OCR
RECOGNISING ACHIEVEMENT

GCE

Physics A

Advanced GCE **7883**

Advanced Subsidiary GCE **3883**

Report on the Units

June 2006

3883/7883/MS/R/06

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All Examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

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REPORTS ON THE UNITS

2821 FORCES AND MOTION (WRITTEN EXAMINATION)

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 an almost complete range of marks but very few scored less than 10 or more than 50. This suggests that the paper contained sufficient material to test the most able candidate. There were a significant number of candidates with less than 20 but the number of candidates scoring more than 50 was less than in previous years. Those candidates with less than 20 were often unable to give acceptable definitions, used inappropriate formulae in their calculations and gave low-level responses in their explanations. The mean mark for candidates in this session was 31.6, which was similar to the mean mark obtained in the June session in 2005 of 33.2. All the questions provided the opportunity for the weaker candidates to score some marks, and each question had at least one part in which the more able candidates were able to show their understanding of the subject. The responses differed widely depending on the Centre. There were many centres whose candidates had clearly been very well prepared but equally there were a number of centres where the candidates had a very poor understanding of the concepts involved. The lack of precision, poor use of English, basic errors in calculations and the failure to read the question carefully reduced the marks of many candidates of the full range of abilities. However, the majority of candidates were able to give good answers to some parts of every question. The first parts of questions one and two allowed a good proportion of the candidates to get off to a good start with the paper. The most able candidates scored highly in all the questions except number six. The written explanations in question two and question six were often of a poor standard by candidates of all abilities. Students from some Centres gave incorrect Physics explanations and in general it was apparent that very little planning of the answer had taken place. 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. The standard of written communication was generally adequate with many candidates scoring at least one of the marks available for written communication. Marks were lost by a significant number of candidates who failed to spell many of the key words correctly or use the required technical language in their explanations.

COMMENTS ON INDIVIDUAL QUESTIONS

Question 1

(a) (i) There were many errors made by candidates on what was considered an easy start to the paper. Candidates on many occasions did not appear to read the question and only underlined one scalar quantity. There also seemed to be a general lack of knowledge of what three quantities were scalars when three were underlined. The vast majority of candidates were able to score full marks in (a)(ii). There were many poor answers to part (b). Candidates did not appear to have been trained to use scale diagrams or simply did not have a protractor available. One of the requirements is a protractor and this is stated on the front of the paper. Good candidates were able to resolve and correctly analyse a right-angled triangle, The ones who were able to successfully draw the vector triangle often used incorrect analysis failing with the cosine rule or applying Pythagoras to a non right-angled triangle. However, the vast majority of candidates did not construct the correct triangle with many joining the ends of the two vectors together with a line to represent the resultant. Pythagoras was then applied to this triangle. The candidates who drew a scale diagram often scored full marks but those who attempted a calculation seldom scored full marks.

Question 2

(a) (i) was answered correctly by the majority of candidates. Weaker candidates used the total distance of 36 m instead of the distance to the water of 30 m. However, many candidates did not use the equations for constant acceleration in (a)(ii) but used time = distance / speed. In Q.2(b) poor statements and explanations prevented most candidates from scoring full marks. The correct terminology at this level is expected for the names of forces. Weight or gravitational force is expected not 'gravity'. Many did not mention weight as a force present in either section. There was some confusion between the bird correctly having a reduced acceleration or it being slowed down when air resistance is present. The same was true when the bird entered the water were reduced acceleration was confused with the correct description of deceleration. The magnitude of the water resistance compared to the air resistance seemed to escape many candidates. A number of candidates suggested that the bird would reach terminal velocity in the water and presumably continue to move downward through the water at this constant speed. The candidates were able to ignore air resistance or include it in their answer to (b)(i) but many did not describe the applicable resultant motion clearly. Acceleration on its own was not considered to be a sufficient answer.

Question 3

There were good scores on this question in general. Q.3(a)(i) was well answered with the vast majority giving the correct solution. Many candidates did not appreciate how straightforward (a)(ii) was meant to be and failed to take the hint of the value determined in (a)(i). Candidates would benefit from more practise of the treatment of the independent analysis of the horizontal and vertical components in projectile motion. The answers to (a)(iii) were generally good with only a small minority attempting to calculate the potential energy gained with the original kinetic energy. The change in velocity was found to be the most demanding part of this question by candidates of all abilities with only the very able obtaining the correct answer. However, the application of error carried forward enabled the majority of candidates to gain most of the marks in the remaining parts of the question. Parts (b) (i) (iii) and (iv) produced good differentiation. The good candidates often scored 7 or 8 marks out 9 for part (b). The weaker candidates tended to score a mark for the equation for kinetic energy and possibly the calculation of the acceleration. The average candidate would score at least five marks.

Question 4

This question produced good differentiation. The common error was in (a)(i) where the definition of the torque of a couple was poorly expressed. The perpendicular distance between the forces was often reduced to the distance to the centre. Many candidates were able to calculate the torque produced by the forces that was required in (a)(ii). In part (b) there was a good distribution of marks with many candidates scoring full marks. Weaker candidates tried to work backwards from the value given for the work done with little success. The power calculation was sometimes thought to be a guess by the weaker candidates who started with the wrong expression but still obtained the correct answer. They were unable to apply the 40 revs per second as a frequency and used it as a quantity of time. No marks were scored for this type of analysis.

Question 5

The performance on this question was generally good. The main weakness was in (b)(ii) were the calculation of the strain energy was seldom completed correctly. Many either new that the analysis involved the area under the graph or 1/2Fe but the vast majority failed to convert the unit for the extension from mm into m. The weaker candidates confused strain with strain energy and failed to complete (b)(ii) and (d) correctly. Candidates from some Centres were unable to give any statement for the Young modulus in (c) but the vast majority were able to score some marks for the explanation of stress and strain even though the final analysis of the extension proved difficult for them. Average candidates tended to show their misunderstanding of the theory in parts (b) and (d) with weaker candidates also failing to correctly read the graph and or extrapolate in part (a). However, good candidates scored at least 9 or 10 on this question.

Question 6

Q.6(a) proved the most demanding on the paper for all candidates. Good candidates tended to score only 3 out of the 5 marks. There were many vague descriptions with friction generally being given as a problem rather than a necessity. Candidates might be given an exercise where they are asked to consider a world without friction. The main problem seems that candidates do not appreciate that the friction between the tyre and the road is the actual motive force acting on the car. A number of candidates assumed the driver could have his/her foot simultaneously on the accelerator and the brake pedal. The resultant acceleration or deceleration was described as dependent on which one of these caused the greatest force. The candidates generally scored more marks for part (b). They were able to give three or four factors but only the good candidates could go on to explain their significance to the braking distance. There was considerable confusion with stopping distance and thinking distance. The weaker candidates described the state of the driver rather than the required conditions of the road or tyres or factors concerned with the car. The word ‘grip’ often slipped into the explanation with no credit being given for this inappropriate term. There continues to be a misconception of the purpose of the tyre tread. There were few references to smooth tyres producing more friction on dry road surfaces and tyre tread having more friction in wet conditions due to channelling the water away. The vague statements that a faster or heavier car is more difficult to stop did not score marks for the explanation. Reference to the car having more kinetic energy if it is travelling faster or has a greater mass is required. The same braking force would require a greater distance to reduce the greater kinetic energy to zero or more work is done by the same braking force is required as the explanation.

2822 ELECTRONS AND PHOTONS - JUNE 2006

GENERAL COMMENTS

For the summer sessions, there is strong evidence that Centres are doing an excellent job in preparing their students for the complexities of this module. There were fewer scripts where candidates had left questions unanswered. Candidates' marks ranged from zero to sixty. Clearly, many Centres took full advantage of previous examination papers and the marking schemes. An increased proportion of the candidates are presenting their thoughts much more succinctly, especially analytical solutions. However, there are still too many candidates with poor legibility and poor arithmetic skills. In a small number of cases it was virtually impossible to decipher the scrawls. One particular script took more than one hour to decode and mark. Examiners were also faced with numerical answers from a small minority of candidates who had incorrectly written 3×10^8 as either 3^{-8} or 3E8. Recall of key equations remains a significant problem for candidates across the ability spectrum. The creativity of some candidates can be quite astonishing with wrong equations like: $\lambda = \frac{h}{0.5mv^2}$, $h\lambda = \phi \times \mathrm{KE}_{\max}$ and $\rho = \frac{R \times \text{volume}}{L}$.

The Quality of Written Communication (QWC) was assessed in **Q6**. It is worth reminding candidates that the two QWC marks can be lost easily with sloppy spelling & grammar or poor organisation of their answers. The majority of the candidates finished the paper in the scheduled one hour.

COMMENTS ON INDIVIDUAL QUESTIONS

Question 1

This opening question was accessible to the majority of the candidates. A large number of candidates scored in excess of five marks.

A very small number of candidates omitted answering **(a)(i)**. In spite of the instruction that the arrow had to be drawn at point X, the vast majority of candidates drew arrows in other parts of the circuit. As long as the direction of the arrows was correct and consistent with good physics, then full credit was given. Surprisingly, a significant number of candidates did get the direction of electron flow wrong even though the direction of the negative ions was given in the conducting liquid. In **(a)(ii)**, some candidates defined current in terms of rate of flow of charge or made erroneous suggestion that the direction of conventional current was '*the direction in which positive electrons travel'*. The majority of candidates used the correct equation in **(a)(iii)** to determine the current in the wire. As expected, some candidates failed to convert the 5 minutes into seconds and ended up with an answer of 0.152 A. A small proportion of candidates used incorrect transmutation of $Q = It$.

In **(b)**, the majority of candidates recognised that the compass needle would point in the opposite direction at point P and scored one mark. The second mark remained elusive for many candidates. Candidates' responses showed a tenuous understanding of magnetic fields for straight conductors. Some candidates made incorrect references to '*fields flowing round the wire*' or '*compass needle pointing south'*.

Question 2

Candidates generally did quite well with this question on electromagnetic waves. Most candidates wrote clearly structured answers addressing the question. Many candidates used their GCSE knowledge of the electromagnetic spectrum to communicate their ideas. Describing the three features was the least productive in terms of marks. A small number of candidates lost valuable marks for contradictory statements such as '*electromagnetic waves can be polarised because they are longitudinal waves*'. A few also lost a mark for quoting the speed of light without the essential unit. Therefore a statement like '*these waves travel at the same speed of* 3×10^8 in space' was not awarded a mark. A small number of candidates got hopelessly confused by mentioning alpha, beta and gamma radiations.

