GCE

Physics A

Advanced GCE **7883**

Advanced Subsidiary GCE **3883**

Report on the Units

June 2009

3883/7883/MS/R/09

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This report on the Examination provides information on the performance of candidates which it is hoped will be useful to teachers in their preparation of candidates for future examinations. It is intended to be constructive and informative and to promote better understanding of the syllabus content, of the operation of the scheme of assessment and of the application of assessment criteria.

Reports should be read in conjunction with the published question papers and mark schemes for the Examination.

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Advanced Subsidiary GCE Physics (3883)

REPORTS ON THE UNITS

2821 Forces and Motion

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 candidates produced a very wide range of responses and the majority of questions provided good differentiation. There was almost a complete range of marks. There were more candidates with more than 40 marks and fewer candidates with less than 10 marks this year. This was expected as this was a legacy paper taken by candidates who were in the main resitting the module at the end of their A2 course. The range of marks obtained suggests that the paper contained sufficient material to test the most able candidates. The well prepared candidates were able to show their knowledge and understanding and obtain a grade appropriate to their ability. The mark distribution showed that there was good differentiation across the ability range. There were fewer than normal candidates with less than 20 marks and a greater percentage obtained the pass mark for this paper. There appeared to be fewer ill-prepared candidates.

The mean mark for candidates in this session was 39.2, which was 12 marks more than the mean for June 2008 and 9.0 marks higher than the mean mark obtained in the January session in 2009 the number of candidates was approximately 1600 compared with over 7500 in June 2008. All the questions except question 5 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. There was a good range of responses to the majority of questions and so differentiation was achieved. The majority of candidates were able to give good answers to most parts of every question. The length of the paper was considered to be about correct with the vast majority of the candidates finishing the paper in the required time. There were very few examples of blank sections and this suggested that candidates had sufficient time to complete the paper. The standard of written communication was generally adequate with many candidates scoring at least one of the marks available.

Comments on Individual Questions

1 This question produced very good differentiation across the full ability range.

(a) Almost all candidates scored this mark.

(b) This part was not expected to cause the candidates a problem. However almost 45% did not know the three scalar quantities.

(c) (i) This part provided good differentiation with almost 65% obtaining full marks and almost 20% gaining zero marks. The candidates who did not obtain any credit were generally unable to draw a sketch to represent the forces acting and hence gave incorrect relationships between the components of the tension, the weight and the contact force.

(ii) The correct answer to this part was only given by 20% of the candidates. Those who had a clear diagram were able to relate the effect of the change in angle to the tension in the rope. Many descriptive accounts were not clearly reasoned and failed to score.

2 This question produced very good differentiation across the full ability range. There were almost 80% with marks of 4 to 6 with 40% obtaining 5 out of the 6 marks available.

(a) (i) Many candidates scored both marks, with less than 15% failing to gain at least one mark. The analysis was carried out correctly in the vast majority of answers. The main errors were made by not reading the question carefully and failing to select the data for the correct section of slope.

(ii) and (iii) The required analysis was carried out correctly by 80% of the candidates.

(b) The majority of candidates could give one method with a correct explanation of increasing the average speed. However, many failed to give two clear explanations. There were some suggestions that were not given credit relating to F = ma. There seemed to an equal split for ideas that involved adding to or reducing the mass in order to obtain greater acceleration.

3 This question differentiated between the average and the very good candidates. Full marks were scored by 30% of the candidates. Half marks or more were scored by just over 80% of the candidates.

(a) The main error in this part was to multiply the weight by g. A few weaker candidates took the weight given in the question as the mass when they substituted into the expression for gravitational potential energy. However, over 80% of candidates obtained the correct answer.

(b) The definition of power was given correctly by over 80% of the candidates

(c) (i) The determination of the component of force down the slope caused, not unexpectedly candidates more of a problem with only around 50% obtaining the correct answer.

(ii) The determination of the power could be approached in two ways. The component not being an essential requirement. However, an ecf was applied for those candidates who obtained an incorrect value for the component. As a result for this part over 65% obtained full marks.

4 This question was well answered by the average to good candidates. Over 80% obtained half marks or more.

(a) The majority were able to obtain two of the three marks available but only 15% obtained full marks. The main omission was to relate the gradient with the acceleration and the main error was to suggest that as the velocity was zero at 2.0 seconds then the acceleration was as well.

(b) (i) The main omission here was to relate the gradient with the velocity. There were more marking points than the maximum allowed and hence many good candidates scored high marks for this part.

(ii) There were over 60% correct answers for the graph of velocity against time. The remainder made some valiant attempts.

5 This question differentiated well and there was a good distribution of marks.

(a) (i) The vast majority obtained full marks for this part. However, there were a few candidates who managed to give the correct expression but then failed to multiply the two values correctly (120 x 2).

(ii) The mark for this part was often not obtained due to poor descriptions or failure to use the correct terminology. Less than 40% scored this mark. Many referred to rotating forces or the system not being balanced. Marks were not obtained for either these descriptions.

(b) The same comments apply to this part as to (a)(ii) with many of the candidates failing to give both conditions for equilibrium.

(c) There were almost 70% of candidates gaining full marks for this calculation. This is a large improvement than in the past for moment calculations.

6 This question differentiated well and there was a good distribution of marks.

(a) The definitions of stress and strain were usually given correctly. Over 70% obtained full marks. A mark was occasionally lost when the candidate did not refer to the original length in the definition of strain.

(b) (i) There was again over 70% of candidates with full marks for the calculation of the extension. Only 10% made errors with powers of 10 or transcribing the given value for the cross-sectional area. Less than 10% managed to gain only one mark for the expression for the Young modulus without making any further progress.

(ii) This part of the question discriminated well. Many of the candidates failed to see the significance of the wire becoming thinner as well as longer and gave answers to only part of the change. There were some very good answers from the high level candidates. Only 10% scored both marks.

7 There was a good range of marks for this question.

(a) The majority of candidates were able to show that the gradient of the graph gave the spring constant.

(b) (i) More than 50% of candidates were unable to show the work done compressing the spring. The half factor in the expression was often an after thought by many of the candidates as they struggled to obtain the correct answer.

(ii) The calculation in this part was carried out successfully by almost 60% of the candidates. Marks were lost by candidates failing to square root their final value or giving only one significant figure.

(c) This part was only completed successfully by the very good candidates. Almost 20% recognised that the kinetic energy or work done would increase by a factor of 4 but less than 10% went on to describe the compression as being increased by a factor of 2.

8 This question produced a good distribution of marks.

(a) (i) & (ii) The calculations were usually carried out successfully with over 60% obtaining full marks in (i) and over 80% in (ii).

(b) (i) There were more than 20% that did not obtain any marks for this part and only 405 obtained full marks. The main reason for loss of marks was the poor terminology used and the failure to explain that the friction force was acting between the tyre and the road surface and stating clearly the direction of this force.

(ii) The required answer here enabled the vast majority of candidates to complete the paper with full marks for this last part.

2822 Electrons and Photons

General comments

The entry for this paper was much less than previous years. This was expected as it is the final opportunity for candidates to take this legacy paper. However, the range of marks obtained was similar to that of previous examinations and there were many good scripts from candidates who had obviously received good teaching and been thoroughly prepared for the examination by the use of past papers. There were still some candidates that did not appear to have benefitted from the opportunity to develop their knowledge of physics beyond GCSE level and were unaware that good examination answers require the inclusion of key points of physics and the correct use of technical vocabulary.

The presentation of some scripts remains poor despite the comments in previous reports. In some cases, poor handwriting made it extremely difficult to follow the candidates' thought processes. In such cases it is impossible to give the benefit of the doubt to the candidate and valuable marks were lost. In a few calculations even the candidates could not read their own figures, this was particularly noticeable with power of ten digits. There is no real excuse for this untidy, casual approach as candidates did not appear to have been put under time pressure on this paper.

As in the last two sessions examiners were marking scripts scanned electronically. In some cases it can be difficult to decipher scripts where words and figures have been overwritten. In previous reports centres have been reminded to instruct candidates to keep their written work within the scanned regions of the paper. As it is likely that more scripts will be marked in this manner in the future, candidates should be advised to include extra sheets rather than cramp their answers by writing into the zone of the next question. These sheets are always scanned and sent electronically at the same time as the paper, together with repeated warnings of their inclusion to examiners and therefore will not be overlooked.

Numerical skills were varied again this year; marks were lost by a significant number of candidates because of problems with powers of ten and poor understanding of significant figures.
There was no evidence that candidates found time to be a problem, with only a few incomplete answers to questions in scripts from weaker candidates.

Comments on individual questions

Question one

Most candidates got off to a good start with a(i) by identifying Fig 1.1 as belonging to a filament bulb, however, a(ii) proved to be much more troublesome. Many concentrated their attention on the axes and stated that "if the axes were switched over then the gradient would be the resistance". At this level it is expected that candidates are aware that resistance is defined by the ratio of the co-ordinates of the point on the graph rather than its gradient. As in previous years no credit was given to those who confused quantities with their units ie R = volts/amps.
It was pleasing to see the number of perfect answers to a(iii) and to see accurate rounding of the recurring decimal. The minority who lost marks in this part attempted to use the gradient to calculate resistance. This further reinforced the view of the examiners that candidates did not really appreciate the subtle distinction highlighted by a(ii).

Question 1(b) proved to be an excellent discriminator since only the best candidates managed to score both marks. The majority had little difficulty in identifying the need for a straight line for the first squares but did not always draw this clearly through the origin. A significant number of candidates realised that the second part of the graph should be curved towards the V axis but then lost the mark by drawing the graph to cut the axis so implying infinite resistance at that point, clearly contrary to Fig 1.2. It was disappointing to see quite a few graphs in which candidates had not used a ruler to draw the first section of the line thus making it difficult to decide if that section was merely an extension of their subsequent curved graph. The examiners also felt that candidates needed greater practice in interpreting graphs of this nature.

Likewise question 1(c) caused great difficult and only a minority realised that a supply voltage less than 0.6 V effectively 'turned the diode off' and hence reduced the current to zero. The most common error was to apply the 0.4 V across the 120 Ω resistor giving a current of 3.33×10^{-3} A. This value was then used to calculate the answer to c(ii). This approach resulted in no credit in view of the wrong physics involved. However, a bald answer of 0.4 V was awarded full marks in c(ii) as the examiners were unable to be certain that candidates had not used the correct argument to arrive at their value.

Question two
This question was much more accessible to the majority of candidates.

There were a lot of good answers to (a) although some did lose marks because they referred to production methods rather than the required properties. Only a very small minority made errors in the wavelengths of the two types of waves.

It was pleasing to see the number of correct answers to (b) where only a small number of candidates tried to use a formula other than $c = f\lambda$. There also seemed to be less arithmetical errors than in previous years but this perhaps reflected the increased number of candidates whose mathematical skills had been honed over two years of A level work.

The vast majority of candidates knew the correct value for the wavelength of X-rays and were capable of proceeding to calculate their photon energy in joule. Even those making errors in part (i) were able to score marks in (ii) using the ecf rule. There were, however, a significant minority who, after correctly giving the photon energy as hf, used their wavelength value as the frequency. The final part of this question was not answered as accurately however and all too many candidates multiplied by 1.6×10^{-19} C rather than dividing. This, of course, resulted in an extremely small value for the energy in eV which would suggest that those candidates did not fully appreciate why this small unit is so useful in atomic physics.

