given, 50 m, so tension = 24 x 50 = 1200. The fact that the length required is the extension. = 100 m with an answer of 2400 N means for them yet another mark lost through carelessness. In part (c) it was expected that candidates would state that the elastic p.e. is given by the area under the *F-x* graph (1) and that since the graph is a straight line that area is ½*Fx* (1), then to manipulate the equation into the correct shape (1). One often seen bad mistake was to write k.e. = ½mv^2 = ½kx^2. There were a number of candidates who did not know that ‘show’ in a question ‘is used when an algebraic deduction has to be made to prove a given equation...’. (d)(i) was answered well but woolly answers abounded in (d)(ii) instead of stating that, for a unit extension, the shorter rope needs a greater force.

Report on Physics Practical Examination 2826/03 June 2007

This summer the examination was taken by nearly four thousand candidates. The standard was generally good with fewer really weak scripts than last year. No candidate appeared to be short of time. There was an unfortunate supply problem with the photocells required for question one, and many centres also found that the cells supplied were of very variable quality. Because of this, those involved in the physics departments at the centres had to put in a lot of hard work to enable the experiments to run smoothly, and they are to be congratulated, with nearly all candidates getting decent results.

Question 1

This experiment investigated how differing numbers of glass microscope slides affected the intensity of light passing through them. Candidates found the experiment easy to do and nearly all had good results, as indicated by the straight-line graph they obtained of ln(V) against the number of slides n.

Some centres were under the impression that the maximum voltage that candidates should obtain, with no slides, should be less than 100 mV. However, the instructions stipulate a voltmeter with full-scale deflection of <u>at least</u> 100mV. The use of brighter lights with higher voltage outputs mostly eliminates the problem of stray light in the laboratory affecting the results. The trend of experimental results was not affected by the use of lower voltages

Results were usually well presented in a table, with units correctly expressed, but a large number failed to spread their readings across the whole range of n from 2 to 20. They were penalised if the largest value of n was less than 17. Many candidates failed to repeat readings of the voltage across the photocell, and in trials this voltage was found to waver slightly. Significant figures for logarithms continue to be a problem and few seem to realise that the number of decimal places in the log should match the significant figures of the voltage reading. In this case less than two decimal places was penalised.

Graphs were good, but for one common fault which was to not use enough of the graph grid in the y direction. In trials a very slight curve was sometimes obtained and this could still earn the quality mark as long as there was no scattering of points. Gradients were good with large triangles and most spotted that it was a negative gradient. Intercepts could generally be read off straight from the graph and yet many candidates used $y = mx + c$ to find intercepts which were staring them in the face. Often due to excessive rounding the calculated intercept differed by more than half a square from the read-off. This was not penalised as long as the substitution was correct. In the future this will be marked more strictly, and if a read-off can be made, that value and no other will be accepted.

As expected, the weaker candidates found the exponential equation difficult to cope with, but most used the gradient and intercept correctly to find the constants, and only answers with 2 or 3 significant figures were credited. Many continue to find it difficult to use a micrometer screw gauge correctly, but percentage errors were generally calculated well.

They were then asked to calculate what total thickness of slides would be necessary to halve the light intensity. Only the best candidates coped with this successfully, realising that $\ln 2 = Bn$, hence n and the thickness. The last part of the question was seldom correctly answered. Few realised that the light intensity was mainly reduced by multiple reflections and not diffraction, refraction, air gaps, dust particles etc.

Question 2

This sort of question should be familiar, but it continues to cause problems. Candidates were asked to find the period of vertical oscillations of a spring, loaded with first a 0.6 kg mass, and then a 0.3 kg mass. The oscillations for 0.3 kg are fairly rapid but there are still those who attempt to time a single oscillation instead of ten. Some centres were unable to obtain the recommended springs and very different periods to those expected were seen. In cases like this the examiner will refer to the supervisor's results to avoid penalising candidates.

They were then asked to justify the number of significant figures (sf) used and this produced the usual confusion between sf and decimal places. "I used 3 sf because the raw readings were to 3 sf" is an acceptable answer, but it was only credited if it matched the actual answer given. Candidates who explained that they reduced the sf because of the limitations of human reactions in timing were also credited. Calculations of constants of proportionality were well done and most results showed that the period is proportional to √mass. Good results were usually obtained, despite all the problems detailed in the evaluation section.

There are a lot of skills needed to correctly time oscillations, and the evaluation section was designed to test knowledge of these skills. The mark scheme lists 14 different marking points, of which 8 were needed to obtain full marks, and only a few candidates scored more than 4 or 5 of these.

They were asked to start the oscillation by pulling the mass down by about 4 cm and then releasing it, and this was supposed to imply that the 4 cm was not an important figure. However, a large number did not realise that period is unaffected by amplitude, and wrote a great deal about the difficulties of measuring the 4 cm accurately. This was not credited at all. In trials for the 0.3 kg mass the oscillations switched between vertical and pendulum motion, which made timing difficult, but good results were still obtained.