Question 3

In **(a)**, slightly more than half the candidates correctly stated Ohm's law. For many candidates, this law is poorly recalled or understood. Answers varied from the strange suggestion that '*resistance was proportional to voltage'* to the most commonly held misconception that this law is equivalent to the equation $V = IR$. Candidates should not be losing the marks for a statement that is central to the study of electrical circuits.

Most candidates gracefully collected the mark for **(b)(i)**. In **(b)(ii)**, a disturbing number of candidates started off with the correct equation but sadly ended up with the wrong answer because of problems with either units or algebra. A good number of candidates worked in centimetres but then lost the unit mark by writing down Ωm. Some candidates demonstrated their shaky understanding of this question by substituting the total surface area of the conductor or the total volume of the conductor into the resistivity equation. There were the inevitable incorrect units for resistivity like ohm per metre, pascal, tesla and newton.

Question 4

This was a high-scoring question with candidates demonstrating good application of their knowledge of parallel circuits.

Almost all candidates recognised the circuit as a parallel combination in **(a)**. Fortunately, only a handful of candidates mentioned series.

The presentation for **(b)** was much better than in previous sessions. In **(b)(i)**, most candidates correctly determined the current in each lamp using the potential difference of 12 V and resistance of 8.0 Ω. A disturbing number of candidates divided their correct answer of 1.5 A by three. The answers to **(b)(ii)** showed excellent use of all the power equations. There were fewer cases of candidates using strange hybrid equations. The most commonly used wrong equation was $P = IR$. The examiners were extremely pleased with the presentation of the answers for the total resistance in **(b)(iii)**. Fewer candidates lost a mark for poor format such as '$R = 1/R_1 + 1/R_2 + 1/R_3 = 3/8 = 8/3 = 2.67$ ohms'. A handful of candidates tried their luck with the equation $R = \dfrac{R_1 R_2 R_3}{R_1 + R_2 + R_3}$.

Candidates continue to be baffled by the kilowatt-hour in **(b)(iv)**. It was clear that many candidates did not equate this term with energy. There were far too many errors with candidates forgetting to convert the total power into kilowatts or calculating the energy of a single lamp in joules and then not using the 3.6 MJ factor. It did not worry candidates when their final answer ran into millions of kWh.

Candidates generally did quite well with **(c)**. Most candidates appreciated that the low resistance lamp would be brighter. However, the reasons for this were not always clear. An answer like '*the lamp is brighter because the electrons travel easily through the lamp'* was quite common. A disturbing number of candidates' thought that the low resistance of the lamp resulted in lower power dissipation ($P \propto R$) and this would make the lamp dimmer.

Question 5

In previous papers, candidates have struggled with questions where they had to define Kirchhoff's laws. Candidates were much content with the format of both **(a)** and **(b)**. Most candidates gained the mark for **(a)** but then struggled with the idea that the second law was an expression of conservation of energy. Some candidates threw in terms like charge, current, voltage and power in the hope of securing a mark.

There were mixed fortunes for candidates in **(c)**. A disturbing number of candidates failed to identify the component P as being a thermistor in**(c)(i)**. Examiners did not allow '*thermo-resistor*' or variable resistor. The answers to **(c)(ii)** were quite disappointing with candidates not being specific enough with their answers. No marks could be awarded for a response like: '*the resistance of the thermistor changes when its temperature is changed'*. A few candidates gave their answers in terms of PTC thermistor. Such candidates were not penalised as long as the physics was correct. **(c)(iii)** polarised the candidates. A good number of candidates managed to determine the current in the 200 Ω resistor but many struggled with working out the e.m.f. of the cell. There were many scripts with answers like 'e.m.f. = 0.026 × (200+700) = 23.4 V' or 'e.m.f. = 9.4 V'. Only candidates in the top 15 percentile appreciate that the e.m.f. of the cell was the difference between the p.d. across the 200 ohm resistor and the p.d. across the 700 ohm resistor.

Question 6

The answers to **(a)** were full of misconceptions and half-truths. The majority of the scripts made no reference whatsoever to the key term photons. It was apparent that candidates had come across terms like work function energy and threshold frequency, but these were not sewn logically into their convoluted responses. Some candidates managed to gain some marks by making clear reference to the Einstein's photoelectric equation. Some candidates were absolutely confused because they had photons being emitted from the zinc plate instead of electrons. There were far too many vague answers like '*the electrons are only emitted when the light has energy greater than the work function energy'* that just failed to score because there was no mention of photons. A few candidates appreciated the idea that energy was conserved when a photon interacted with an electron. Most candidates did not appreciate the role of intensity in the photoelectric effect or its link with the rate of photons. A significant number of candidates managed to secure two QWC marks here. However, as indicated earlier, the legibility of some candidates is giving many examiners cause for concern.

The answers to **(b)** were either quite good or simply appalling. In **(b)(i)**, many candidates could convert the 1.5 eV into joules. Some candidates incorrectly divided the 1.5 eV by 1.6 × 10^{-19} J. Few candidates even attempted to use the expression $1/2mv^2$ for kinetic energy. The question **(b)(ii)** was only accessible to about a quarter of the candidates. Some candidate managed to secure a mark for determining the frequency of the radiation or the energy of a single photon. Poor use of algebra curtailed the progress of many candidates. The most common incorrectly rearranged expression was $\phi = hf/\mathrm{KE}_{\mathrm{max}}$. A few candidates were not even deterred by negative values for the work function energy.

Question 7

In **(a)** an omission of either a tick or a cross in the last column was taken as an error. The modal mark for this question was one. The majority of candidates thought that the third statement was correct. This was in spite of getting full marks for using the de Broglie equation in **(b)**.

The answers to **(b)** were much better presented than in previous years, but a significant proportion of the candidates remain bewildered by the ideas of wave-behaviour of particles. The majority of candidates managed to correctly recall the de Broglie equation. Poor rearranging prevented some candidates from getting full marks. Candidates on the whole were more successful with rearranging after they had substituted the values into the de Broglie equation. Fewer candidates than in previous years used $\lambda = h/mc$ and got 3.0 × 10^{8} ms^{-1} for the speed of the carbon atoms.

2823/01 WAVE PROPERTIES

GENERAL COMMENTS

The general standard of work was similar to that of 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 with the vast majority of students being able to attempt every question in full.

COMMENTS ON INDIVIDUAL QUESTIONS

Question 1

This was intended to be an easy opening question but some had difficulty in correctly defining the symbols c_i and c_r . Some suggested that they represented the angles of incidence and refraction. Most were able to draw a reasonable ray-diagram to show the refraction of light passing from air to glass but many did not label the normal and this made their diagrams ambiguous. Most correctly calculated the angle of refraction to be 36^o but only about fifty percent of candidates scored full marks for the correct determination of the wavelength of the light in glass. Some thought the wavelength would remain constant with the frequency changing and others believed both would change.

Question 2

This was also found to be a straightforward question by most candidates but again many failed to label the critical angle C on Fig. 2.1. Most could correctly complete the ray-diagrams showing a good understanding of total internal reflection and the meaning of critical angle (making it all the more peculiar that they failed to label the critical angle C – perhaps failing to read the question carefully enough). Virtually everyone was able to score at least one of the two easy final marks for explaining a practical application of TIR.

Question 3

Candidates had been told that <u>four</u> of the statements were incorrect but a significant number nominated three, five or six errors! Most were able to make appropriate corrections but a common error was that '<u>all</u> transverse waves can travel through a vacuum'.

Question 4

This is a regularly examined aspect of the specification and most candidates showed a good awareness of the double-slit arrangement. Some, however, were unable to quote a suitable value for the slit-separation: any value between 0.1 mm and 2 mm was accepted. Part (b) proved to be a good differentiator with only the more able candidates being able to offer a correct set of answers for the path difference for points O, A and B. Likewise, only the best candidates could offer a convincing explanation of why the fringe separation would shorten if blue light replaced the red light.

Question 5

Identifying differences between sound and light posed no real problem for the majority of candidates and many were obviously familiar with the ripple-tank experiment to demonstrate diffraction of plane water waves. Answers were sometimes too vague about exactly what was being vibrated in the water. To produce plane wavefronts it was important that candidates referred to a straight vibrating object rather than an ambiguous reference to a ‘dipper’. Most could complete the diagram showing the semi-circular wavefronts emerging from the narrow slit but some failed to score the ‘constant wavelength’ mark.

PRINCIPAL MODERATOR'S REPORT FOR 2823/02 AND 2826/02

GENERAL COMMENTS

It is difficult to say anything new about this well-established area. Centres and Candidates should be congratulated on the high quality work that is being presented.

Mark schemes are, on the whole, well understood and the vast majority of Centres suffered no alteration to their marks.

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

Detailed annotation and mark schemes were offered by many Centres, thus greatly assisting the moderation process. Only one Centre Authentication Form is needed to cover all the candidates entered. Centres must try to ensure that the work they present is that of individual candidates and not a collective exercise. The marker does sign that this is the candidate's own work, but unfortunately downloaded scripts and direct copying still seem to get authenticated.

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

I beg to offer the same general advice as last time; the comments continue to apply.

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

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

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

The major problem with A2 remains the linking of work back to other areas of the specification (bold type in the mark scheme); this must be done to get above level 3. Candidates should be encouraged to make these cross links clear in their work and where this is done an annotation from the marker would be of great assistance.

Planning

Attention should be paid to the progressive increase in scientific knowledge and understanding as the basis of the mark descriptors. There should be a variety of external sources referred to in the text. An area often missed is the detailed discussion on the choice of equipment to be used (in terms of precision and reliability). This will severely hinder progress to the higher descriptors.

Implementing

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

Analysing

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

Where ICT is used, strict attention should be paid to the significant figure problems that may be introduced. Again, the use of good scientific knowledge and understanding is at the root of these descriptors.

Evaluating

The numerical evaluation of uncertainties is required and then the combination of these uncertainties into the final values to give, where possible, an “x +/- y” result.

Comparison with a recognised value is of use to assess reliability but is not what this section is about. The level of work involved needs only to be similar to that found in the appendix of “ Physics 1”

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

2823/03: PRACTICAL EXAMINATION 1

GENERAL COMMENTS

The general standard of the work done by candidates was again similar to last year. It was particularly encouraging to see an improvement to the analysis section of question 1 with many more candidates using their gradient and *y*-intercept values. Plans submitted are still very Centre dependent. Presentation of results and graphical work continues to be done reasonably well although weaker candidates do not always gain some of the marks due to lack of care. The evaluation section in question two could be improved further.