Question three
There were many very good answers to (a) where only a small number of errors in reading the current value from the graph were apparent. As usual the extended writing expected in (b) caused difficulty to weaker candidates although it was clear that many knew the relevant physics. Many candidates failed to realise that the current in the circuit was causing the thermistor to heat up and that this process would lead to a 'levelling off' of the current when the thermistor was losing heat to the surroundings at the same rate as it was gaining it from the passage of the current. The mark scheme for this question had three relatively easy marks for candidates who recognised the properties of the thermistor and could apply them accurately to the situation and two marks for the more difficult concepts involved in the stabilisation of the current. As a result only a small number of weak students failed to score any marks at all, mostly as a result giving a description of the graph rather than explaining the physics which underpinned it. This question was also assessed in terms of the quality of written communication which was significantly better than in previous examinations – further reflecting the nature of this year's entry.

Question four
Most candidates gave the correct equation for magnetic flux density for (a), and explained the symbols used. The most common error here was failing to explain that the length of wire used in the formula should be that which is contained **within** the magnetic field. This is clearly a point which needs emphasising to students in their preparation for the examination.

Most candidates in (b) could identify two differences in the magnetic field at X and Y although a significant number lost marks by suggesting that "the directions of the fields were different". This was not considered to be sufficiently precise and credit was restricted to a clear statement implying **'opposite'** directions.

There were many accurate answers to (c) where candidates had clearly taken on board the comments from previous sessions regarding the use of the vague term 'down'; the majority giving a clear description of the direction of the force using the words 'into the paper'.

There were many excellent answers to (c)(ii) where the vast majority spotted the need to convert the units for length to metre. Even the more tricky calculation for the average force on one electron was attempted by almost all candidates and a pleasing number managed to achieve full marks. The major difficulty experienced in this part was the inability of the weaker candidates to calculate the number of free electrons present in the given length of wire.

Question five
The sketch graph required in (a) should have been an easy mark for most candidates but a large number gave totally incorrect sketches. Marks generally were lost here through wrong physics rather than poor drawing. This was particularly disappointing in view of the fact that virtually all the candidates knew the correct equation relating Q, I and t and proceeded to use it accurately in (ii). A few errors were seen in converting hours to seconds! Generally the unit for the charge was known and it was rare to see composite units such as A s and A hr.

It was a relief to see that most candidates knew the required formula for (b)(i) and could transpose it accurately. Whilst many scored three marks, a significant minority lost their final mark by rounding the answer to 2 decimal places rather than 2 significant figures. This is a careless error at AS level given the stated accuracy of the data in the question.

For many candidates (b)(ii) was an accessible question and scores of at least two marks, were common. It was, however, disappointing to see so many including the internal resistance of the battery as part of the parallel arrangement giving a total circuit resistance of 0.343 Ω. Another common error was to omit the internal resistance completely. A significant minority were unable to calculate the current drawn from the battery, usually as a result of using the internal resistance of the battery instead of the total circuit resistance calculated in the previous section.

Part b(iii) proved to be beyond all but a handful of candidates. Many of the answers given were centred on the belief that the additional resistance 'shared the current' so reducing the amount available to the lamps. This, of course, makes the assumption that the current into the parallel arrangement remained the same. Virtually no one realised that the addition of extra resistors in a parallel array **reduces** the total resistance and so increases the current drawn from the supply; thus resulting in an **increase** in 'lost voltage' over the internal resistance. The examiners expected that this would cause difficulty to weaker students but were surprised at the very small number who, in their answer, actually realised that the internal resistance played a key role even if they were unable to formulate a precise explanation. This question clearly highlights an area where the fundamental knowledge of candidates remains weak. It is to be hoped that teachers will use this type of situation in the future in order to remedy this gap in their student's understanding of electrical circuits.

Question six
(a) was generally well answered which reflects the good teaching in many centres. Those candidates that did not score a mark here mostly failed to identify what happened to the electrons after interacting with the incoming photons.

Although it was clear that virtually all of the candidates had been thoroughly prepared for a question involving photoelectric effect it still surprises the examiners how many try to score marks without using the word **photon** in their answers. This year the question focused on two types of photons associated with red and blue light, and many candidates gave answers in which the distinctions was far from clear. Many of the answers to (b) contained good physics, which unfortunately did not address the question asked. It was as if candidates had learnt previous mark scheme points and believed that all that was necessary was to repeat these points without reading the question in detail. In fact less than a quarter of the candidates managed to score 3 or more marks in this question which was somewhat disappointing given that the topic has commonly appeared in past papers. It was rare to see an answer which addressed the effect of high intensity on the emission process. It was also disappointing to see so many answers involving the phrase 'threshold energy'. This suggests that there is still considerable confusion between ‘threshold frequency’ and ‘work function’ in the minds of students.

Few candidates marked the position of W correctly in (c) and in (ii) only a small minority identified Planck’s constant as the gradient. A pleasing number managed to score two marks by carefully drawing a parallel straight line graph to the right of the given line in Fig 6.1. This was clearly the easiest way to gain credit in this question and students should be advised to include such drawings wherever possible to clarify their written statements.

Less than a quarter of the candidates were able to give a correct explanation for (d)(i) the most common erroneous answers referred to how tightly the electrons were bound to the atom and to a supposed range of photon energies. Such answers were a sharp contrast to those given for (ii) where the examiners were delighted to find that more than half of the candidates scored full marks for this quite demanding calculation. Those who did not score any marks generally were unable to recall the required formula and resorted to using the mass and charge of the electron in a variety of incorrect ways in the hope of gaining some credit.

2823-01

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. Candidates generally answered the numerical questions better than those requiring continuous prose.

Comments on individual questions

Q1. This was generally well answered by the majority of candidates but some carelessly lost marks in the opening part by failing to define the refractive index of a medium correctly. Most scored full marks for the calculations of the speed of light in the glass but only a minority of candidates could correctly complete the ray diagram showing the passage of light through the prism.

Q2. Most candidates showed good knowledge of multipath dispersion but only a small minority could convincingly explained why a large critical angle would reduce it.

Q3. This question was answered well by the majority of candidates. The only significant error made was failing to show the wavelength does not change when diffraction occurs.

Q4. The early parts, a) and b), of this question were answered well by most candidates but some carelessly omitted the negative sign when identifying the displacement when $t = 1.8$ ms. Part c) caused more problems for many candidates with only a small minority answering parts (iii), (iv) and (v) correctly.

Q5. Most could explain the meaning of superposition by correctly referring to the resultant displacement of the interfering waves. A surprising proportion of candidates, about 40%, failed to score the easy mark for stating the path difference corresponding to the first minimum. Most could correctly label the position of the first maximum but very few scored full marks for the determination of the slit separation because they used a value of 3.6 mm for the fringe separation instead of 7.2 mm.

2823/02 & 2826/02 Principal Moderator's Report

There is little new to say about this legacy examination. The number taking the A2 coursework option remained about the same and a full range of results was obtained. In fact some centres (presumably with assessors new to the specification) still produced the same errors as their predecessors. Overall, the standard was a little higher at AS since the entry was only a small number of re-sit candidates trying to improve their grades. The quality of candidates work at A2 was greatly improved. I have given a full report so that centres will not need to look at archive material to get any help they may require on resit candidates next season.

The comments on the individual descriptors are the same as in previous awards and my reports from earlier years remain relevant.

There is rarely any point in repeating investigations eg the resistivity of a range of materials or finding "g" in several ways, the full range of descriptors can be covered with one in-depth study. Briefly the main features of each skill are as follows.

Planning

A preliminary experiment should be carried out to guide the final investigation, rather than be an early run of exactly the same work. The range, scales, safety and equipment choice should be influenced by this preliminary work. One or two detailed references to books or internet sites are needed at level 7, it would be good if these were taken into account in the body of the work, rather than just used as a means of securing the mark.

Equipment should be chosen taking into account precision and reliability rather than just offering a list of the equipment used, with little justification as to why these particular instruments or methods have been chosen.

Some good science should be shown, to allow the higher descriptors to be met.

With 2826, reference must be made to other areas of the specification. There should be an appreciation that Physics is about simple ideas applied to differing areas of study and that similarities occur based on theses simple rules. Annotation to show where other areas of the specification are brought into the work would greatly aid the moderation process.

The use of the 8 mark should be reserved for really excellent work making the investigation a truly first class study, the mark should be awarded very sparingly. Where given the top mark should be supported by annotation showing exactly why the marker felt if was worthy of full marks.

Implementing

It is important to watch for consistency of observations carried out. They must be to the precision of the measuring device eg 10cm. In a table of results is not to the same precision as 14.1cm. The readings should always be to the maximum precision available with the apparatus used.

The "a" descriptors can only be judged by the centre. A good table of results with consistent readings, repeats and correct units is all that is needed to score up to I7b.

Analysing

Good graphical work is needed with gradients and intercepts taken and used for the award of A5a and A5b. Science of a high level and the correct use of significant figures in the final quoted result are needed for the level 7 descriptors. Again linkage to other parts of the specification is required for A2.

It is difficult to gain high marks here if the investigation does not lead to a straight-line relationship. The careful use of statistics and IT should be encouraged bearing in mind that the final answer should be given with significant figures correctly based on the experimental observations.

Again the award of 8 marks should be viewed very carefully and annotated in detail where the centre feels it is valid.

Evaluating

An objective discussion is needed with identification of where uncertainties lie and how they might be overcome. The identified sources of uncertainty need to be looked at in terms of the numerical effect that they have on the final result. That final result should be given in the form a +/- b, with correct significant figures for both the result and the uncertainty and with the correct units. Improvements should be offered to the procedures to increase the reliability of the results, with the maximum effort being expended on the data with highest uncertainty. A treatment similar to that found in the appendix of “Physics 1” will yield all the “b” descriptors here.
The idea that error is the difference between the observed result and a book value must be avoided.

2823/03 Practical Examination 1

General Comments

This was the last occasion when candidates could take this paper and therefore the cohort was unusual in that there were very few low marks gained. Candidates continue to find the analysis section in question one and the evaluation section in question two the most difficult parts of the paper.

All Centres had the appropriate equipment 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. There were many instances where the planning section of the paper had been carefully researched, however, plans were very Centre dependent.

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

Comments on Individual Questions

Plan
Candidates were required to plan an experiment to investigate how the acceleration of a wheel and axle rolling down a slope varies with the diameter of the wheel. This proved to be a much more open-ended task than previous years

The majority of the plans were of an appropriate length. Many were word-processed, which obviously helps examiners in their assessment, but what a pity that so few use a spell and grammar check.

Candidates were expected to draw a workable diagram of the apparatus that included inclined rails (or track) supporting a wheel mounted on an axle. Candidates were also expected to explain their procedure which must be workable. The diameter of each wheel should be measured by a vernier calliper or equivalent set up. Many candidates were unable to correctly find acceleration from their data. Marks were available for a correct link between their measurements and a relevant equation of uniformly accelerated motion. Confusion between average speed (velocity) and final speed (velocity) led to calculations for acceleration being out by a factor of two. Frequently, all details were surrendered to light gates and computers for a solution.