To obtain more accurate results the usual remedies were credited, ie timing more oscillations, timing against a fiducial marker at the centre, repeating and averaging readings, and plotting a graph using several pairs of values of mass and period (see the mark scheme for details). Use of a video camera was not credited, because this is usually less accurate than skilled stopwatch timing, but a correctly positioned motion sensor was.

Planning Exercise

To teachers this was the familiar exercise of estimating the thickness of aluminium sheet by measuring the number of beta particles that are able to pass through the sheet in a given time. To most candidates this was clearly not a familiar experiment, and it gave opportunities for plenty of research and, in some cases, preliminary work in the laboratory.

There were some straightforward marks available for such things as a diagram of the apparatus, a source and the reason for choosing it, and the method. The method was only credited if the rate was measured for a minute or more, or if repeat readings were taken. It was rather strange that many candidates did not select the obvious Strontium 90 as a source, but instead opted for such isotopes as tritium, krypton, thallium etc. In the guidance notes, it says that the plan should be based on the use of standard equipment and materials found in the standard school or college science laboratory. This also means of course that there is no need for a set of rollers in the apparatus, and many candidates included this in their diagram. They were not penalised.

The next marks were for measuring and subtracting the background radiation (generally done well), using a micrometer to measure the thickness of the aluminium (this was often missed), and for the expected graph of count-rate (or ln count-rate) against thickness. A large number gave a lot of explanation of the mathematics of exponential decay graphs, but seemed unaware that the beta particle absorption graph is not exactly of this type. However, the straight-line ln graph, meeting the y-axis, was accepted, as was the straightforward curved absorption graph, also meeting the y-axis.

Four extra detail marks were available for such items as a description of the working of a Geiger-Muller tube, and for a knowledge of the range of thicknesses of aluminium for which the method would work. Collimation of the source, discussion of the energy spectrum of the source, and discussion of secondary emission, could also earn these marks.

They were finally asked to explain why nearby magnetic fields in the vicinity of the apparatus would affect the results, and what could be done about it. Many had clearly researched this well, and explained that beta particles (electrons) would be deflected (not attracted) by magnetic fields, and described how the apparatus should be shielded by a ferrous metal. Extra credit was given for research, with a reference, into shielding materials, and many candidates earned this mark.

Most earned the two marks available for more than one good reference, from the web or from a book, quoting page numbers. It is surprising that there are still some candidates who do not earn these easy marks. The two quality marks were given for most of the plans, which were generally well-presented. There were fewer overlong plans this year.

Centres are being warned, as they were in the last report, that the planning exercise in future may not have a link with the subject matter of question one in the test.

Finally, there is one instruction that too many centres are not following, and that is to tag the test and plan together, with the **test on top.** Having them the wrong way round causes extra work and hence frustration among examiners. Please would centres take care to get this right next time.

Advanced GCE Physics 3883/7883
June 2007 Assessment Series

Unit Threshold Marks

Unit		Maximum Mark	a	b	c	d	e	u
2821	Raw	60	45	39	33	28	23	0
	UMS	90	72	63	54	45	36	0
2822	Raw	60	47	42	37	32	27	0
	UMS	90	72	63	54	45	36	0
2823A	Raw	120	93	82	71	61	51	0
	UMS	120	96	84	72	60	48	0
2823B	Raw	120	93	82	71	61	51	0
	UMS	120	96	84	72	60	48	0
2823C	Raw	120	88	79	70	61	52	0
	UMS	120	96	84	72	60	48	0
2824	Raw	90	60	53	46	39	33	0
	UMS	90	72	63	54	45	36	0
2825A	Raw	90	65	59	53	47	41	0
	UMS	90	72	63	54	45	36	0
2825B	Raw	90	61	54	48	42	36	0
	UMS	90	72	63	54	45	36	0
2825C	Raw	90	68	61	55	49	43	0
	UMS	90	72	63	54	45	36	0
2825D	Raw	90	59	52	45	39	33	0
	UMS	90	72	63	54	45	36	0
2825E	Raw	90	64	57	50	43	37	0
	UMS	90	72	63	54	45	36	0
2826A	Raw	120	89	79	69	60	51	0
	UMS	120	96	84	72	60	48	0
2826B	Raw	120	89	79	69	60	51	0
	UMS	120	96	84	72	60	48	0
2826C	Raw	120	86	78	70	62	55	0
	UMS	120	96	84	72	60	48	0

Specification Aggregation Results

Overall threshold marks in UMS (ie after conversion of raw marks to uniform marks)

	Maximum Mark	A	B	C	D	E	U
3883	300	240	210	180	150	120	0
7883	600	480	420	360	300	240	0

The cumulative percentage of candidates awarded each grade was as follows:

	A	B	C	D	E	U	Total Number of Candidates
3883	20.0	37.6	54.7	70.7	83.8	100.0	7263
7883	27.2	49.6	69.8	84.6	95.3	100.0	5774

For a description of how UMS marks are calculated see;
http://www.ocr.org.uk/exam_system/understand_ums.html

Statistics are correct at the time of publication

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