A few Centres queried the exact apparatus requirements for question 1. Most contacted OCR at an early stage. It is essential that Supervisors ensure that they have the appropriate apparatus in good time. The issue of the Instructions to Supervisors is based on provisional entries; Supervisors are advised to check that examination officers do actually make these entries in the Autumn term.

Candidates appeared to complete the paper within the necessary time allocation. As mentioned in previous reports candidates should be encouraged to show all the steps clearly when carrying out calculations. In addition candidates should be encouraged to include greater detail in their answers to descriptive type questions, giving explanations where necessary.

Practical examinations rely very much on the preparation from Supervisors within Centres. Both the Supervisors' report and a specimen set of results should be completed and sent with the scripts to the Examiner. Where candidates do not submit a Plan, it would be very helpful if this could be indicated on the Supervisor's report. Centres are reminded that the cover sheet of the Plan needs to be signed by both the candidate on page 2 and the Supervisor on the front page. It is also extremely helpful if Supervisors could arrange the candidates' scripts so that the Test is attached to the Plan with the Test on top.

During the practical examination Supervisors must be particularly vigilant to ensure that candidates have set up their particular experiments correctly. Supervisors may give assistance with the physical set up of an experiment so as to enable a candidate to gain results. The extent of the help given to any candidate must be detailed in the Supervisor's report. Sadly this year there were a few instances where help had been given on the analysis section in question 1. Supervisor's are reminded that help with the presentation and analysis of results is **not** permitted under any circumstances. Inappropriate help may be treated as malpractice.

COMMENTS ON INDIVIDUAL QUESTIONS

Plan

Candidates were required to plan a laboratory experiment to investigate how the output from a photocell depends on its distance from a point source of infra red radiation.

Supervisors must ensure that the work produced is the work of the individual candidate.

Parts **(a)** to **(g)** on the planning sheet are designed to focus candidates' attention to relevant areas where marks will be awarded. As mentioned in previous reports candidates should be encouraged to give a response to each section <u>with reasoning</u>.

In part **(a)** candidates should have described the procedure to be followed and included the range of readings that should have been taken. Large labelled diagrams were required and should have included the distance. Some candidates did not explain their procedure clearly. It was expected that candidates would state that they would measure the distance and measure the output from their photocell, then change the distance and measure the new output. Good candidates usually included a specimen table of results. The latter usually included a suitable range of distances.

The aim of using the term “photocell” was to encourage candidates to carry out research. All relevant photocells gained credit. Circuit diagrams had to be correct. Common errors included ammeters in parallel with voltmeters. Credit was not given for the (vague) use of a multimeter. It is expected that candidates will use the correct circuit symbols.

Credit was given for an appropriate range of the output meter. Additional credit was given to candidates who calculated or researched the range used.

Two marks were awarded for appropriate methods of reducing spurious radiations for example keeping the ambient temperature constant or shielding the experiment from other sources. Vague answers did not score.

Further marks were awarded for further detail such as:

relevant safety precautions;
use of infra red filter;
method of producing a point source;
method of keeping source output constant;
method of aligning source and detector.
There was also a mark awarded for good evidence of preliminary experimental work. Candidates should be encouraged to explain their ideas clearly.

Two marks were available for evidence of the sources of the researched material. Detailed references should have page numbers or be internet pages. Two or more detailed references scored two marks.

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 greater than 750 words did not gain both marks. Candidates are asked to indicate the number of words in the margin at approximately 100 word intervals.

1) In this experiment candidates were required to investigate how the current in an electrical circuit depended on the length of a piece of resistance wire and from their results determine the resistivity of the material of the wire.

   (a) Most candidates set up the circuit correctly. Supervisors’ observations at this stage of the examination are essential so as to ensure that the candidates can take results.

   (c) Candidates were asked to justify the number of significant figures used for $1/I$. There are still many candidates who confuse decimal places and significant figures. It is expected that candidates would refer explicitly to the number of significant figures that they measured I. Vague answers did not gain credit.

   (d) The majority of candidates took the necessary readings and calculated $1/I$. Results tables were generally well presented. Most candidates labelled the columns correctly although a large number of candidates did not correctly gain the unit of $1/I$. It was expected to see A^{-1}. It is expected that all raw data should be included in a table of results. The measurement of x was expected to be to the nearest millimetre.

(e) Most candidates labelled their axes correctly. A number of weaker candidates used awkward scales which were penalised.
A very large number of candidates did not use as much of the graph paper as possible. It is expected that points should be plotted on at least half of the graph grid in each direction even if this means that there is a false origin.
Points were usually plotted accurately to the nearest half square. Where errors were made it was often very obvious and candidates could have rectified the problem by re-checking their plots.
The majority of candidates drew their line of best fit with a fair balance of points. Lines that were too thick or where several lines had been drawn were penalised. Candidates should be encouraged to use clear 30 cm rulers.

(f) (i) 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 indicate the points that they have used and show their calculation clearly. Some silly marks were lost by misreading the graphs.

(f) (ii) A large number of candidates did not realise that there was a false origin on the *x*-axis. Where there is a false origin it expected that candidates will use their value for the gradient and substitute a point from their best fit line into $y = mx + c$. Examiners do check that the point chosen lies on the best fit line.

(g) Answers to the analysis section were better this summer. Candidates who substituted values from their table of results into the given equation did not gain credit. Good candidates equated the gradient to ρ/AE, equated the intercept to R/E and gave sensible answers with appropriate units and significant figures. Weaker candidates often gave answers to too many significant figures and omitted or gave incorrect the units. Some candidates did not know and could not work out the unit of resistivity.

2) In this question candidates were required to investigate how the period of oscillation of an equilateral triangular structure depended on its side length and then write an evaluation of the procedure.

(a) Very few candidates were unable to measure the length and period correctly.

(b) It was encouraging to see that a large number of candidates calculated the percentage uncertainty correctly. Some candidates determined a percentage uncertainty in T instead of L.

(c) Again most candidates were able to repeat the experiment for the shorter wire correctly.

(d) Candidates were asked whether their results supported the proposed relationship that T^2 was directly proportional to L, explaining their reasoning clearly. No marks were awarded without reasoning. Good candidates calculated a constant of proportionality using their results and then drew an appropriate conclusion. Weaker candidates' answers were vague and lacked explanation. Candidates are expected to conclude whether their results support the relationship.

(e) As in previous years weak candidates are still evaluating experiments by describing the procedure they followed. Good candidates scored well by describing relevant problems and suggesting specific ways to overcome them. Vague suggestions such as "use a computer" or "human error" without explanation did not gain credit.

The following problem areas were credited:

Difficulty in making equilateral triangle
Difficulty in making triangle coplanar
Difficulty in knowing when to stop timing
Oscillations are not always in the vertical plane
Time taken for two oscillations is too short
Two readings are not enough to verify the relation between *h* and *d*

For each problem area there was a mark available for a relevant detailed solution. Some of the creditworthy solutions include:

Use a protractor or measure the sides of the triangle;
Use of a reference mark or plumb line
Slow motion video replay
Time more oscillations or repeat timings and find the average time
Take many readings of a range of L and T and plot a graph of T^2 v L.

Two marks were available for spelling, punctuation and grammar in this part.

2824: FORCES, FIELDS AND ENERGY (WRITTEN EXAMINATION)

GENERAL COMMENTS

Candidates are very familiar with the layout and style of the question paper which has remained unchanged. Most candidates appeared to have time to complete all the questions. There was more descriptive writing on this paper than has been the custom through the inclusion of Q3(b). Despite this, it was the norm to see two full sides written on Q7. Almost all parts of all questions were attempted. Many middle of the range candidates scored widely different marks on different questions, showing significant knowledge of some topics and little of others. The most successfully answered questions by all candidates were Q5, Q6 and Q7. Most of the weaker candidates found something familiar and were able to show their knowledge to score some marks. In this paper it was possible to obtain an E grade pass by recall without having to apply knowledge to solve problems in unfamiliar situations. Candidates must be reminded that the rubric on the front of the paper states that you are advised to show all the steps in any calculations. Examiners look closely at questions written in the form show that to ensure that the candidate has completed the calculation and not just copied the numerical answer from the question.

COMMENTS ON INDIVIDUAL QUESTIONS

Question 1

(a) This first part on calculation of momentum and its unit was usually correct however a few candidates gave Nm or Ns^{-1} in error.

(b) The explanation of force required to accelerate the steel bar was usually poor or inaccurate. Few appreciated that a resultant force was needed to accelerate the bar or referred to the change of velocity. Many considered that the bar was already being pushed by a force further to the left. The position and direction of the arrow was also badly drawn and there were many and varied answers for the time calculation. Often the calculation of the force was given credit by application of error carried forward.

(c) The most common and incorrect answer was that a beta source should be used. Candidates did not appreciate that the given thickness of 20 mm would absorb all beta particles.

Question 2

(a) (i) Many defined gravitational field strength in terms of Newton's inverse square law. In (ii) r was often used instead of R and so the mark was not given. In general at least one mark was obtained in part (iii) by taking suitable points from the graph. The second mark was often lost by not showing working to obtain an (approximate) answer. In part (iv) few mentioned the origin. In part (v) most candidates found at least one of the distances. Explanations given were often 'use of the formula' or by finding the gradient of the straight part of the graph. Few recognised that the question could be completed quickly by using ratios of powers of ten.

(b) The calculation of the mass of the moon was only completed correctly by the more able candidates. The variety of errors included attempting to equate F to zero and incorrect or non-use of $(0.9r)^2$.

Question 3

(a) The definition of simple harmonic motion and subsequent calculations were usually given correctly. Some failed to change the 5mm for amplitude into the correct unit.

(b) In the explanations of resonance the majority identified the need for a driver at the natural frequency but few mentioned the maximum amplitude, choosing instead to repeat the given words in the question. In parts (ii) and (iii) few realised that these were about 'off resonance conditions'. Many expected the frequency of the mirror to shift, rather than stating that the resonance frequency of the mirror would change and hence the amplitude at the given frequency would be reduced. Damping was often given as a reason for the reduced amplitude.

Question 4

(a) The voltages were usually correct although a surprising number reversed the two answers.

(b) Part (i) was usually correct and in part (ii) both marks were usually obtained by sometimes unnecessarily detailed explanations.