Some candidates made it clear that their wheels would be rolling down the slope. This occasionally led on to a discussion about the magnitude of the angle of the slope and that by increasing friction on the axle sliding would be prevented. Hence one of the factors to be kept constant was the inclination of the slope. The other factor expected to be constant was the diameter of the axle of every wheel used.
References to the mass of the wheel were treated as neutral.

There were four marks available for extra detail eg

Evidence of preliminary investigation in the laboratory
Further detail for finding acceleration from experimental data
Discussion about structure of slope eg rigidity/height at bottom end/

securing rails
Discussion of the effect of friction/Method of ensuring wheel rolls
Discussion of the angle of the slope
Repeat individual measurements and average/Take several readings of diameter and average.

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. Plans that were too long did not score both marks.

Question 1
This question asked candidates to investigate how the force required to support a metre rule depends on the position of a weight on the rule. ..

Candidates were initially asked to set up the apparatus. Very few candidates needed help; if help was given, one mark was deducted.

Part **(c)** asked candidates to justify the number of significant figures that were used for *Td*. Good candidates referenced their answers to the number of significant figures in both *T* and *d.* Results tables in part **(d)** were generally well presented. The majority of candidates labelled the columns with both a quantity and the appropriate unit. 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. Common errors in this part were to have inconsistent readings (distances not measured to the nearest millimetre) or not to use a suitable range for x.

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. There was also a mark for the quality of the experimentation – in this practical six very good trend plots were expected.

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. Where candidates could not read off the *y*-intercept, it is expected that they should substitute a point on their line into the equation $y = mx + c$. Only occasionally a false origin was used and this resulted in an incorrect *y*-intercept.

In part **(g)** candidates were asked to determine values for W and *R*. Again weak candidates did not use their answers for the gradient and *y*-intercept; failure to use these values prevented candidates gaining four marks. Good candidates equated the gradient to W and the *y*-intercept to *Rgd*/2. Most candidates correctly gave the unit for W as ‘N’.

Part **(h) (i)** asked candidates to determine the percentage difference between two values of *R* and then in **(h) (ii)** explain whether their results indicated random and/or systematic errors. Weak candidates found determining the percentage difference difficult often not finding a difference. The answers to Part **(h) (ii)** have improved since the previous paper. Poorer candidates often failed to refer to their results often just describing errors that might have occurred in their practical work or differences in their values of *R*. Examiners expected the scatter of points on their graph would help candidates explain the whether random error existed. Candidates were expected to give an appropriate conclusion. Too often candidates' answers lacked clarity and thus did not score marks.

Question 2
In this question candidates were required to investigate how the time taken for a cylinder to roll a fixed distance is related to the vertical height it falls and then write an evaluation of the procedure.

In part **(b)** many candidates failed to give repeat readings for the time to roll 1.000m and so lost a mark.

In part **(c)** very few could determine the percentage uncertainty of t and then double it to find a corresponding value for t^2. Many candidates did not use an appropriate absolute uncertainty of between 0.1 and 0.5 second.

In part **(d)** it was expected that candidates would gain a larger value for *t*. There was evidence that many weaker candidates were unable to read a stop watch correctly.

In part **(e)** candidates were asked whether their results supported the relationship that $1/t^2$ is proportional to *h*, 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 for both sets of results. It is expected that candidates will then draw a conclusion based on their results.

In part **(f)** 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.

Credit worthy problems:
Difficultly in timing over a given length,
Difficultly with the direction in which the cylinder rolled,
The ramp being twisted or flexing,
Time taken was too short
Effect of human reaction time
Two readings of *t* and *h* are not enough to verify the suggestion.

Credit worthy solutions:
Use a marker at top or bottom of slope,
Use of smoother cylinder
Use two retort stands or more rigid ramp,
Use a longer distance or smaller height for slope,
Use light gates with a suitable named timer
Use many different heights and plot a graph relating h and $1/t^2$.

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

This was the sixteenth paper set on this specification. Candidates appeared to have enough time to complete the paper and most attempted every part of every question. There was a wide spread of marks and many questions discriminated well. The quality of written communication seemed to be higher than in some recent papers. The mathematical ability was good in solving a problem involving exponential functions in question six, but too many candidates lacked the skills to rearrange a formula correctly in question two.

Question six proved on average to be the highest scoring question, ahead of question one, where some candidates made it more difficult than it was. Candidates often did not read the questions carefully to appreciate what was required of them. This was especially true in question three where for example it was stated that the satellite was used to observe the Earth whereas the question referred to observation of the Sun. Sadly some candidates lost a significant number of marks by writing the answer to question seven (a) as (b) and vice versa.

Comments on Individual Questions

Question 1

(a) (i) Most candidates were able to show the conservation of momentum but a large number also added all the momenta without considering direction. In (ii) some subtracted the kinetic energies, ie considering energy as a vector quantity, yet still managed to obtain the required answer. In (iii) a surprising number were not able to identify which of the masses was the neutron. Many students made comments on the value of the neutron's kinetic energy without giving its value, so scoring no marks. Part (iv) was often done correctly where it was necessary to use 3 significant figures.

(b) The most frequent approach was to calculate the mass defect and then use Einstein's equation. Some converted u initially using 931 MeV to achieve a successful outcome. Weaker candidates used the kinetic energy formula or were unable to proceed further than 0.019 u.

Question 2

(a) The definition of SHM was usually correct.

(b) There were rather untidy attempts to draw arrows on the diagrams, for example, with T alongside the string. A common wrong answer was to include extra arrows on the diagram, such as centripetal (or even centrifugal) force.

(c) (i) Data was usually correctly retrieved from the graph and the length of pendulum often calculated correctly. A large number had problems with transposition, being unable to make the length the subject of a correct equation. Almost all of those who could achieve the correct answer for (i) managed to do (ii) correctly.

(d) Answers varied widely but it was rare to find students who could give a reasoned argument. It was hoped that candidates would consider the projection of the circular motion of the bob onto a diameter which is the same motion as the pendulum bob to this approximation. However each sensible comment, for example, considering that the lengths of the two pendulums are the same, gained a mark.

Question 3

(a) There were many good and complete solutions but all too often M, m, m1 and m2 were used without clarification or explanation when they were ignored or cancelled in deriving the required equation. R and r were also used indiscriminately.

(b) Most indicated the increased velocity factor but rarely was the smaller circumference included in the full answer. Again many candidates made incorrect statements of the form 'v is inversely proportional to R' ignoring the square root sign.

(c) (i) Many failed to mention the same time of orbit and so lost this mark. In part (ii) most of the diagrams were correct. In part (iii) it was often the mass that was to be adjusted to make the satellite move at the correct speed. Rarely was the reduced resultant gravitational force even mentioned as being a contributory factor in establishing a stable orbit at an unnatural speed. It seemed that many candidates thought a satellite could be given the correct speed by booster rocket or by use of correct mass, and all would be well, without reference to resultant force. The convenience for such an observatory often centred on the ease of transport to and from it; confusion in the mind between a low altitude terrestrial orbit and a solar orbit putting the observatory around 1.5 million km from the Earth.

Question 4

The idea of capacitors charging and then discharging seemed to be poorly understood by many candidates, as well as the resulting changes in current and voltage around the circuit. Answers also showed that potential difference is still poorly understood and it frequently 'flowed through' various places. (a)(i) Very few candidates referred to the fact that the capacitor was uncharged and therefore there were zero volts across the resistor in parallel. In (ii) many gave an equation to show that the current was 3 mA, without really justifying that there were 12 V across the 4 kilohm current-limiting resistor.

(b) (i) Few showed the correct final values of current. Some gave 1.5 mA for both, presumably giving half the total initial value shared between the two meters. Others gave 3 mA and 0 again, the other way round. (ii) Some recognised the two resistors as a potential divider whilst others that the resistor and capacitor are in parallel. Few gained both marks whereas in part (iii) both marks were often obtained.

(c) This was quite well done. Most were able to gain some credit for the graph, possibly with errors carried forward. Most attempted sensible decay curves. The time constant often had a power error. Many confused time constant with half life when drawing the graph.

Question 5

(a) There were few instances where candidates drew the field lines within the iron core.

(b) (i) Some candidates had muddled ideas about the definitions of flux, density and linkage. The equation was often given without the accurate reference to cross-sectional or perpendicular area. . In (ii) the most popular choice was B, but much evidence of change of mind and uncertainty. When flux was selected, the reason was by default, that is, because turns and area vary, hence cannot be flux density or flux linkage. In (iii) and (iv) the main mistake was with flux density where n=4 was selected because of largest area. Flux linkage was well answered. Those who chose flux density in (ii) gained marks by error carried forward for flux by choosing n = 4 because of the largest area.

(c) Most candidates were able to quote Faraday's law but in this example of core heating few candidates mentioned or described eddy currents. The cause of heating was usually given as heating in the coils being passed on to the core.

Question 6

(a) This question was answered well by many candidates. Most gave 94 for the answer to (i) but other near values were also offered. (ii) was usually correct as was the answer to (iii).

(b) In part (i) some candidates failed to understand that moles are defined in terms of grammes not kilogrammes so the error of 1000 was often suppressed to achieve the answer given in the question. In (ii) the calculation was usually done correctly to the appropriate number of significant figures. Part (iii) was usually done correctly. In part (iv) many gained the correct time showing a good understanding of exponentials. A small proportion misread the question and found the fall to 1% rather than fall by 1%

(c) Both answers were usually correct although some of the hazards given were quite fanciful and descriptive.

Question 7

In general, descriptions of alpha particle scattering (b) were more successful than the scattering of X rays or electrons (a), although some candidates used electrons or beta particles in Rutherford's experiment. There was much confusion between terms deflection/diffraction/reflection/back scatter. Sadly some confused (a) and (b) and wrote answers the wrong way round, scoring no marks.

(a) Candidates often focused on one aspect only, such as the set-up, but not the results, or the wavelength but not the equipment. Those who followed the X-ray route tended not to be as confident about the resulting interference pattern. Quite a few wrote about X rays and electrons rather than concentrating on only one in enough detail. In many cases ‘an atom’ was described as the target rather than a crystal. Rarely was a very clear or accurate diagram given. Rarely were the electrons described as low energy. However those candidates who had been taught these experiments and who understood them gained a large proportion of the marks.

(b) Again, most candidates referred to the correct classic Rutherford scattering experiment and were able to gain useful marks. Many of the details of the experiment were known, although marks were lost due to vague or incomplete answers. For example candidates mentioned the large volume of empty space in the atom but did not go on to describe the properties of the nucleus so missed many of the marks available. The quality of written communication was of a higher standard than in many previous papers.

2825/01 Cosmology

General Comments

The entry was slightly up on the previous year but the overall standard of work demonstrated a similar range of achievement. There were a number of outstanding scripts and at the other end of the scale, few candidates who scored very low marks. Candidates who were well prepared were able to give correct definitions, describe events and processes in detail and use diagrams to illustrate their answers. The mathematical skills shown were very variable: it is understandable that there might be some problems with logarithms, but it was surprising to see difficulties manipulating algebra or interpreting a straight line graph which passes through the origin.

There were very few instances of candidates having insufficient time to complete the paper. Where this happened the candidate often tried to put too much detail into the Cosmology section, leaving insufficient time for the last question, so it is certainly worthwhile to emphasise the importance of time management.

It was evident that many candidates had made good use of past papers and mark schemes but, as detailed below, there were many instances of marks being lost through simple arithmetic errors. It was evident in the descriptive questions that those candidates who structured their answer tended to gain more credit.

Comments on Individual Questions

Question 1

(a) (i) This question was generally well answered and it was acceptable to have a diagram only, so long as it had a relevant label.

(a) (ii) The explanation of how phases arise was found to be harder. Many candidates confused phases with eclipses and stated that they were caused by the Earth coming between Venus and the Sun - a case of exam nerves overcoming common sense. A labelled diagram here often helped illuminate the written answer.

(b) Most candidates knew of Galileo's observation of the 4 moons orbiting Jupiter and scored full marks.

(c) This question was reasonably well answered. Some candidates lost a mark by not making it clear which model of the Solar System their answer referred to.

Question 2

(a) Kepler's laws of planetary motion were well known but a significant minority of candidates failed to state that the Sun was at one focus of the ellipse. Weaker candidates confused distance moved with area swept out and a number of candidates wasted time by going on to describe the variation of a planet's velocity during one orbit.

(b) (i) Almost all candidates gave the correct value for the cube of the orbital radius to three significant figures. Where necessary, the error was carried forward to the rest of the question so no further marks need be lost due to one arithmetic mistake.

(b) (ii) Candidates generally plotted the points well and drew a good straight line of best fit. There are still instances of lines drawn without the use of a ruler; lines drawn in two stages which then do not quite meet or lines drawn using pen which contained a mistake causing the candidate to have problems crossing out and re-drawing. All of these errors were penalised, but were easily avoidable.

(b) (iii) This part could be answered either by using the gradient of the line or substituting a pair of values directly into the equation linking the period and orbital radius. Fewer than half of all candidates gained full marks. Common errors included incorrect reading of numerical values from the graph; forgetting to transcribe powers of ten from the graph; use of values from the table of data which were not on the line of best fit and algebraic and arithmetic errors in the calculation.

It was clear from the answers that many candidates would benefit from increased practice with powers of ten in calculations.

(b) (iv) This was a general question and most candidates were able to cite a sensible advantage, in particular the ability to analyse the full range of wavelengths from the electromagnetic spectrum.

(b) (v) A significant minority of candidates failed to realise that the mass of the central body had increased and so quoted Kepler's third law as justification for the gradient to remain unchanged.

Question 3

(a) Many had learned this definition correctly. A very few dropped a mark by using magnitude as opposed to apparent magnitude.

(b) (i) Not all candidates were able to perform this calculation and clearly did not know the conversion factor.

(b) (ii) The required equation was well known and many candidates obtained the correct result. The two most common errors were that of dropping a minus sign or, more seriously, using the distance in light-years rather than parsecs.

(b) (iii) Very few candidates were able to describe the shape of a spiral galaxy, but most gained the mark from a sketch.

(b) (iv) The majority of candidates knew one other classification for a galaxy.

(c) This question produced a wide range in the quality of diagrams. Most candidates scored 2 of the 3 marks but lost credit because the arms on both sides were too short in relation to the central bulge or by having the Sun incorrectly positioned.

Question 4

(a) This part was well answered by many candidates, who were expected to make it clear that the process was fusion involving hydrogen nuclei or protons, which overall resulted in the production of helium. It was not uncommon to have the process described as 'fussion', which was given the benefit of doubt. However, those candidates who referred to atoms were penalised. The description of p-p equations were credited fully, even though they are not within the specification.

(b) (i) The great majority of candidates correctly identified the position of the Sun on the graph and read off the corresponding surface temperature, although some forgot to include the power of ten and so put the surface temperature of the Sun as 6K, another instance where a quick check avoids a penalty.

(b) (ii) This question proved to be straight forward for most candidates.

(b) (iii) In this part, full marks were common and it was pleasing to see that candidates had a firm grasp of the link between the mass of a star and the time spent on the main sequence.

(c) Some candidates thought that the luminosity would decrease with the surface temperature, but a significant proportion knew the correct relation although explanations, in terms of surface area and work done through expansion, were poorly expressed.

(d) The meaning of the astronomical unit was well known, together with its value in metres.

(e) Few candidates scored this mark. Most answers placed Betelgeuse to the right of Z on their diagram but since the question states that the star is red in appearance, it should also be to the right of the Sun and most candidates failed to do this.

(f) Answers to this question demonstrated quite a good knowledge of the events which would take place after the red giant phase, but they were frequently put in the wrong order. The best descriptions were sequential with about a sentence of description for each stage. Many candidates used an 'either, or' approach to distinguish between a star which evolves into a white dwarf and one that becomes a neutron star or black hole. This type of answer can be difficult for the examiner to assess and the candidate risks losing credit if it is decided that two alternative answers are being given. Some answers mentioned the white dwarf as a kind of halfway stage on the way to further evolution and this also ran the risk of muddling an otherwise well-structured response.

Question 5

(a) (i) The Doppler equation linking speed with change in wavelength was known by many candidates and the majority of these successfully substituted the required values and made the necessary rearrangements to obtain the correct answer with a suitable number of significant figures. A recurring error was to substitute the wavelengths incorrectly.

(a) (ii) A surprisingly large number of candidates failed to realise that the wavelength was blue-shifted, meaning that the star was moving towards Earth.

(a) (iii) Many answers to this question suffered from similar problems to those already mentioned in 4.f. The important points were often presented in a random order which had the effect of detracting from a candidate who knew the facts. There were no marks for use of language, but well-structured answers often scored more, so candidates would be well advised to give some thought to this in the future.

Weaker candidates often moved on to Olbers' paradox and discussed critical density.

(b) This question was generally well answered, although few candidates felt the need to state that it was the intensity of the cosmic microwave background radiation which is constant.

Question 6

(a) Relativity is one of the more challenging parts of the course, but a good number of candidates could answer this part. A common error was to use 'speed' in place of 'velocity' and this was penalised.

(b) Answers to this thought experiment were better than in recent years. It is not possible to tell whether this is due to improved preparation on the part of the candidates or that this particular experiment was easier to describe. Diagrams were clearly labelled and unlike previous descriptive parts, it was usual for the experiment to be given in a sensible order. With very few exceptions, the experiment described was that of the train entering a tunnel, or its equivalent, and so that has been put on the mark scheme. The main area for confusion was between the position of the lights and the subsequent observations.
In this question, it is important to distinguish between a thought experiment, used to explain why length contraction is a necessary consequence of relative motion, and a simple example which essentially states that a moving rod appears shorter to a stationary observer. Some candidates having the latter failed to score many marks at all on this part.

(c) (i) This question was answered well, although some candidates were penalised for rounding the answer down to two significant figures when it should have been rounded up.

(c) (ii) This proved to be one of the harder questions on the paper. Candidates who showed their reasoning were in a better position to pick up marks than those who simply scattered their calculation around the answer space. A few candidates calculated the time of travel in the reference frame of the moving particle and found the distance moved from this, showing a good understanding of the processes involved and receiving full credit. Weaker candidates who showed no working found it difficult to gain credit.

2825/02 Health Physics

General Comments

This paper caused a wide spread of marks. Many candidates were well prepared and responses showed thorough grounding and preparation. The questions that required written prose tended to be a major influence in discrimination. The content of the common question caused weaker candidates to struggle.

Comments on Individual Questions

Question 1

(a) Candidates were required to translate the defect described in the introduction into diagrammatic form. A significant number failed to draw two rays from the same point on the object. Many more failed to show any refraction at the cornea. It was expected that the rays were shown to cross in front of the retina. Many candidates were able to do this.

(b) It was common to see responses which described short sight, but which failed to link the sight of the person in the question to that of a normal eye.

(c) Most candidates were able to state the defect and the effect on the rays when a corrective lens was inserted in front of the eye.

(d) (i) Again, most candidates were able to quote the correct equations and substitute in the appropriate values. A small number of candidates stuck in their own value for the cornea-retina distance and lost one of the three available marks.

(d) (ii) Many candidates were able to get four marks for this part. The most common error was to see the omission of the minus sign.

(d) (iii) This response was generally weak. Many candidates expressed their answers in a way that was ambiguous and many answers failed to address the question.

(e) There were many responses that indicated that the candidate knew what the defect was. However they were unable to describe in words what they wanted to say.

Question 2

This 10 mark essay question proved difficult for many candidates. Most chose the lower arm/biceps muscle system. Most candidates were able to score a reasonable number of marks with the more organised hitting maximum marks as they addressed all of the points in the question.

Question 3

(a) This part of the question has been set on a number of occasions in the past. The frequency range caused the biggest problem, with a number of candidates failing to get the most sensitive frequency mark through poorly scribbled sketches.

(b) (i) This part of the question asked candidates to translate information from one form into another. It proved difficult for many but allowed the top candidates to gain full credit.

(b) (ii) While most candidates were able to describe the meaning of the term ' normal hearing' they failed to go on to explain why the scale has a negative section.

(c) This was usually well done. A few candidates substituted 50 as the 'intensity' in the equation.

Question 4

(a) This was not well done by all candidates. Many knew how light passed through optic fibres but presented phrases such as ' light is reflected if it's bigger than the critical angle' or 'light is reflected if the refractive index of the core is greater than the cladding'. Knowledge was there but not enough was offered to trigger the mark.

(b) (i) Most were able to gain some credit for this part of the question.

(b) (ii) A significant number still have problems converting first from mm into m and secondly from a diameter into a radius. Most errors in this part arose from one or both of those errors.

(c) Nearly all candidates scored two or more of the available marks. However the sentence construction of answers and the failure of candidates to read the question caused many to throw away two marks. Each reason offered needed an explanation for the second mark.

Question 5

(a) Most candidates are now getting marks on this topic. The most common problem was in the interpretation of the 'micro' prefix.

(b) About half of the answers were correct.

(c) Many candidates gave explanations that referred only to the absorption of the energy by bone and made no comparison with the absorption by surrounding muscle/soft tissue.

(d) (i) Few answers described the density of ionisation.

(d) (ii) This was again well answered.

Question 6

(a) (i) The most common error was to leave the mass in g.

(a) (ii) This was well answered.

(a) (iii) Many responses were not detailed enough to trigger the mark. Eg 'the hand had to move other things'

(b) Most candidates got full marks here.

(c) While most candidates had an idea about the physics, (shown by reading all of the answers as a paragraph) they were not triggering the mark in each sub section. This was due to poor sentence construction and poor organisation.

(d) (i) This was usually a jumble of letters, again poorly described by most.

(d) (ii) While most knew what diodes did, they did not make reference to the capacitor and its discharge.

(d) (iii) Most were unable to describe the sequence of events when a magnet falls through a coil.

(d) (iv) Very few were able to reason many marks from this section.