(c) Both parts here were badly done. In part (i) poor words of explanation were used. Statements like the reading on the ammeter stayed the same could have meant 'constant' or could have meant 'stayed the same as A_2. Often no marks were given here. In part (ii) sketches were poor and often ambiguous or unclear. Again rarely were all three marks awarded.

Question 5

(a) Positive was usually identified as the charge but often reasons were poor. Some assumed an oil-drop type upward force despite the clear question wording.

(b) Unfortunately there were several routes to finding the kinetic energy and speed. Candidates often used a circular argument in both parts. It was also common to see the formula ½ *QV* quoted for the energy and then to use 600 V for *V* to arrive at the correct answer. Examiners were suspicious that the candidates were using the formula for the energy stored in a capacitor not the energy change when a charge Q moves through a p.d. *V*. Very few mentioned that the charge only moved through a 300 V p.d. Also, often, the calculation for speed did not show *evidence* of the calculation.

(c) This part was however done well. The main errors occurred where candidates tried to use a radial field formula

(d) The diagram was usually correct though the quality may not have been good. Some failed to complete semi-circle. The calculation of the diameter of the path was often either done completely or not at all. Sometimes the answer was left as the radius.
A surprising common error was to confuse the v in the formula Bqv as the voltage between the plates.

Question 6

(a) Stating the numbers of neutrons and protons was usually correct

(b) Showing the value of the decay constant was usually done well but showing the value of the curie was less successful. Most knew that $A = \lambda N$ but not all could calculate N. There was some confusion relating g or kg to moles Often the answer was eventually obtained but the steps taken to arrive at the answer were not clearly explained.

(c) Often this part was either completely correct or not attempted. Some candidates used the fact that 1u = 931 MeV, others either forgot the alpha mass or to convert □m to kg.

(d) The derivation was often started with a correct heat capacity formula but rarely were candidates able to continue adequately. The stumbling block was the failure to recognise that the activity is 1Ci from the earlier part of the question

Question 7

(a) Stating Faradays law was not well done by many. The use of 'current' and missing out the words 'rate of change' were common errors. There was much talk of 'flux cutting', with failure to identify symbols in equations. Many candidates did not split up *magnetic flux* and *magnetic flux linkage* into separate explanations as was required

(b) Most drew an acceptable graph. There were often inconsistencies of amplitude and/or period. The term 'increasing' rather than 'doubling' was often given in the explanation of the effects of the changes which limited the number who could score full marks. Most stated that the emf decreased when the iron core was removed but few gave a mark-worthy reason.

The quality of presentation and the standard of writing varied very considerably from excellent to almost illegible. In part (a) many showed some element of planning by presenting a logical comparison of the properties of the radiations

2825/01: COSMOLOGY

GENERAL COMMENTS

The marks on this paper ranged from 1 to 89 out of 90 but the number of very low scoring scripts was few despite an increased entry compared to last year.

It was pleasing to see a very large number of well-prepared candidates who were able to display their knowledge of Cosmology across the entire paper and in some cases beyond the limits set out by the syllabus. Candidates generally expressed themselves well, showed the reasoning behind their answers, used diagrams appropriately and produced graph work of a high standard.

Whilst the formula for the volume of a sphere proved a larger hurdle than expected, many candidates were able to manipulate logarithmic equations and generate the gradient of a graph from an exponential expression, so the overall mathematical competency displayed was generally very good. Arithmetic errors and simple errors from using powers of ten were not infrequent and candidates are well advised to check numerical answers. Where physical quantities are calculated, candidates can expect the result to reflect typical values in existence, so a density of 10^{-19} kgm^{-3} should prompt a check to be made.

COMMENTS ON INDIVIDUAL QUESTIONS

Question 1

The opportunity for extended writing in this question allowed most candidates to show their knowledge of the Copernican system together with the modifications made by Kepler, including many correct references to the Sun's position at the focus of the ellipse. When discussing Newton's contribution, the point about gravity being the force responsible for maintaining the planets in their orbit was often overlooked, but many candidates gained marks by quoting the universal law of gravitation and explaining the terms. It was not unusual to see Kepler's 3rd law derived using an expression for the centripetal force and this gained full credit. The expression $g = GM/r^2$ by itself was insufficient, but credit was awarded where candidates went on to explain briefly that the acceleration due to gravity was inversely proportional to the square of distance or proportional to the mass of the Sun.

Very few candidates described Newton's idea of a static Universe of infinite extent.

Question 2

(a) (i) The position of the planet was expected to be placed less than a quarter of the way around on the upper part of the orbit and this was done by the great majority. The most common error was to split the ellipse into sections using a vertical and horizontal line through the centre and then place the planet exactly above the central point. A good number of candidates attempted to sketch sectors of equal area, but this sometimes resulted in the wrong conclusion when the areas were incorrectly judged.

(ii) Kepler's second law was well known but there was some confusion between area swept out and distance travelled. The application of the law to explain the motion of the planet proved harder and answers which used either the principle of equal areas or the change in speed around the orbit were accepted. Weaker candidates frequently quoted the third law and then found it impossible to gain the second mark.

(b) Most candidates knew Kepler's third law, but only about half completed the calculation successfully. The factor of 0.4 proved troublesome and there were many examples where this was left out of the main calculation completely. Credit was given for rearranging the equation and candidates who showed their working could benefit, despite having an error elsewhere.

Question 3

(a) The positions of white dwarfs, red giants and main sequence stars on the HR diagram were clearly known by most candidates. Some indication of the distribution of main sequence stars was required, for instance by using a diagonal line. The axes were generally labelled correctly but 'magnitude' by itself is unspecific and similarly, use of the letter M leaves some doubt. Luminosity was accepted on the vertical axis but brightness was deemed insufficient. On the horizontal axis spectral class was accepted in place of temperature, but it was not enough for candidates to simply designate the classes by a series of capital letters.

(b) This section had many full answers which correctly described the evolution of a main sequence star from the end of hydrogen burning to the formation of a neutron star. It was pleasing to see frequent references to the Chandrasekhar limit and Fermi pressure of electrons. The most common misconception is that all hydrogen is converted to helium within a main sequence star, which is far from the true situation. Some confusion was evident over how the initial mass of the star governed its final fate. Candidates were required to refer to *gravitational* collapse since this is ultimately the origin of all the energy released in the subsequent supernova explosion.

(c) (i) Calculation of the density caused many more problems than expected. The formula for the volume of a sphere was poorly understood by a significant minority and errors in algebraic manipulation were not uncommon. A number of candidates failed to cube the radius, perhaps distracted by the conversion from *km* to *m*.

It is a worthwhile exercise to learn the mathematical requirements detailed in the syllabus and in the course of the exam it is sensible to check over working, especially when powers of ten are being entered into a calculator.

(ii) The density of a neutron star relative to matter on Earth was well known. Many candidates stated that a teaspoonful of material from a neutron star would weigh several tonnes. This confused mass with weight and unfortunately did not answer the question.

Question 4

(a) (i) The majority of candidates knew the difference between apparent and absolute magnitude and for the latter correctly stated the 10pc factor.

(ii) Weaker candidates repeated the distance idea when attempting to explain an advantage of absolute magnitude, not realising that, by notionally placing all stars at the same distance from Earth, an accurate comparison of brightness or luminosity can be made.

(b) (i) Candidates have not been asked to transpose and combine logs in quite this way before and it was pleasing to see very many correct answers. Most candidates started from the relation $m - M = 5\log(r/10)$ whilst others quoted $m = 2.5\log(I) + c$ combining it with the inverse square law for the variation of intensity with distance.

(ii) The calculation caused few problems. Errors, where they occurred, were usually the result of interchanging signs, resulting in a very improbable value for the apparent magnitude.

(iii) Interstellar gas was frequently cited as a possible cause for the absorption of light travelling across a galaxy but deflection by gravitational lensing was rarely seen. References to pollution were not accepted.

Question 5

(a) (i) Most candidates knew that very high energies are required to reproduce the conditions thought to have existed in the early universe and they frequently went on to explain that these energies are very difficult to reach.

(ii) Many gained credit for stating that the temperature has subsequently decreased, but fewer went on to give a sensible reason.

(iii) Full marks were rarely gained in this question and a large proportion of candidates were clearly guessing. There were some examples of excellent answers but many attempted to explain transparency as going hand-in-hand with an expanding universe in which photons are presented with a clear path when the gaps between matter are sufficiently large. Many candidates would benefit from having a clearer picture in their mind of capture or scattering of photons by electric charge.

(b) Many references were made to the microwave background radiation but only a minority described the important properties of the microwaves as being uniform intensity with a very small ripple. Responses then split fairly evenly between redshift data and the unusually high ratio of helium to hydrogen nuclei.

Question 6

(a) The cosmological principle was known by many but perhaps half of all candidates quoted only half the answer, choosing either the homogeneous or isotropic aspect.

(b) (i) The calculation produced a range of performances. Many candidates knew that they were aiming to calculate the inverse of H_o but made errors on the way, typically in forgetting to convert km to m, not allowing for 10^6 in megaparsec or simply making arithmetic slips in the calculation. Candidates who showed their working were penalised 1 mark for each error but for those candidates who made errors without showing their method, credit was sometimes more difficult to award.

(ii) This question was not answered as well as expected. Candidates had some difficulty in describing the asymptotic condition and rarely resorted to the critical density to explain the scenario.

(iii) Graphs were generally sketched clearly and neatly, most realising that the line would curve downwards if the mass of the universe were to be larger.

(iv) A closed Universe was identified by many in the last part of this question.

Question 7

(a) A pleasing number of candidates gave good answers to the first part of the question. Many candidates made no distinction between *time* and *rate of time* but statements to the effect that 'time was always constant within Newtonian mechanics' were given the benefit of any doubt.

(b) (i) Candidates displayed little difficulty in calculating the logs correctly, complete with minus signs and a suitable number of significant figures.

(ii) The points were plotted accurately by most candidates with fewer errors than in recent years. When (0, 0) is given as part of the data this point can be used to help form the graph, otherwise the origin should be treated with caution. A small number of candidates made plotting errors but then usually went on to draw the best straight line.

(iv) Candidates were expected to use the gradient of the graph to find a value for *k* by applying natural logs to the equation given. More than half of candidates were successful in doing this and in cases where just a single value for $ln(n/n_0)$ was taken from the graph or table of data, a value for *k* being found by simple substitution, just 1 mark was awarded.