2825/03 Materials

General Comments

The general standard of the work on this paper was somewhat disappointing. Most of the questions involved subject matter covering fairly familiar ground relative to previous papers, but many answers were of inexplicably poor quality. This applied particularly to questions requiring extended writing, where unwarranted repetition of the same ideas was prevalent, rather than the coverage suggested by the bullet points and required by points in the mark scheme.

'Show that' questions require candidates to arrive at an answer by a series of coherent steps, including a recognisable introduction to the approach being used. This was frequently not the case in questions of this type in this paper and marks were unnecessarily lost. Calculations of the conventional type do not require such a stringent approach and marks on these were generally adequate. However, to award compensation marks when answers are wrong requires clear explanation of the steps being undertaken. The overall performance in calculations was of the usual standard.

Compared with previous June sittings of this paper, the proportion of candidates gaining 70+ marks was well down, and the number gaining fewer than 25 marks was significantly greater.

Question 1

(a) Most candidates could use the graphs to read the information required with sufficient accuracy, but there were many examples of wrong units being quoted for one or both of the answers.

(b) The number of candidates failing to arrive at a correct number of atoms was minimal, but the working in many cases lacked explanation of the approach being used. All that was required was a statement such as 'number of atoms = area of cross-section of wire/area of cross-section of atom' or an acceptable equivalent.

(c) A minority of answers dealt adequately with the assumptions made in the previous calculation. Describing the structure as 'perfect' gained a mark, but a description in terms of layers of atoms and their orientation in the wire was seldom given. Answers tended to concentrate on the presence of imperfections in the structure, but give little detail on their effect on the breaking force. It was unusual to be able to award more than 3 or 4 marks out of the maximum available.

Question 2

(a) (i) The answer required reference to motion with varying speeds, in random directions and with changes of direction on collision with atoms, each with a mark. The first of these aspects was missed in most answers.

(a) (ii) Most candidates correctly specified the continued random motion, with motion in the opposite direction to the current superimposed, but very few included accelerated motion between collisions with atoms.

(b) (i) It was rare for candidates to correctly refer to required mean or average velocity of the electrons.

(b) (ii) Maximum marks were rare. Few answers gave sufficient detail about the length of wire containing the free electrons involved in their derivation.

(c) (i) In this case the full 3 marks could often be awarded. Sufficient detail of formulae being used was generally included.

(c) (ii) The formula required to calculate the drift velocity is well known and could be used successfully.

Question 3

(a) (i) The single words ‘vacancy’, ‘substitution’ and ‘interstitial’ were sufficient to gain the 3 marks. Those who stated ‘impurity atom’ as a replacement for the first two of these were usually at a loss to name a third, and consequently gained only 2 marks.

(a) (ii) A bubble-raft or 2-dimensional ball-bearing model could be quoted by most candidates.

(b) There is a tendency to believe that dislocations and slip planes only arise when stress is applied. In general candidates found it difficult to make clear and relevant statements. It was unusual to be able to award maximum marks.

(c) (i) Sketches were of very variable quality. A mark could usually be awarded for a single close-packed layer of atoms, but the relative placing of atoms in a second layer was often inaccurate or confused, sometimes because the sizes of circles used for atoms was so inconsistent.

(c) (ii) 1. Success was usually achieved in the description of the placing of the atoms in the third layer for an hcp structure. 2. In general candidates found it difficult to give a clear description for the ccp structure.

Question 4

(a) In a previous report on this option the lack of perception as to how a superconducting material can be used to produce a magnetic field has been pointed out. Many candidates believe that the superconducting material itself has magnetic properties and is not simply a substitute for, say, a copper wire performing the same function. Such candidates referred to inducing a magnetic field in the superconductor or using it as the core of a solenoid. In these circumstances it was impossible to apply many of the possible marking points, and a substantial number of candidates could necessarily only achieve at maximum about half of the marks available. Candidates with a better understanding of the principles involved clearly did better, but many of these were unclear about some of the advantages over using conventional conductors.

(b) The Hall voltage formula could generally be recalled and used successfully.

Question 5

a) Most candidates were able to gain at least 2 or 3 of the 4 marks. The most frequent omission was in failing to address the high-frequency aspect

(b) (i) This calculation was deceptively difficult. Many candidates used a wrong approach and arrived at an incorrect answer of 0.20 W. This approach would have been clearly seen to be wrong if the efficiency to be used in the calculation had been rather lower than 98 %. The correct approach required substitution into an appropriate version of the efficiency formula.

(b) (ii) As with (i) this was a testing question. Many candidates are unclear about the relationships between power loss and frequency under the three column headings. The most common misconceptions were that coil power loss is proportional to frequency (and not independent of it) and that hysteresis and eddy current losses are both proportional to the square of frequency.

Question 6

(a) Most candidates could correctly work out the difference of the energy levels in joules. Some failed to convert this correctly to electron-volts.

(b) This type of calculation has proved difficult in past papers, but on this occasion the overall success rate was higher than previously. A mark for involving the inverse fourth power was available and very frequently gained. A correct substitution in an applicable formula was less common, but in cases where it was, a correct final answer was usually reached. Some wrong answers were arrived at because of mistakes in using a calculator to evaluate a fourth power.

(c) (i) A correct reference to Rayleigh scattering was usually given.

(c) (ii) There were three possible ways to gain the 2 marks, involving the enhanced power of a laser, the smaller material dispersion with a laser, or the more efficient switching with a laser. Some candidates failed to take note of the 'state and explain' aspect of the question.

2825/04 Nuclear and Particle Physics

General Comments

As usual there was a wide spread of marks reflecting a corresponding range of abilities and knowledge. There were many scripts of high quality which scored throughout to achieve highly commendable scores. There were also a few candidates who clearly had not prepared adequately. It was pleasing to note that few had difficulty in completing the paper. There were however some areas where improvement could be made. One general area is the choice and use of technical language. Many candidates lost credit by failing to use the correct term, or using it inappropriately. Thus there were many references to 'atoms' and 'particles' when the candidate meant 'nuclei'. In Q. 5 candidates referred to the proton being 'smaller' than other baryons instead of 'having a smaller mass'. In other questions there was not enough clarity of the distinction between a number (eg of lines cut) and a rate (of cutting lines). These distinctions are important in verbal as well as numerical parts.

Some candidates still do not distinguish between the request for him/her to calculate an answer and the instruction to show that… an answer is correct. In the latter case full credit cannot be won without showing the steps in the calculation. Others lost marks by failing to carry forward enough significant figures in a calculation. This is particularly important in calculations to find mass defect; when two approximately equal masses are subtracted the accuracy of the difference depends entirely on the last few s.f. so these must not be ignored. In general, answers to 2 s.f. are acceptable but to achieve this, candidates must work to at least 3 s.f.

An area where there is still misunderstanding is that of mass and energy. There were weaker candidates who regard these as two separate quantities which can be changed into each other rather than a single quantity of which mass and energy are merely different aspects. Thus statements such as '.. when electrons speed up some of their energy is changed into mass..' were not uncommon.

Finally, many candidates still need to take greater care to present their answers more carefully. This is in some cases a matter of poorly legible handwriting and in others a seeming inability to make clear the steps in a numerical answer. Candidates must remember that the examiner can reward only what can be read and understood. An area which figured particularly in this paper was that of freehand graphs. Many candidates lost credit through careless or imprecise sketching of graphs in Qs. 1, 2 and 3.

Comments on Individual Questions

Question 1

(a) Candidates, given a graph of strong force against distance x, were expected to sketch a force against $1/x^2$ graph to represent the electrostatic force between the same two protons. This should have been asymptotic to both axes and should have cut the strong force graph fairly close to the x axis. Many candidates lost credit because their graphs did not intersect at all, or did so at too large a force. Others sketched graphs which hit one or other axis. A few lost a mark by simply failing to sketch a credibly smooth curve.

(b) Here candidates were expected to state that the strong force is short range because the graph hits the x axis whereas the electrostatic force is long range because the line never reaches the x axis showing that this force never becomes zero. This was quite well done though marks were probably lost by some candidates by not stating clearly what they obviously knew. Worryingly, a few candidates seemed not to understand the word 'exponential'. It was used by such candidates as meaning 'asymptotic'; thus they saw no contradiction in part (c) in also describing the same curve (correctly) as having an inverse square law form.

(c) Here candidates were expected to state that the electrostatic force varies as the inverse square of the separation, or to give the mathematical relationship between FE and x. This was well done by most but a minority stated the quantities to be inversely proportional or to vary exponentially.

(d) (i) Candidates needed first to give the full expressions for the electrostatic and gravitational forces, to insert them into the given fraction and then to cancel them down to their simplest form. Many were able to achieve this though some used the wrong constant (eg including 4π in the gravitation formula) or failed correctly to reduce the expression to its simplest form, having cancelled x2. They were then expected to state that every quantity in the expression is a constant. Many omitted this last step. A few lost some credit by inverting the required fraction.

(d) (ii) This required that candidates substitute values into the expression and evaluate it. This was achieved with a remarkably high degree of accuracy by the great majority of candidates who attempted it.

Question 2

(a) (i) Finding the energy released in a fission reaction, given the graph of binding energy/nucleon against nucleon number was successfully completed by the great majority of candidates. There were few errors in the reading of either quantity from the graph and nearly all candidates were able to then evaluate the energy. A small number of candidates omitted to multiply by the nucleon number and so lost most of the credit.

(a) (ii) Candidates were expected to state that immediately after fission the energy is in the form of kinetic energy of either the neutrons or the fission fragments and then to explain that this energy is transferred by collision to other nuclei. The energy then becomes random kinetic energy of the nuclei or atoms of the material. This was not well done; many candidates misunderstood the question and described what happened to the neutrons rather than the energy. Thus many stated that they lose some energy and eventually go on to cause further fissions.

(b) This required candidates to sketch the M-shaped curve to illustrate the distribution of fission products with nucleon number. Most candidates were familiar with the graph in question though a minority lost part credit by careless sketching. The examiner was principally concerned with the symmetry of the graph. Its precise shape would depend on the origin (a true origin was not shown) and whether the yield axis was a logarithmic or linear scale.

(c) (i) Most candidates who had sketched an acceptable graph in (b) were able to mark the position of P at the bottom of the dip. A surprisingly large number, however, marked two points P at the tops of the graph peaks and a few marked a single point to one side or the other of the correct position.

(c) (ii) Most candidates were able to form the correct equation for the fission in which a uranium-236 nucleus splits into two equal parts though a few erroneously included product neutrons despite the exclusion of these in the question. A few, also, showed an emitted neutrino or beta-particle.

Question 3

(a) (i) Nearly all candidates knew the half-life of plutonium-239 though a few gave 2400 instead of 24000 years.

(a) (ii) The quality of the graphs of the decaying plutonium and generated uranium varied greatly. The plutonium graph was expected to be exponential, decaying to about a quarter of N0. The uranium graph should have represented the variation of (N0 – NPu). To achieve the latter, candidates really needed to draw a horizontal line at N0 to achieve enough accuracy with the second graph. Marks were lost by many candidates because the plutonium was shown to have decayed too much or too little, because the uranium graph was not drawn accurately enough or was the wrong shape or the graphs were not labelled as instructed. (iii) Candidates were expected to realise that when half the plutonium nuclei had decayed to a equal number of uranium nuclei, that the two numbers would then be equal and therefore the required time was equal to the half-life of plutonium ie 24000 years. Error in (i) could be carried forward for credit here. The commonest error here was to halve the half life to 12000 years.