(v) The half-life was calculated correctly by most candidates. Errors, where they occurred, were chiefly caused by difficulties surrounding powers of ten and are perhaps indicative of time pressures at this stage of the paper.

(vi) Once again the calculation using special relativity theory caused widespread problems. The Lorentz factor was treated as a separate part of the calculation, enabling some candidates to score 1 mark, but less than a quarter of candidates scored fully on this section.

(vii) This last part was poorly answered overall. Candidates generally failed to point out the significance of the measurements, despite the discussion initiated in the opening part of the question. It was not enough to simply state that time was dilated and only about a quarter of answers appreciated that the data provided evidence in support of Einstein's theories.

Question 8

A wide range of performances was seen in the synoptic question and candidates responded well to the demands made of them. Generally, good attempts were made to parts (a), (b), (c) and (d) but part (e) proved more testing. Some examples of candidates running short of time were apparent, but these were fewer than in previous years and on the whole time management was not an issue in this paper.

(a) Most candidates realised that reflection of radiation would lower the efficiency of the solar panel or could state an alternative energy change that might occur when a photon was absorbed.

(b) (i) The required surface area was correctly calculated by many. Errors, when they occurred, included omitting to invert intensity, having the percentage calculation upside down or failing to convert *kW* to *watts*.

(ii) Many recognised the satellite would not be in direct sunlight continuously. When discussing energy losses the best answers were very specific, making reference to a process or a particular part of the electric circuit such as the internal resistance of the batteries.

(c) This part was well answered with many candidates referring to the decrease of intensity with distance.

(d) (i) The calculation was completed correctly by many candidates and there were few errors regarding conversion of units of time or powers of ten linked with the *mega* pre-fix.

(ii) This second part of the calculation was a little more problematic than d.i. but the majority of scripts showed correct calculations with some working evident. Weak candidates often took 25% of 60W and rounded this up to the required 20W.

(iii) This calculation caused problems for a good many. Some were unable to make the conversion from *electron-volts* to *joules* whilst others failed to realise that using the power in seconds would lead directly to an activity in *becquerel.*

(e) (i) The relationship between half-life and the decay constant is given in the list of formulae at the front of the paper but despite this a good many candidates left the question unanswered.

(ii) The majority of candidates could not recall the dependence of activity upon particle number and so could not attempt this part of the question. Where necessary errors were carried forward from d.iii and e.i so candidates who showed their methods were at an advantage.

(iii) Use of the Avogadro constant proved to be too difficult for many. It was also common for the answer to be given in grams, not kilograms as required. Where the unified atomic mass constant is used care should be taken not to inadvertently take the rest mass of a proton from the data given at the start of the paper.

(f) Candidates for whom previous parts had been too demanding could nevertheless draw some of the threads together and make sensible conclusions using information provided. It was pleasing to see a well-developed sense of responsibility towards matters associated with health and safety has been engendered within the cohort but candidates should be aware that at this level they are expected to give clearly reasoned answers so bald statements to the effect that the situation may be very dangerous do not, by themselves, get credit.

2825/02 HEALTH PHYSICS

GENERAL COMMENTS

The general standard of performance by the candidates during this session was similar to that of previous years. There was an noticeable increased number of candidates who scored in single figures while at the other end of the spectrum well-prepared candidates continue to achieve marks in excess of 70. A significant number of candidates have calculator-related problems, namely inputting '10^{-12} ' into the calculator which frequently ends up as '10^{-11} '.

COMMENTS ON INDIVIDUAL QUESTIONS:

Question 1

(a) Most candidates were able to recall three peaks with most able to correctly label the colours in the right order. The most common failing was to extend the range of visible light detected to include both 200 nm and 800 nm.

(b) (i) Again most candidates were able to associate photopic vision with the cones. About half of the candidates made reference to higher light intensity conditions or day-light conditions.

(ii) Most candidates were able to associate the rods with lower intensity lighting conditions.

Question 2

(a) (i) Many candidates chose the simplest route, subtracting the power of the eye at the near point with the range of accommodation. A number of candidates guessed at the retina-cornea distance and used their value of *v* to calculate the power.

(ii) Most candidates were able to gain credit here. Many candidates however, did not show the full working here.

(b) The most common error made was to subtract the calculated power from 61.3 D giving a negative power.

Question 3

(a) (i) This was generally well answered. A significant number of candidates entered 10^{-12} incorrectly into the calculator. This was penalised once in the sub question and ecf was allowed through to the answer. Where candidates found the value of $10 \lg I_1 / I_2$ it was rare to find it equated to *change in intensity level.*

(ii) This was generally answered well. A number of candidates confused *threshold of hearing* with *loudness*.

(b) Where candidates were able to calculate the intensity of one intensity level, they usually went on to score full marks.

(c) Most candidates were unable to convert 60 mm^2 to 6.0 x 10^5 m^2.

4 (a) Full credit was frequently gained here.

(b) The low-level marks were easily gained by most. The difference in area between the oval window and ear drum leading to a rise in pressure at the oval window was gained by a number with less able to gain credit for the amplification of *force* due to the lever system of the bones in the middle ear.

5 It was clear that many candidates had not come across the *intensifying screen*. However these candidates were still able to gain three quarters of the marks available by describing the production of an X-ray image using an X-ray film

6 (a) This definition was not well recalled.

(b) (i) Where answers were offered, they were usually correct. It was equally common to find the unit recalled as J kg^{-1} as Gy.

(ii) Many candidates were unable to explain the meaning of the term *quality factor*. The subsequent calculation were well performed.

7 (a) Many candidates omitted the *alternating* description of p.d. across the crystal. A even larger number omitted the matching of the frequency of the source with that of the resonant frequency of the crystal.

(b) It was not uncommon to find diagrams drawn with the positions of the three missing ions unchanged from their original positions in the first diagram. Candidates were thus unable to link their understanding of the term *piezoelectric* and to relate the change in shape of the crystal to the applied electric field.

(c) (i) This was well answered.

(ii) Candidates have been well-rehearsed in the explanation for the use of gel in ultrasound imaging.

(d) The most common error was to omit the ‘out and back’ factor of 2 from the calculation.

8 (a) The effect on living matter of exposure to ionising radiation was well recalled as were the recollection of three factors that determined the extent of the damage.

(b) Most candidates scored one mark out of the two available.

Question 9

(a) A few candidates suggested that some of the incident solar energy was converted to *sound*.

(b) (i) It was more common to see 0.24 rather than 1.5 m^2.

(ii) Many responses included the inefficiency of the solar panels with a few referring to *night* time.

(c) Many responses made reference to being further from a source but failed to state the obvious namely that the intensity of light is too low.

(d) (i) This was answered well by most.

(ii) This was poorly answered with many using the incorrect period of time.

(iii) It was common to find the conversion of MeV to J to be out by a factor of 10^6.

(e) (i) Most candidates had a go at converting the time of 88 years into seconds.

(ii) About half of the candidates were able to proceed to this part of the question.

(iii) Few candidates were able to use either of the routes to the answer.

(f) A number of candidates thought that the plutonium was to be used as a fuel for 'take-off' from the Earth and proceeded to describe the hazards involved.

2825/03 MATERIALS

After the June 2005 paper, the report suggested that as the number of past papers in the option increases, the quality of the answers increases. In the case of many candidates that remains the case, and answers of real merit were given in all aspects of the questions. These candidates showed excellent recall of learnt material, wrote explanations with fluency and understanding and tackled calculations with apparent ease.

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

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

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

Question 1

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

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

Question 2

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

(b) (i) Many of the candidates' answers revealed serious misconceptions about the nature of a superconducting material. The major misconception is that a superconductor is itself magnetic. The following are examples of candidates' ideas as to how a superconducting material may be used to obtain a very strong magnetic field.
'Place the superconductor in a strong magnetic field.'
'Pass a large current through a solenoid wound around a superconducting core.'
'The dipoles in a superconductor are easily aligned.'
'The material is soft and can be magnetised and demagnetised easily.'
Comparatively few answers could be given full marks.

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

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

Question 3

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

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

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

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

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

Question 4

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

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

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

Question 5

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

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

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

Question 6

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

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

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

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

2825/04 NUCLEAR AN PARTICLES PHYSICS

GENERAL COMMENTS

This paper revealed a wide diversity of ability and knowledge among candidates. There were excellent performances from well-prepared, able candidates but, sadly, a few candidates seemed unable to engage fully with the paper and scored poorly as a result. More of the weaker candidates than usual ran out of time and were unable to finish, having presumably found the paper taking longer to complete than they expected.

Particular problems were the poor setting-out of answers to numerical questions, resulting no doubt, in a few cases, in candidates failing to gain credit for work which the examiner could not follow. Another widespread shortcoming was the unwillingness among many candidates to use standard form for answers, obliging the examiner to count up to 9 zeroes in order to establish the correctness of a figure. This is not only inconvenient for the examiner; in a few cases it caused candidates to make power of ten errors. More candidates than usual lost credit for ignoring significant figures in data, so arriving at an inaccurate or incorrect answer.

Candidates should also be reminded of the difference between 'Calculate ..' and ' Show that ..' questions. Whilst the former requires only the deduction of a correct answer by means of a valid method, the latter requires the candidate to set out clearly each step in the calculation. This usually requires some *words* as well as symbols to be used. Perhaps candidates' attention should be drawn, again, to the rubric instruction '..to show all the steps in any calculations.'

It was noticeable, especially in question 7, that many candidates have no conception of the likely order of magnitude of quantities they are writing down. Thus, in *7(d)(iii)* for example, it was common to read that the activity of a plutonium energy source is many orders of magnitude less than 1 Bq.

Once again it is necessary to remind candidates to address their answers to the question as asked. This was particularly relevant to *4(b)*.

Astonishingly, after nine sittings of this paper, there were still a few candidates who did not realise that the last question is one on General Physics and who complained indignantly to this effect. Again this feature of the paper is made clear in the rubric.

COMMENTS ON INDIVIDUAL QUESTIONS

Question 1

(a) (i) Candidates were expected to know that r and r_0 stand respectively for the radius of the nucleus and the radius of a single nucleon. Most were able to state this though some gave r_0 as the radius of a hydrogen nucleus and this was allowed. Most also realised that A represents the number of nucleons in the nucleus. 'Mass number' was accepted, but 'mass' was not. A small number of candidates identified A as the atomic number. This is a term little used today but refers to the number of *protons* in the nucleus and so was not accepted. It was important for candidates to distinguish in their answers between *nucleus, nuclei, nucleon and nuclide.* References to *atom* usually lost credit.

(ii) It was expected that candidates would sketch a curve from the origin, curving with a decreasing gradient but never becoming horizontal. Some candidates presumably confused this polynomial curve with an exponential curve which would be asymptotic to a constant value. Curves whose gradients became zero at some point lost this mark. In a few cases graphs had curvature in the wrong direction for part of the range and the worst examples of this were penalised. A few candidates drew a *straight* line and failed to score.

(b) (i) Most candidates recognised that the value of A for the iron nucleus is 56 and calculated the value of r accordingly. Only a small minority used 26 as the value of A. Surprisingly, a small number of candidates took the value of r_0 to be 1×10^{-15} m. Some weaker candidates divided 56 by 3 instead of finding the cube root. A few candidates lost credit by failing to give their answer to 3 significant figures, as requested.

(ii) Two main steps were required here. Candidates were expected to write the formula for calculating mass from volume and density; they also needed to recall the expression for the volume of a sphere. It was pleasing to note that most were able to do this and to score full credit.

(c) (i) Nearly all candidates were able correctly to state the number of protons and neutrons in the iron nucleus.

(ii) Likewise, few failed to calculate a correct value for the total mass of the protons and neutrons.

(d) The difference in mass between the nucleus and the sum of the protons and neutrons of which it is made was also correctly calculated by most candidates.

(e) To calculate the binding energy of the nucleus it was necessary to use the equation $E = m c^2$ where m was the mass difference. Only weaker candidates failed to do this. Regrettably, an error in the Physics of this question had slipped through. The mass of the whole nucleus should have been *smaller* than the mass of the separate protons and neutrons. Fortunately, this did not cause any disquiet among candidates, though had any candidates pointed it out and refused to do the calculation, they would, of course have been entitled to full credit.

Question 2

(a) This proved a difficult question. Candidates were expected to realise that, in an elastic collision between a neutron and another nucleus, the neutron would transfer the greatest amount of momentum to the nucleus when the two particles were nearest in mass to each other and that a moderator consisting of such nuclei would require the fewest number of collisions by the neutron in order to slow down sufficiently to cause further fissions in uranium-235 nuclei. Many candidates failed to mention momentum at all and were not able to score more than one of the two marks. Others thought that it was necessary for the two masses to be equal in order for the collision to be elastic. Yet others made statements such as ' collision with a small nucleus means the neutron loses too little energy (or momentum) but collision with a large nucleus means it loses too much energy (or momentum).' Apart from the impossibility of a nucleus of smaller mass than the neutron, this kind of answer revealed a lack of knowledge or understanding of elastic particle collisions. Other candidates stated that momentum is *lost* from the neutron, rather than transferred to the other nucleus and these candidates usually failed to score. Yet others asserted that 'momentum is conserved because the collision is elastic'. Few referred to the need for less collisions if the momentum transfer is greater. It was apparent that many candidates have a poor understanding of momentum.

(b) (i) Candidates were usually able to write a correct nuclear equation for the fission of a uranium-236 nucleus into rhodium-110 and silver-121 and to balance the equation by including 5 neutrons. Those who started with the absorption of a neutron by a uranium-235 nucleus, followed by the required fission, were able to score full credit. However, a significant minority attempted to represent the absorption of a neutron by a uranium-*236* nucleus. This could score one of the two marks, providing the equation had been balanced by the inclusion of an extra neutron. Surprisingly, a few candidates expressed the neutrons by the symbol $^{5}_{0}n$ and failed to score.

(ii) It was gratifying to note that the great majority of candidates were unfazed by the need to plot points onto a log. graph and most were able to plot all points correctly. A few took the nucleon number axis as corresponding to a relative yield of 0% rather than 0.01% but most scored full credit. However, a small number of candidates did not notice the instruction to plot the data given and so gave a freehand sketch, and so were able to score only one mark for the curve.

(iii) There were few difficulties with sketching a curve through these 6 points. Candidates were expected to show the usual two-humped shape, make their curve pass through every point and be smooth and sensibly symmetrical. Since the number of points given was minimal, candidates were given leniency as to the quality of the curve. A very small proportion of candidates, clearly unfamiliar with this part of the specification, sketched an elliptical or other curve through the points.

(iv) Candidates' estimates of the relative yield of the products of an equal division at fission were not expected to represent accurately a logarithmic conversion and were again marked leniently, allowing any value between 0.01% and 0.02% for a correctly drawn curve.

(c) (i) The formal representation of a nuclear reaction by an equation is a standard part of this paper and candidates' responses to it have improved over the years. Hence many candidates were able to score both of these marks. Credit was lost by some for omitting the neutrino or misrepresenting the beta particle. Few candidates, happily, now try to show the beta particle emerging sideways from the reaction arrow.

(ii) Candidates were usually able to state that the effect of a β^--decay is to increase the number of protons by one and to reduce the number of neutrons by one. Some lost credit however by stating the change in the number of protons and neutrons in *this particular* decay. Others stated that the number of neutrons remains constant.

Question 3

(a) Candidates were asked to describe briefly the quark model of hadrons. Three particular aspects of their answer were prompted by the three bullet points. Many candidates were able to respond satisfactorily to these but not all attempted to describe the quark model in full. Thus, only a minority mentioned that quarks are fundamental particles, that every quark has an equivalent antiquark, that these antiquarks have negative values of charge, baryon number and strangeness, that quarks are held together by the strong force or that charge, baryon number and strangeness are conserved in quark reactions. The mark scheme required only two of these to be mentioned but sadly many failed to go beyond the bullet points. Some candidates lost credit here by stating that the top, bottom and charm quarks are the antiquarks to the up, down and strange quarks. A few also failed to mention baryon number, referring to 'mass' instead. Some candidates, often the more able, spent time describing the structure of *mesons* despite having been asked only for *baryons.*

(b) (i) Most candidates were able to identify the charge, baryon number and strangeness of the particle **X**. Helpfully, many showed their working as well.

(ii) It was also pleasing to note that some candidates were able to identify **X** as a π^+ particle. Although superficially **X** might have been thought to be a positron, the absence of a neutrino should have ruled this out.

Question 4

(a) Candidates were expected to state that a plasma consists of a mixture of positive ions or nuclei (not 'nucleons') and free electrons. It was not enough to state that a plasma is the result of stripping electrons from an atom without stating where these electrons and the resulting nucleus are afterwards. A surprising number of candidates thought that a plasma is a liquid. A few confused 'nuclei' with 'nucleon'. About half were able to score this mark.

(b) Here candidates were expected to state that the ions (or nuclei) and electrons that form the plasma are charged and that *when moving* they experience a force in the magnetic field; that they in fact follow spiral paths along the magnetic field lines and so are confined within the field. Many candidates spent most of their time describing in some detail the particular circumstances of the confinement of plasma inside the JET reactor. This led to descriptions of the three factors which contribute to the magnetic field inside this reactor, but did not always make reference to the basic physics which the question required. Marks were also lost by some candidates for referring only to the plasma as a whole rather than the charged particles within it. It needs to be borne in mind that since a plasma contains both positive and negatively charged particles, it will not behave as a single entity. Some also lost credit for stating that a magnetic field *attracts* charged particles. A significant minority described in detail the action of the plasma in the JET reactor as the secondary of a transformer arrangement. This absorbed the candidates' time and space and often led to a loss of all of these marks. Others tried to answer in terms of the *current*, without reference to the charged particles.

(c) (i) This type of question is specifically referred to in the specification and has occurred on these papers for many years. Better candidates were able to convert the binding energy per nucleon to a binding energy per nucleus and then, after subtracting the binding energy of the reactants from the binding energy of the products to find the energy in MeV released, were able to change MeV into joule as required by the question. A surprisingly large proportion of candidates failed to find the binding energy per nucleus but simply found the difference between the two binding energies per nucleon. In attempting to convert MeV to joule, a few candidates confused the value of the electron charge read from Data with the value of the atomic mass unit. A few also lost credit by using 1.1 instead of the 1.11 MeV given in the table.

(ii) Nearly all candidates were able to state that the deuterium-tritium reaction is preferred because it generates more energy.

(d) This was an almost identical question to one which appeared on the June 2005 paper so it was disappointing that the majority of candidates scored poorly. Some received credit for remembering that the neutron absorbs 80% of the available energy but the majority were unable to show a reasoned deduction of this. It was apparent that many candidates are ill at ease with pure algebra and had to resort to numerical values, making their answers both longer and more error-prone. This was also a question which required an orderly setting-out of candidates' answers, with some *verbal* explanation of their steps but many candidates seemed poorly equipped to do this. A particular weakness was failure to explain at the outset which symbol referred to which particle. As a consequence many failed to engage properly with the question at all.

(e) Candidates were expected to realise that neutrons are suitable for this energy exchange because they carry most of the energy of the reaction and, having no charge, are unaffected by magnetic fields and so can escape from the confining field. Many candidates stated that neutrons have no charge but failed to explain why this is relevant. Only a minority referred to the proportion of the energy that they carry. A few clearly did not understand their role at all and confused them with thermal neutrons, sometimes going on to say that they should be slow moving.

Question 5

(a) This proved to be the most challenging question on the paper. Virtually all candidates attempted it but with varying degrees of success. The basic features of the structure of the cyclotron were best described by means of a simple labelled sketch. This needed to show at least the dees with a source of alternating p.d. across them, and a magnetic field. There were many original labels for the electrodes; 'drums', 'plates', 'rings', 'd-rings', 'semicircles', 'semi-circle discs' and 'dee-sections' were all used. The customary term 'dees' was preferred however. There was a mark for describing the magnetic field as uniform (not just 'constant') and perpendicular to the dees. A few candidates thought that a radioactive source was used to inject particles into the centre of the cyclotron. Yet others stated that the particles were accelerated before entering the cyclotron. In their description candidates were expected to state that the charged particles gain energy only in the gaps between the electrodes, because of the potential difference between them, which creates an electric field. Candidates were then expected to explain that the magnetic field exerts a force on the particles which acts at right angles to their motion and therefore acts as a centripetal force and that the particles, inside the dees, change their direction of travel but not their speed, travelling in a circular path. Candidates should have stated that the particles spend the same amount of time inside each dee and that this is why the frequency of the applied p.d. must remain constant. No formal algebraic derivation of this was required. Many candidates confused an alternating *p.d.* which is needed to accelerate the charged particles with an alternating *current* which is irrelevant (and virtually zero) in this case.