(a) (iv) It was expected that candidates would realise that since the uranium is also decaying (slowly) the answer in (iii) could be only approximate (albeit a close approximation). Credit was given for stating that radioactive decay is a random process and that the half-life itself is therefore only an approximation. Many candidates were able to give one (or both) of these reasons though some stated that the decay is random without pointing out the relevance of this to the question.

(b) This part was well done. Most candidates were able to use the nuclear masses given to find the mass defect and hence, using $E = m c^2$, to determine the energy released in the decay of plutonium-239. Some candidates used the figure of 931 MeV u-1 to score full credit. In either case it was necessary to explain the steps of the calculation as this was a 'Show that…' question. As stated in the General section above, it was essential to retain all the significant figure of the masses until the difference had been found. A few candidates used the value of the electron charge instead of the unified atomic mass constant (no doubt confused by the similarity of 1.6 to 1.66) in their calculation.

(c) (i) Many candidates were able to equate the energy calculated in (b) to $1/2\ m v^2$ in order to find the speed of the alpha-particle. A few candidates failed to multiply the proton mass by 4 in the expression for the kinetic energy of the alpha-particle.

(c) (ii) There were a number of correct explanations as to why the actual speed of the alpha-particle is less than the value calculated in (i). These included stating that the recoiling uranium nucleus took some of the available energy or that the alpha-particle was travelling at a speed that is not negligible compared with the speed of light so the alpha-particle gains mass and, for a given amount of kinetic energy, its speed will be less. Marks were lost here by candidates who stated that it was the plutonium nucleus that recoiled; others lost credit for stating that the energy loss had gone to the uranium, without making clear that they were referring to a nucleus rather than the material as a whole. Some stated that the kinetic energy of the alpha-particle is less, without offering any explanation as to why this might be so. Weaker candidates suggested that energy could be lost as heat or due to collisions with air molecules!

Question 4

(a) Only a minority of candidates realised that the direction of the magnetic field at P and Q is out of the plane of the diagram at both points; many thought that the field acted in opposite directions at the two points.

(b) In attempting to explain why synchrotrons are designed with a large radius, few candidates were able to state that a large radius reduces the centripetal acceleration and therefore reduces the required magnetic field strength needed to make the particles move in a circular path. Those who referred to the emission of synchrotron (or simply electromagnetic) radiation and stated that the energy loss from this would be less, also scored fully. However, most candidates thought that the reason for the large radius was to give the electrons enough travelling distance to gain the amount of energy they need.

(c) (i) This was a straightforward calculation to find the speed of the electrons moving round a circle, given radius of the circle and the frequency of rotation. Most candidates arrived at a correct answer though some lost credit by failing to show how they derived their answer. A minority, perhaps misled by the flux density being given, tried to equate magnetic to centripetal force but could make no progress because they would have needed the mass of the electron which was not given. A few confused frequency with time period.

(c) (ii) This time it was necessary to equate centripetal and magnetic force in order to find the electron mass. Many succeeded in doing this though some had used remembered derivations of the required equation but since this was an instruction to calculate the mass, it was not necessary to go back to first principles and a remembered formula could achieve full credit.

(c) (iii) Many candidates were able to state that the answer to (ii) is greater than the value in Data because the electrons are moving at speeds comparable with the speed of light and so they experience relativistic increases of mass. Some candidates showed a poor understanding by stating that '…some energy is converted to mass..'. A few made the contrary statement that '…some mass is converted into energy…'! Both groups have clearly failed to understand that mass-energy is one quantity, not two.

(d) This part too tested a fundamental aspect of the candidates' understanding of basic physical laws. It was necessary to state that two particles of identical mass and speed, moving towards each other from opposite directions have a total momentum of zero and that therefore the photons produced must also have zero overall momentum. This can be achieved only by two photons (of equal frequency) moving off in opposite directions. A single photon has non-zero momentum so the law of momentum could not be satisfied if only a single photon were produced. Candidates who lost marks here usually confused momentum with kinetic energy or failed to explain fully the significance of the momentum law in this situation. A significant minority thought that two incoming electrons must result in the creation of two outgoing photons so one photon would not be possible, somehow implying that each lepton gives rise to one photon. A few stated that if only one photon were produced its speed would have to be greater than the speed of light, and since this is impossible, only one photon cannot be produced.

Question 5

(a) Candidates were given four baryon decay reactions and asked to identify those which might and those which might not be possible. This was a fairly routine test of candidates' ability to compare the particle parameters of charge, baryon number and strangeness in order to test the possibility of each reaction. Many candidates scored full credit and those who did not often failed through carelessness or failure to spell out the full conclusion eg that reaction 2 is possible because charge and baryon number and strangeness are conserved. Some candidates gave only their conclusions (without any Q, B and S equations). Whilst full credit was still awarded if the conclusions were correct, these candidates had failed to show all their working, as advised in the rubric, and if their conclusions were in error it was not possible to award any compensatory marks. A few candidates irrelevantly made statements about the lepton number being conserved.

(b) Here candidates were merely expected to point out that since only baryons have baryon number and since baryon number is always conserved, decay of a baryon must always result in the production of another baryon. It was not possible to give a reasoned answer using the concept of quarks and such answers scored zero.

(c) This was a short data analysis question so candidates were expected to use the data in their answer. The two salient points were that the proton has the smallest mass (not '… is the smallest baryon…') and therefore cannot decay into any other baryon and that the neutron's mass is greater than the sum of the proton plus electron (not just the proton) so the neutron can decay into a proton and an electron. These were not well done and the vague statements such as '…protons are more stable because they have a small mass but neutrons are unstable because they have a greater mass …' were all too common. Many candidates seemed to have ignored the statement that all other baryons have rest masses of more than 1000 MeV. The equation for the neutron decay equation was successfully given by many candidates. Some merely stated the half-life values of the neutron and proton.

(d) Nearly all candidates were able to state that the neutron is stable when it is inside a nucleus. A few stated that the neutron would be stable '…when it is a thermal neutron..'.

Question 6

(a) Candidates were asked to describe the conditions inside the Sun which make fusion possible, with particular reference to how they occur and how they do make fusion possible. It was expected that candidates would identify high temperature and high density as essential conditions and point out that the high temperature ensures that some protons in the Sun have enough energy to fuse when they meet. There was additional credit for stating that the matter in the plasma state, that this is a mixture of nuclei and electrons, for explaining how this plasma forms, for stating that the Sun's gravity pulls the nuclei into close proximity, increasing the frequency of collisions or for showing an awareness of the Coulomb barrier and the necessity to overcome it in order for nuclei to fuse. A few candidates correctly referred to the fact that gravity had the effect of causing the high internal temperature during the Sun's formation. A minority of candidates were able to score full credit in this part. However there were a number of common misconceptions. 'Heat' was often stated where 'temperature' was needed; many candidates stated baldly that the strong gravity field caused the high temperature, without any reference to the formation process; many candidates referred to 'atoms', or even 'molecules' in the Sun and 'fussion' was, as usual, referred to by some. Some candidates used the vague term 'particles' throughout their account, never once mentioning 'protons' or 'nuclei'. High pressure was also considered an important factor in causing particles to fuse. No credit was given for this because temperature is quantity which has meaning only in relation to large numbers of nuclei whereas the likelihood of fusion is increased only by factors which apply to individual nuclei.

(b) In this part, candidates were asked to describe the process of nuclear fusion in the Sun with particular reference to the nuclear equation for the fusion reaction, to explain why the reactions generate energy and why only a small proportion of proton-proton collisions result in fusion. Candidates were expected to give the equation which summarises the fusion reactions and to use the concept of binding energy or mass defect to explain the generation of energy. They should then have pointed out that the mean energy of the protons in the Sun is far less than the minimum energy needed but that the protons have a range of energies so a few do have the necessary energy. They could also have said that most collisions are not head-on and that the fusion reactions summarised in the required equation form a multistage process which only a very small proportion of nuclei complete. This part was not well done by the majority of candidates. Many failed to give the correct summary equation. In some cases this was because they gave the electron rather than the positron as a product particle. Some attempted to derive it from the individual reactions of which it is a summary, usually without success. Some equations featured neutrons among the products, suggesting that the distinction between fusion and fission was not very clear in some candidates' minds. A few even mentioned thermal neutrons. A significant minority of candidates quoted the reaction in which deuterium and tritium are fused, presumably confusing fusion inside the Sun with fusion in the JET experiment.

Question 7

This question on general Physics was well answered by able, well prepared candidates but proved difficult for weaker candidates though even they could score well in the earlier parts. The question described a torch rechargeable by repeatedly causing a magnet to fall through a coil.

(a) (i) Most candidates were able to calculate the loss of gravitational potential energy when the magnet fell through 6.0 cm though a few omitted g or forgot to convert 6.0 cm to metres.

(a) (ii) Most of those who succeeded in (i) were able to calculate the work done in 84 inversions. Those who had not scored in (i) could still score here using the error carried forward concession.

(a) (iii) Many realised that the main reason why the student does much more work than was calculated in (ii) was that s/he also had to lift the torch and/or hand etc. Reasons involving friction or inefficiency were not rewarded because they would not have resulted in '..much greater..' work, as asked in the question.

(b) Most candidates realised that 10.5 J of energy, used at a rate of 55 mW would take a time of 10.5/(55x10-3) seconds though there were some power of ten errors and a small number of candidates wrongly inverted the fraction.

(c) Candidates were given a graph of e.m.f. against time for one fall of the magnet and then required to explain a number of features of it.

(c) (i) Surprisingly few candidates were able to state that the reason why the positive period of e.m.f. was greater than the negative region was simply that the magnet was accelerating under gravity. Some mistakenly stated that the acceleration (rather than the speed) increases with time.

(c) (ii) Candidates were simply expected to state that the reason why an e.m.f. is induced is that magnetic lines of flux are being cut by the coil. A few scored fully by stating that there is a change in magnetic flux linkage but many lost this mark by stating that the magnet cuts flux lines, that flux lines have to be cut by a current or that the magnet passes through an electric field.

(c) (iii) Here candidates needed to state Faraday's law of electromagnetic induction and state that the magnet is cutting flux lines at a greater rate between B and C than between A and B. Many failed to achieve this.

(c) (iv) The e.m.f.s in the two regions are in opposite directions because in AB the magnet is entering the coil but in BC it is leaving the coil and therefore there is a reversal in the direction in which the flux linkage is changing. Many candidates thought that the direction of motion of the magnet was changing. Others gave answers to the effect that during AB the north pole of the magnet is causing the e.m.f. but during BC it is the south pole.

(d) (i) 1 Better candidates were able to manipulate the two equations in order to show that the total charge which has flowed is the ratio of the flux change to the circuit resistance. Many candidates, even the better ones failed to set out their answers in a logical way and the examiner had to search the whole area to find relevant steps in the deduction. As mentioned above, this is an area of competence which many candidates need to work at.
2 This merely required candidates to substitute known values in the equation just derived. Though many were able to do this, a surprisingly large number of candidates lost this mark, usually though powers of ten shortcomings; they either failed to make clear that the charge is 8 millicoulombs or omitted a correct unit for the answer. This was a 'Show that..' question so all steps should have been shown.