This kind of lapse was not usually penalised. A few candidates thought that the *magnetic* field imparts energy to the particles. Indeed some wrote that the magnetic field 'attracts' the particles. A few lost all the available credit by describing the *synchrotron*. In comparing the cyclotron with the linac, candidates were expected to state that both devices accelerate the particles many times, that the linac also accelerates particles using an electric field between the electrodes, that the linac also uses a constant frequency or that particles in the linac also spend equal times inside each electrode. Very few candidates scored full marks on this part but able, well-prepared candidates were able to score 7 or 8 out of the available 9 marks.

(b) (i) Many candidates were able to use the equation $E = mc^2$ to calculate the minimum energy needed to create a proton-antiproton pair and convert their answer from joule into MeV, though some failed to make the energy units conversion correctly.

(ii) It was expected that candidates would realise that 1.9 GeV is enough energy to cause the particles to travel at a speed comparable with the speed of light and that at this energy the particles would gain mass. This will change their time period of rotation and will cause the particles to get out of synchronisation with the applied alternating p.d. It was not sufficient to state that the mass of the particles 'changes' or simply that the particles experience the effects of relativity. Many candidates referred to an increase in 'relativistic mass', as if this is another kind of mass; it is in fact the particle's (normal) mass which increases. There was no penalty for this. Others, having stated that the increase in mass is due to an increase in speed, then said that this increase in mass causes the particles to slow down, and that this is the reason for them getting out of synchronisation with the p.d.! The particles are, of course still travelling faster as they move outwards but not fast enough to cover the increased path in the same time as before. A common misconception, no doubt arising from recollections of the synchrotron, was that the cyclotron could not accelerate particles to this energy because it would need to be too big. But however big a cyclotron is made, the particles would still gain mass and become unsynchronised. Nearly all candidates failed to show that they realised 1.9 GeV is a very large amount of energy and that this would have the effect described above.

Question 6

(a) Candidates were expected to realise that the two graphs for neptunium and plutonium were exponential in shape and that because one neptunium nucleus decays to one plutonium nucleus, the total number of nuclei at any instant was constant at 3.0×10^{20}; also, that the plutonium has a much greater half life than the neptunium and therefore negligible numbers of plutonium nuclei will decay during the period of the measurements. Many candidates described the curves as 'mirror images' of each other in the line $N = 1.5 \times 10^{20}$. Whilst true, this assertion did nothing to *explain* their shape.

(b) This part tested candidates' ability to cope quantitatively with the decay discussed in *(a)*. It was of a type which they must have met in earlier work in module 2824 and able candidates were able to score fully. Some credit was lost by those who took the number of neptunium nuclei as 2.7×10^{20} rather than 0.30×10^{20} and these candidates arrived at a time period much shorter than required. A significant minority used 24100 years rather than 2.36 days as the half-life in their calculation. Yet others took this half-life value to be the decay constant, λ. Some weaker candidates were unable to manipulate the natural logarithm equation which emerged, usually by *dividing* logarithms instead of subtracting them.

Question 7

Able candidates were able to score almost full credit on this question. Unfortunately many weaker candidates appeared to run short of time and left some parts blank.

(a) (i) Most candidates were able to state that the 84% of incident energy not converted to electrical energy is wasted as heat in the solar panel, or is reflected.

(b) (i) There were two steps in the calculation of the minimum surface area of solar panel; to create an expression for the area of panel needed to collect 360W of power for a 100% conversion and then to modify this to allow for a 16% efficiency. Candidates divided themselves fairly evenly into those who scored one or other of these two points and those who scored both.

(ii) Many candidates realised that the area of solar panel would have to be larger than was calculated in *(i)* because the satellite would spend some time in the shadow of the Earth, because the incident solar radiation would not always be perpendicular with the panel, because the panel has to power other functions such as positioning or that the storage battery and electrical circuits are not 100% efficient. Two of these were needed for full credit. Many candidates lost these marks by stating that the panel is only 16% efficient, a factor which had already been allowed for in *(i)*. Others attributed the extra area to the need to compensate for variation in the solar intensity due to the satellite's distance from the Sun varying or the Sun's output fluctuating.

(c) (i) Some candidates were able to state that the intensity of the Sun's radiation would diminish with distance from the Sun and that at the distances suggested the power incident on the panel would be insufficient the power the satellite's circuits; a much larger number, although seeming to have grasped this point, were unable to express themselves clearly and examiners needed to interpret what was written. Some better candidates pointed out that the solar intensity decreases according to an inverse square law, but this was not a required part of the answer.

(d) (i) Better candidates were also able to calculate the total energy expended when a p.d. of 12V drives a current of 5.0A round the circuit for 120 minutes and arrive at 4.32×10^5 J which, to 1 significant figure is 0.4 MJ.

(ii) This part was less well done. Candidates needed to find the average power needed to store 4.32×10^5 J in 24 hours. This gave an answer of 5 W. Since the battery charging system is only 25% efficient, the generator needed to produce 20 W. Some candidates however used a charging period of 120 minutes, arriving at a power of 60 W. These then took 25% of this to obtain 15 W which they stated to be approximately 20 W. Others achieved an answer close to the correct value but had taken the charging time to be 22 instead of 24 hours and lost some credit.

(iii) Here candidates were expected to convert the alpha particle's energy to joule and to divide this into the 20 joule per second of power generation to find the number of alpha particles needed per second i.e. the activity of the alpha source. Only a minority of candidates was able to do this. Many seemed at a loss to make progress at all and working was difficult to understand. Some candidates scored full credit by converting 20 W to MeV and dividing this by the alpha energy in MeV.

(e) (i) Many candidates were able to calculate the decay constant of plutonium-238 by using the formula given in Data and converting 88 years to seconds. A minority used the half-life of plutonium-239 (24100 years).

(ii) Candidates were required to recall the equation $A = \lambda N$ to find N, the number of plutonium nuclei. This was a simple calculation and many candidates completed it and were rewarded with the help of the error carried forward concession, having arrived at incorrect values of A in *(d)(iii)*.

(iii) Candidates were then expected to calculate the mass of plutonium by multiplying the number of nuclei found in *(ii)* by the mass of a plutonium nucleus. The mass of the plutonium nucleus could be calculated either using the proton mass in Data, or by using the Avagadro constant, also given in Data. Both methods were used. Of those who attempted this part, about half were able to give a satisfactory answer. Some candidates omitted the factor 238 and, in effect calculated the mass of a nuclide of mass number 1.0. A few put the Avagadro constant on top of the fraction instead of underneath, producing a mass many magnitudes too large.

(f) Candidates were expected to realise that the plutonium would pose a hazard only if there were an explosion within the earth's atmosphere and that the plutonium released would then be spread in the atmosphere and could be ingested by people. This was not well done. Many candidates assumed that there were astronauts aboard the satellite or that the plutonium would explode as a bomb.

The biggest single cause of failure on this question, however, was inability, through lack of time or otherwise, to attempt all parts.

2825/05 TELECOMMUNICATIONS

Despite its influence on their lives, the overwhelming majority of Physics students clearly do not push hard for the option of Telecommunications into their A level. This is unfortunate and the number of candidates studying this options continues to fall with only one hundred and twenty five presenting themselves for this summer's examination. On the positive side, however, it was pleasing to note that among this number there were very few really poor scripts and most candidates were able to demonstrate a commendable knowledge and understanding of their chosen topic.

QUESTION 1

(a) The majority of candidates provided a reasonable answer to why frequency restrictions are a good idea in the telephone system. However, quite a few stated that this was because the human voice does not generate any frequencies beyond 3.4 kHz and this is not the case.

(b) The majority of candidates were able to calculate the 8.0 kHz sampling frequency and to state that this was more than twice the highest audio frequency. Similarly, most candidates correctly arrived at 1.152×10^8 bits and a total bit duration of 0.288 seconds per 30 minute call.

(c) While almost all candidates were partially rewarded for their explanations of multiplexing, only a few scored all five marks. Usually, their description of time-division multiplexing was unclear or even opaque and only about half considered the reduction in cost to be the main reason for its importance.

(d) The majority of candidates produced an answer close to the theoretical maximum number of 6250 callers who could share the line.

(e) Very few candidates scored the available mark for their explanation of why the maximum number of callers would not be 6250 and most simply stated that space had to be allowed to avoid overlap. This was not acceptable. They should have pointed out that in practice, some of the time slot must be used for addressing/identifying/control codes.

QUESTION 2

(a) Most candidates correctly stated the LED or laser as the transmitter and a photodiode or phototransistor as the receiver. The LDR was not acceptable as a receiver.

(b) Most candidates correctly calculated the signal generator output to be 25 kHz.

(c) Most candidates correctly calculated the time delay to be 24 μs, the speed of light in the fibre to be 2.0×10^8 ms^{-1} and the length of fibre to be 4800 m.

(d) Only a minority of candidates scored all seven marks for their analysis of the two oscilloscope traces. They should have highlighted that the received pulse is attenuated (commenting on its lower voltage), the fibre core produces multipath dispersion (commenting on the pulse's greater duration) and the signal has picked up noise (commenting on the ragged/random outline of the pulse). Their conclusion should have been that the fibre is a multi-mode step-index type.

QUESTION 3

(a) Although almost all candidates scored some marks for their statements of the conditions for a geostationary satellite, very few scored all five available for explaining why each is necessary. They were expected to point out that the period is 24 hours because the satellite must stay locked into the Earth's period of rotation, the plane should be equatorial because the axis of the orbit must be the spin axis of the Earth and the direction should be the same as the Earth's rotation otherwise the two would counter rotate.

(b) Almost all candidates scored some marks for their explanation of the advantages of satellite analogue TV over terrestrial analogue TV although many did not make it clear which system they were writing about. The essential comparison to make is that satellite TV uses one transmitter to cover a huge area with high bandwidth signals which would otherwise require many terrestrial TV transmitters.

(c) While the path of the polar-orbiting satellite was generally well known, very few candidates scored full marks for an explanation of why satellites are placed in these orbits. They were expected to point out that in low earth orbit the satellite moves quickly with a time period much less than 24 hours while the Earth spins slower under it. Thus sooner or later the satellite will find itself above every point on Earth. The uses of polar-orbiting satellites was generally well-known.

QUESTION 4

(a) Almost all candidates scored some marks for adding the missing words.