(d) (ii) Many were unclear as to why diodes would be required, usually concluding that they were necessary to protect the capacitor from destruction. They clearly had not realised that two e.m.f.s in opposite directions would otherwise leave the capacitor with no charge at all since the second part of the process would simply reverse the first.

(d) (iii) Here candidates were expected to state that since 8 mC are stored during AB a second charge of 8 mC would also be stored in BC, making 16 mC in all. Answers to the effect that 16 is twice as great as 8 did not score.

(d) (iv) Candidates were asked to show that after 84 inversions, 10.5 J of energy would have been stored on the capacitor. There were several ways of achieving this, using either charge or voltage. The former was quicker since the charge had already been calculated; those who opted for the voltage route needed to find the voltage first. This proved a difficult calculation and only a small number of candidates scored fully.

2825/05 Telecommunications

For every year, since its inception in 1992, Telecommunications has been consistently the least popular module of those on offer in OCR's Physics specification and this year did not prove an exception to that order. Only seventy six candidates presented themselves for the examination and of that number about three quarters were reasonably well prepared and were able to score at least some marks for every question. The remaining quarter, however, found the going hard and quite a few seemed to be out of their depth with this level of Physics.

Question 1

(a) Almost all candidates correctly answered Amplitude Modulation for AM.

(b) Although almost all candidates knew the time period to be the reciprocal of the frequency there were a few careless errors made in trying to show the carrier and audio periods to be 25 μs and 250 μs respectively.

Most candidates were able to draw a graph of an AM waveform with the correct 25μs carrier period but a significant number did not make the modulation time period to be 250 μs.

(c) The majority of candidates correctly stated the waveband to be the Low Frequency. It was not considered appropriate to accept an abbreviated answer of LF.

(d) The majority of candidates correctly labelled the axis to be frequency and drew three vertical lines to represent the carrier and sidebands before stating the bandwidth to be 8 kHz.

Question 2

(a) A surprisingly large number of candidates failed to score a mark for stating the meaning of *noise* in telecommunications. Many answers were either plain wrong or too woolly to be awarded a mark.

Similarly, a significant minority failed to state that the *signal-to-noise ratio* <u>decreases</u> with length, and of those who did, many failed to explain why: the final mark was for stating that noise power is more or less constant while the signal power deceases.

(b) Perhaps half of the candidates were unable to state that transmitter X will be a laser (LED was accepted) and that transducer Y will be a photodiode (phototransistor or LDR were also accepted). Many clearly did not understand the question as they tried to argue that X was an ADC and that Y was a DAC.

(c) The calculations comparing the signal transmission in coaxial cable and optic fibre were not well done and only the better candidates made any headway with them. Using the logarithm formula they should have shown the lowest acceptable signal power at either receiver is 2.4mW and thus the attenuation in the coaxial cable is 25dB. Dividing this answer by 6.4 allows a maximum length to be 3.9 km. For the optic fibre the 12% efficiency was almost invariably incorrectly used; the power input to the fibre is 760mW x 12% = 91mW (about half the candidates scored this mark) while the power output from the fibre is 2.4mW ÷ 12% = 20mW (very few scored this mark) In this way, the attenuation of the optic fibre is 6.58dB and the maximum length is 14km.

(d) Almost all candidates scored some of the available marks for the superiority of optic fibre transmission but some were clearly confused as to the meaning of state and explain.. In order to score full marks they were expected to make a statement (eg that optic fibre has a greater bandwidth) and then explain the consequences (eg a much greater information carrying ability).

Question 3

(a) Only about half the candidates knew that an oscilloscope would be needed to make the required measurements (and of those, very few showed it connected to the input and output). Many candidates simply answered “a voltmeter” and this was not acceptable; the examiner would have accepted “an a.c.voltmeter” but no-one answered this way.

(b) The majority of candidates were able to state that the input and output would be 180° out of phase and the examiner was generous in accepting a sketch graph to show this.

(c) While a majority of candidates wrote the gain formula as R_f/R_i and correctly calculated a numerical answer of 400 many of them were penalised a mark for omitting the negative sign and quite a few were penalised another mark for adding units of V. The saturation of the amplifier for too large a V_{in} was reasonably well known but very few stated that the gain calculation becomes invalid under saturated conditions. A maximum V_{in} of about 35mV was correctly calculated by about half of the candidates.

(d) This question proved to be the most difficult on the paper and only one or two understood what was required. They should have answered that V_{out} and V_{in} should be measured over a wide range of frequencies so that a graph can be plotted of gain versus frequency. The range of frequencies over which the gain has a maximum value (more precisely 0.7 of its maximum value) is the bandwidth.

Question 4

(a) A surprisingly large proportion of candidates could not provide a simple definition of refractive index in terms of the speeds of light. Similarly, many failed to state that the reason for making n_{core} greater than $n_{cladding}$ is to allow total internal reflection to occur.

(b) The examiner penalised very many woolly answers to the meaning of critical angle with a typical example being “the angle which allows TIR to occur”. This answer does not state whether it is the angle of incidence, refraction or reflection and even if it did state the angle of incidence it would still be in error since it would have to be qualified by the minimum angle of incidence. However, most candidates correctly used the given equation to calculate the critical angle to be 80.6°.

(c) In their calculation of how long ray A takes to travel along the centre of the fibre, many candidates omitted the refractive index in the speed of light, some forgot to change to 24km to metres and some could not convert the power of ten correctly into 120μs. A large number of candidates arrived at the factor 1.014 (more precisely 1.0135) by simply dividing the 1.5 by the 1.48 without showing any geometry or providing any explanation of why this was the answer. They were consequently penalised for this omission. In calculating how long ray B takes to travel the fibre they should have multiplied their answer to (c)(i) by 1.0135 to give (c)(iii) as 121.6μs.

(d) The duration of each pulse on exit should be (c)(iii) – (c)(i) + 1 μs and the highest frequency should be the reciprocal of this answer. The examiner rewarded many error carried forward calculations.

Question 5

(a) The majority of candidates correctly calculated the transmission frequency to be 600 MHz.

(b) It was pleasing to note that most candidates correctly stated that the meter reading would stay constant as the dipole radiates equally in all horizontal directions.

(c) While a large proportion of candidates correctly realised the meter reading would fall to zero at 90^o then return to original at 180^o then return to zero at 270^o before returning to original at 360^o only a minority correctly stated that this was due to the wave being polarised.

(d) Almost all candidates correctly stated that the meter reading would decrease.

Question 6

(a) While most candidates correctly calculated the loss in GPE to be 0.141J and that the work done on the magnet is 11.9J, there were many woolly answers to the final part as to why the student would do more work than this.

(b) Most candidates correctly calculated that the LED would operate for 191 seconds.

(c) While most candidates correctly answered that the time AB is shorter than the time BC because the magnet is accelerating this was awarded only one of the two marks. To score the remaining mark they were expected to say that the magnet was falling under gravity. An e.m.f. is induced because the coil cuts lines of magnetic flux but many candidates answered that the <u>magnet</u> cuts lines of flux for which they were penalised the available mark. Only a minority of candidates were able to provide a satisfactory explanation of why V_2 is greater than V_1 ; they were expected to state that as an e.m.f. is proportional to the rate of change of magnetic flux the e.m.f. will be greater where the magnet's velocity is greater. Although candidates clearly had difficulty in explaining why the induced e.m.f. had a positive and a negative region, the examiner was reasonably generous in accepting a fairly simple but correct answer (eg AB represents the magnet entering the coil while BC represents the magnet leaving the coil).

(d) A majority of candidates were able to show the rearrangements of formulae to prove that the charge on the capacitor after time AB is $N\ \Phi/R$ and to make the correct substitution to show Q is 8.1mC. About half the candidates realised that the diodes (actually, a diode bridge) is necessary to stop the capacitor discharging (actually, and then charging in the opposite polarity). About the same number of candidates realised that another 8.1mC of charge will be stored during the fall time BC (actually, this only applies if the diodes are ideal). Very few candidates were able to show the capacitor would store 10.5J after 84 inversions and many who attempted it got tied up in knots of irrelevant formulae. It is only necessary to multiply the 16.2mC stored in each fall by 84 to obtain a final stored charge of Q = 1.36C; then the formula $\frac{1}{2}Q^2/C$ can be used to arrive at the 10.5J.

2826/01 Unifying Concepts in Physics

General Comments

Virtually all the candidates completed this paper in the allotted time. Marks on the paper, which was taken by about 5700 candidates, ranged from one candidate with 56 marks down to 13 candidates with 3 or fewer marks. The bulk of the marks (5000 candidates) were between 15 and 50 marks, with relatively few marks in the 40s.

As is usually the case, it is the numerical questions where wholly correct answers can be found. It is also true that many of the weaker candidates could improve their standard appreciably by altering their technique for answering numerical questions. These candidates need to get more meaning into their numerical work. Too often an entire question is nothing more than a jumble of symbols and numbers. The final answer is put on the answer line without reference to anything apart from the figures on the calculator. Words are desperately needed to give some meaning to the working. A distinction needs to be made between a generalised equation and that equation when applied to a specific situation. Common sense then needs to be applied to every answer written..

Improvement in answering descriptive questions is also needed. Frequently a mark scheme will give credit for a variety of valid points made and for a logical argument. Candidates are inclined to make a single statement and then repeat it using different words. This necessarily results in few marks. In general it would appear that candidates have too little practice in answering descriptive questions.

Comments on Individual Questions

Question 1

This question produced good discrimination between candidates. Some of the weaker candidates could do little more than give names to two conservation laws, gaining just two marks, whereas some able candidates were capable of scoring 15 or 16 marks. The main problem with parts (b)(i) and (ii) was that candidates often just repeated the statements of the laws given. What was required was the connection between the terms used in the statement and the conservation law. Charge is the conserved quantity in (i) and the statement that current is the rate of flow of charge needed to be included in the answer. In (ii) the conserved quantity is energy and e.m.f.s are energy supplied per unit charge. Just stating that both e.m.f.s and p.ds are voltages means nothing here. Part (iii) was answered well, although some candidates, having stated that momentum was conserved managed to give whole answers in terms of conservation of energy. Part (iv) produced some very strange ideas. Many candidates thought that the law could be applied because the atmosphere or the ozone layer somehow absorbed or reflected the radiation. Some went as far as to write that the radiant energy did not reach the Earth's surface. Have they never felt hot when out in the sunshine? Another common misconception is that the heat energy is converted into chemical energy by plants and so therefore does not count in any energy equation. Surely candidates know that on a clear night, especially in winter, the ground cools appreciably. Radiation takes place from all bodies, not just hot ones. The fourth mark here was for some reference to the difference between the balance of energy absorption and radiation by day compared with night or in summer compared with winter.

Question 2

This question was tackled successfully by more candidates than any other question. In (a) only a few candidates did not see the significance of the 600 N force at time zero for a mass of 61.2 kg. Those who did not see this usually inserted a guessed figure. Too many candidates could not be bothered to read the graph accurately to get a value just below 3300 N and many regarded the pull of the Earth at 200 km from its surface as 9.2 N. Answers to (b)(i) in most cases concentrated on minimal effects rather than major ones. The small air density at high altitude is partly/mostly compensated for by the increased speed of the rocket and the distance from the Earth's surface has only a small effect on the rocket's weight. The major change is the loss of mass because of the burning of fuel. The answer expected for (b)(ii) was in terms of the graph showing only the magnitude of the force. Some candidates correctly stated that the force could be slowing the rocket down if it was in the opposite direction at some stage. Unfortunately many candidates stated that because the graph is a force-time graph the change in momentum cannot be obtained. They would have needed a mass-velocity graph.

Part (c) required a realisation that the value of g from the graph answered the question. Some candidates correctly used the inverse square law and the figure of 9.8 m s^{-2} at the surface to calculate the new value. A few knew the mass of the Earth and used Newton's law of gravitation. The use of v^2/r was correctly used in many cases for obtaining the answer to (d)(i), though the resulting speeds in many other answers ranged from less than a millimetre per second to over 1000 times the speed of light. Candidates are very poor in general at looking critically at their own answers. Almost everybody could work out an answer to (d)(ii).

Question 3

Most candidates could handle the trigonometry necessary to answer part (a). When candidates used sines instead of cosines and did not have equal forces, why did they not try cosines? Common mistakes in answering part (b) were not realising that with 11 cables the pylon supported 22 times the answer in (a) and why candidates thought that a single cable had a tension in it of a mere 5.0 N reinforces the need for candidates to look critically at their answers. Here they could then have seen the 10^6 factor they had missed earlier.

The most common mistake in answers to part (c) was to omit constant forces altogether. Additionally, many candidates did not refer to forces, but moments, traffic, mass, etc. Marking allowed four marks for two constant and two variable forces plus two marks for difficulties in determining the value of variable forces. Few candidates considered possible problems that could occur with a bridge that might last for up to a hundred years. Accidents and bunching of heavily laden lorries were common answers together with various weather related problems.

Question 4

Answers to this question were often poor and were frequently centre dependent. It was very obvious where the topic had been taught in detail, with these centres able to obtain all six of the marks for part (a). The marking scheme for part (b) was very flexible as it is accepted that making decisions about a suitable experiment in an examination room is difficult. A stopping potential method is most appropriate but candidates who suggested deflection experiments in electric and/or magnetic fields were given appropriate credit, as were those who suggested experiments along the lines of a de Broglie diffraction. Those who worked with a current to a positive electrode were given some credit even though this just measures the energy supplied by the potential difference rather than the energy of the emitted electrons. Too many candidates just left this as a blank space. These are the candidates who think of an exam solely as a memory test, which it is not.

Question 5

This question did not work well because far too many candidates of all abilities did not follow the instruction "State where the physics is incorrect ….". Far too many concentrated their answers on the social, political, economic or linguistic aspects of the real quotes. Probably only 50% of candidates registered that a power unit was used in (a) where an energy unit is required. In (b) it was necessary to imply that this is impossible unless consumers in the houses do not require an electrical supply when it is not windy. The implication in (c) is that by putting in more and more generators, more and more power can be supplied. Candidates could have referred to the fact that no system can possibly produce more power output than *mgh*, where *m* is the mass per unit time and *h* is the total drop. In (d) the only way tidal power can be utilised by a barrage system is by letting water in or out at times when there is a difference in sea levels on either side of the barrage. This necessitates tides on both sides of the barrage, albeit at different times and durations from the situation when here is no barrage. Answers such as ‘hydroelectric dams should be built in places that are not tidal’ and ‘river birds are different from sea birds’ are not appropriate here.

2826/03 Physics Practical

About four thousand candidates sat this examination; the paper proved to be a little harder this year, with fewer marks over 50 (out of 60), but still with very few really poor candidates. Candidates did not appear to be short of time. There were no supply problems with the apparatus, but some centres had difficulty with the larger current asked for in question 2.

Question 1
The candidates were asked to find how the period T of an oscillating mass suspended from a triangular loop of string varied with the length d of the horizontal side of the triangle. The graph of T^4against d should have been a straight line.

A minority appeared to only time one oscillation rather than 10, or at least failed to record the raw readings. Otherwise the table of results was usually well presented. Repeats were credited, as was the range of the values of d selected. Nearly every candidate correctly completed the column headings, and used consistent decimal places for the raw times. However, distance d was expected to be measured to the nearest mm, which it was easy to do, but d was often quoted only to the nearest cm. A lot of candidates found it difficult to justify the number of significant figures (sf) used for T; the answer expected was to use the same sf as the raw data, with reference to decimal points losing credit.

Most candidates obtained a decent straight line graph, except for those who had over-rounded before calculating T^4, because here the rounding error will be increased fourfold. Graphs were generally well set out, but starting the x-axis at d = 0 leads to the penalty of not using sufficient width of graph paper for the plots (at least 4 large squares must be occupied horizontally). Awkward scales, such as 1 to 3, were more common this year, and these were penalised. Gradients and intercepts were well calculated, and nearly all got the minus sign for the negative gradient. There were some who took the y-intercept straight from the graph, even though a false origin had been used.

The analysis, using the gradient and intercept to find the acceleration due to gravity g and the constant k in the given equation, proved just as challenging as usual, even though no logarithms were involved this year. The equation was given in the form y = c + mx, which caused some confusion, and there were some minus signs to untangle. Substitution methods were not accepted. Very few candidates got the correct units for k (m), but most used the correct number of significant figures.

The last part of the question asked for an estimate of the percentage uncertainty in the period T, and hence T^4. Most mistakenly compared the uncertainty in the raw reading, Δt, to the period T instead of to the original raw reading t. However, the majority knew that the uncertainty in T^4 was 4 times the uncertainty in T.

Question 2
In this question, candidates were asked to measure the deflection of a mass suspended from a horizontal wire as current was passed through the wire, ie the old “hot wire ammeter”.

They were required to set up the apparatus and circuit themselves, and the majority seemed to have no problems with this. The clamp stands needed to be secured to the bench by G-clamps or heavy weights and it was apparent, from the comments in the evaluation section, that this was not always done. In trials the deflection y was found to be related to the current I by the equation $y^2 = kI^3$, where k is a constant, and candidates were asked if their results justified this assumption. However, less than half of the experiments led to this result. Nearly all candidates were able to calculate k for each trial, and either decide whether the two values were close enough for agreement (generally within 10%) or not. If the percentage difference was calculated by the candidate, any sensible conclusion was accepted.

As usual the evaluation section was not answered well. It was out of 8 marks and 3 or more of the marks should have been available to any candidate who had practised these papers. Two sets of readings are not enough to form a conclusion (1 mark), so take more sets of readings and plot a graph (1 mark), the graph should be y^2 against l^3, and should be a straight line (1 mark). Other straightforward marks were parallax error in reading the height h (1 mark), read it at eye level (1 mark), repeat readings of h and average them (1 mark). Many candidates suggested clamping the ruler vertically to get an accurate value for h. This was not credited because in trials it was found to be quite unnecessary. Similarly, accurate levelling of the wire and finding the exact mid point did not lead to greater accuracy.

After changing the current the wire continued to expand for a few seconds before settling down, and those who commented on this and suggested a short wait gained two marks. There were 15 marking points altogether so it was disappointing that only a few candidates scored more than 4 out of 8. Many accounts were full of explanations of how difficult it was to adjust the current properly. This was not credited.

The two marks given for spelling, punctuation, and grammar were usually earned; most candidates make a decent effort to produce a presentable piece of work.

The Planning Exercise

This was the familiar Stokes' Law experiment, but, as expected, to most candidates it was clearly not at all familiar. The best answers were usually obtained by those who had tried the experiment themselves, to see what the problems were.

The necessary theory was given in the question, and this was often repeated at length, and unnecessarily, in the scripts. Examiners were looking for practical details such as timing the fall of ball bearings between two markers on the vertical tube containing the viscous liquid, usually glycerol. A stop clock was expected for the timing, but light-gates had to be accepted as so many candidates wanted to use them. It would be very difficult to use light-gates for the smaller ball bearings.

Repeats of timings for the same ball-bearing, use of $v = s/t$, and use of a micrometer for measuring diameters were all credited, as was a good labelled diagram of the tube with markers or positioning of light-gates. Quite a few candidates did not specify which liquid they were using and were penalised. A method for checking that terminal velocity had been attained by the first mark was also required.

Extra detail marks were awarded for preliminary work (numerical evidence needed), recovery of bearings with a magnet, removal of attached bubbles, and a commentary on the necessary diameter of the tube. This section was generally where the stronger candidates gained extra marks. Practically every candidate sketched the correct graph, the gradient of which led to the viscosity. In practice, in the school laboratory, this graph is not straight, but flattens out for the larger bearings because of the extra resistance they encounter. Only a very few commented on this.

At the end of the plan was attached a little question about parachutes which proved to be a good discriminator. Candidates were asked why Stokes' law would not be useful for predicting the movement of a parachutist. The answers credited were (i) the parachutist is not a sphere, and (ii) the speed would be too high, hence the flow would be turbulent and not streamline.

Nearly all candidates gave enough detailed references, but as usual, some omitted them altogether and lost two marks. Most earned the two quality marks, and there were only a few overlong accounts which lost one or two of these marks.

Grade Thresholds

Advanced GCE Physics A (3883/7883)
June 2009 Examination Series

Unit Threshold Marks

Unit		Maximum Mark	A	B	C	D	E	U
2821	Raw	60	47	43	39	35	31	0
	UMS	90	72	63	54	45	36	0
2822	Raw	60	45	41	37	34	31	0
	UMS	90	72	63	54	45	36	0
2823A	Raw	120	96	86	77	68	59	0
	UMS	120	96	84	72	60	48	0
2823B	Raw	120	96	86	77	68	59	0
	UMS	120	96	84	72	60	48	0
2823C	Raw	120	92	85	78	71	64	0
	UMS	120	96	84	72	60	48	0
2824	Raw	90	58	51	44	38	32	0
	UMS	90	72	63	54	45	36	0
2825A	Raw	90	67	61	56	51	46	0
	UMS	90	72	63	54	45	36	0
2825B	Raw	90	70	64	58	52	47	0
	UMS	90	72	63	54	45	36	0
2825C	Raw	90	59	53	47	41	35	0
	UMS	90	72	63	54	45	36	0
2825D	Raw	90	61	54	47	41	35	0
	UMS	90	72	63	54	45	36	0
2825E	Raw	90	66	59	52	45	38	0
	UMS	90	72	63	54	45	36	0
2826A	Raw	120	83	74	65	56	47	0
	UMS	120	96	84	72	60	48	0
2826B	Raw	120	83	74	65	56	47	0
	UMS	120	96	84	72	60	48	0
2826C	Raw	120	77	70	63	56	50	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	25.7	47.2	66.6	82.5	94.9	100	1387
7883	28.9	50.5	69.1	84.9	95.8	100	5901

For a description of how UMS marks are calculated see:
http://www.ocr.org.uk/learners/ums_results.html

Statistics are correct at the time of publication.

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