(b) Almost all candidates knew that the voltage gain was defined V_B/V_A and that the voltage gain of the circuit was the resistor ratio -4. (Although many omitted the negative sign).

(c) Almost all candidates scored something for their drawing of the output voltage V_B but to be awarded full marks they had to have a triangular wave of the same frequency, 180 ^{0} out of phase, a voltage gain of 4 and saturation at around ± 12 V.

QUESTION 5

(a) Almost all candidates seemed to have a fairly good understanding of the processes by which information is transferred via the internet from a home computer in London to one in Paris.

(b) Almost all candidates were able to describe four ways in which society has adapted to the availability of the internet, although quite a few failed to be awarded a following mark for simply repeating a previous point.

QUESTION 6

(a) Almost all candidates correctly suggested reflection or absorption as heat for the 86% of light energy.

(b) While just over half the candidates correctly calculated the 1.5m^2 as the minimum surface area of solar panel required, the majority scored only one mark for their reasons for needing an area larger than this. Most simply stated that the satellite will not always be in direct sunlight when they could have pointed out that the panels may not be perpendicular to the sunlight or radiation damage (from cosmic rays) will reduce the number of useful cells. Or they could have stated that the electrical circuits and battery charger are not them selves 100% efficient or that the satellite requires extra power for position control.

(c) Almost all candidates correctly stated that in deep space the intensity of sunlight is too small or that the area of solar cell required would be impossibly large.

(d) While most candidates scored some marks for their calculations many clearly had difficulty with this question. Having shown that the energy required for transmission is 4.32×10^5 J per day, they were meant to show that an efficiency of 25% means four times this amount is needed, and then divide it by 24 x 3600 to produce the RTG power output of 20W. Then, using an alpha energy of 8.0×10^{-13} J, they should have calculated the activity required to be 2.5×10^{13} Bq.

(e) Most candidates were able to show that the decay constant λ is $2.5 \times 10^{-10}\ s^{-1}$ although fewer went on to calculate 1.0×10^{23} as the required number of nucei and 0.040 kg as the mass of Plutonium required.

(f) The majority of candidates realised that the major risk is during the launch of the spacecraft when a huge amount of energy is used to attempt to escape the Earth. An explosion at this point could vaporise the Plutonium which would then be dispersed by the wind. Quite a lot of candidates commented on the risks to “the astronauts inside the space craft while in deep space” and this was a surprising revelation considering it was a Physics examination at A Level.

UNIFYING CONCEPTS IN PHYSICS PAPER 2826/01

GENERAL COMMENTS

The paper had a balance of questions that enabled weak candidates to answer much of the paper as well as stretching the able candidate. Unfortunately this had the effect of reducing the standard deviation and the overall discrimination of the paper. Many weak candidates found that they could gain 20 out of 60 marks. Many of the better candidates did not give answers of sufficient depth and so the number of candidates scoring more than 50 marks was disappointingly small. A problem which many candidates suffered from was poor reading of the question. This was particularly apparent in question 2 where candidates were told to give the full name of the unit. It was extraordinary how many candidates wrote things like C, F, Hz.
A continuing problem from too many candidates was general sloppiness. The 'it will do' concept was all too apparent from these candidates. On the other hand, some whole centres managed to produce uniform high quality of presentation and these centres generally gained far better ability to show understanding of the physics. Virtually all the candidates completed the paper in the allotted time.

COMMENTS ON INDIVIDUAL QUESTIONS

Question 1

This straightforward question did not result in uniformly high marks. Candidates usually had the right idea in (a) about measuring the thickness of the book and dividing by the number of pages but few mentioned the difference between the number of pages, as marked by the author, and the number of sheets of paper. Some seemed to be trying to use the volume of the book and the density of paper. Many wrote about measuring the width of the book. Thickness was acceptable, even if they did not avoid using the covers. No problem was found with (b) although too many suggested just using one paper clip. With (c) the only real problem was with candidates who thought that the circumference was πr^2. Most could see the problem with direct measurement but only a small percentage used the word 'parallax'. Few candidates scored 4 for part (d). Many answers were trivial. It was expected that a careful method would be used for the distance and that in measuring the speed some method would be given for determining the time accurately. Often candidates simply suggested 'measure how long it takes for the car to go along the road' without any indication of how this can be done with reasonable accuracy. Some suggested timing how long it took for the car to pass the observer.

Question 2

Scores of 7 on this easy question were extremely rare. Many thought that tesla was the unit of magnetic flux rather than weber. Tesla metre^2 would be correct. Too many thought that newton was the unit of gravitational field. One examiner, perhaps not surprisingly, counted 25 different spellings of becquerel.

Question 3

This question worked very well in that weak candidates often scored fewer than 5 marks and some good candidates were able to gain full marks. Most candidates got three marks for 425 m in (a)(i) and the better candidates were able to construct the distance time graph. A sequence of straight lines was too common here, however. The curves should neatly link with the straight sections. Most could do (b) but too many still cannot reliably find the gradient of a graph.

These candidates often had the e.m.f. equal to the gradient rather than its reciprocal. Part (c) caused some problems. It was decided to mark the two sections as 3 and 1, rather than 2 and 2. Some took logs of the log values and many gave the denominator as 7.2 – 0. There was an accuracy mark here. The numerical value of the gradient was required within 0.02 of 1.96. Candidates are far too inclined to use values only on a grid line. They cannot be bothered to interpolate. Here, these candidates lost a mark. Many candidates did not notice that the graph had a negative gradient and even fewer were able to relate the value of the gradient to the power so getting an inverse square law.

Question 4

This was a classic case of inability to answer the question. Most candidates could give an adequate Key Stage 3 description of a solid, liquid and gas but very few could go beyond that and describe what happens at melting and boiling. The key to this question was explaining that melting and boiling do not involve a change in temperature and therefore there is no change in the kinetic energy of the molecules. The internal energy increases because of the increase in the potential energy of the molecules. If candidates had worked through the question using the guidelines they might have given much better answers. All too often when marking, it is apparent that the candidate has seen a few key words and has just written a standard answer. Inevitably answers such as this will not fit a mark scheme and the outcome is likely to be a low mark. If bullet points are given it is highly recommended that the candidate stick to the order given and not ramble over the subject in a haphazard manner.

Question 5

This question proved to be difficult for candidates. The first part was meant to be obvious and easy. Handling the standard kilogram might transfer some greasy sweat on to it and cleaning it might rub some of it away – when dealing with hundredths of a microgram. No doubt neither of these activities is allowed by those responsible for looking after it. Candidates however, mostly trotted out ‘temperature’ and ‘pressure’. The next problem they encountered was in working out how many micrograms there are in a kilogram. Too many wrote 10^6 as a result of not thinking carefully enough. In (c)(i) the main problem was the volume of a sphere. The specification is absolutely clear in stating that candidates should be able to calculate the volume of geometrical shapes, including a sphere, but many could not do so. Many gave an equation in terms of r^2, which cannot possibly be a volume. Even after this difficulty there were far too many candidates who could not give the equation for density. Mass x volume, volume/mass and mass/area were common. A disturbing number of candidates do not have any concept of the distinction between volume and area. Very few candidates know that the uncertainty in a cubic term is three times the uncertainty in the term itself. No doubt, if an expression had been written to include $r \times r \times r$ they would have added the three individual uncertainties. Part (d) proved more difficult than expected. If the structure is not regular then there may be spaces where an atom is assumed to be. An impurity atom will have a different mass and will probably alter the regular pattern. Candidates tended to concentrate on the diffraction pattern. Poor expression often limited the total mark in (e). Too many wrote that isotopes have different numbers of neutrons but did not write ‘the same number of protons’. In (ii) they needed to state that isotopes have different mass and therefore the proportion of each needs to be known accurately if the average mass is to be known accurately. (Since isotopic proportions vary slightly from sample to sample the suspicion is that this attempt to standardise the kilogram will fail.) The difficult part (iii) was answered well by able candidates. They knew that chemical means of separation are impossible and many suggested separation using mass spectrometers or diffusion. One very common misconception about isotopes is that they are all radioactive. So many answers here thought that decay would take place.

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2826/06 UNIFYING CONCEPTS IN PHYSICS PRACTICAL EXAMINATION

Planning Exercise

In the planning exercise candidates were required to design an experiment to damp the vibrations of an aluminium sheet, using eddy current damping caused by suitably arranged electromagnets. A diagram of how the apparatus should be arranged was specifically asked for, and many marks could be earned by large clear well-labelled diagrams of the experimental set-up.

As we have come to expect with the plan, answers were very centre dependent, with the same ideas and solutions appearing for most of the candidates within the centre. This should not happen. Candidates and Supervisors do after all declare that Candidates have produced the work without any help from other people. One set of good answers involved having one end of the aluminium sheet clamped to a bench, and the other end “twanged” to initiate vibrations. The other possible answer had the sheet clamped at both ends under tension, and vibrations initiated by pulling at the centre of the sheet and releasing it. Other quite common but invalid set-ups had the aluminium sheet swinging sideways like a pendulum, or hanging from strings.

Much time and space was wasted by many candidates with overlong accounts of Fleming’s right and left hand rules, electromagnetic damping and so on. But most realised that the magnetic field had to be parallel to the plane of the sheet so that the vibrations cut the field. Helmholtz coils were a very popular choice for the electromagnets, but it is probable that the field produced by these coils would be too weak to have much damping effect; nevertheless, the idea was credited. Better solutions used soft iron cored electromagnets. Correct circuit diagrams were credited when they showed how the current in the magnets could be varied, either using a variable resistor or a variable power supply. Candidates need to be reminded that circuits need to be complete, and that they should use the correct symbols (the thermistor symbol was a very popular choice for a variable resistor).

It was expected that a Hall probe would be selected to measure the magnetic field strength, and extra ‘detail’ marks were available for further discussion of the use and calibration of the probe. The amplitude of the vibrations was to be measured using a sensor and datalogging equipment. It was pleasing to see that nearly all candidates produced viable set-ups. Credit was given for showing the sensor facing the front of the sheet, and for graphically illustrating the decay of the amplitude, showing the ‘half-life’, i.e. the time taken for the amplitude to halve.

Marks which proved more difficult for most candidates to score were for good practical detail. A few used a signal generator and oscillator to initiate the vibrations. Some attempted preliminary experiments in the school laboratory, but this was only credited where real evidence was shown (for example some numerical results).

Many candidates had clearly done a lot of research on the internet to find out all about high precision sensors and some interesting examples were seen. Extra marks were available for further discussion and explanation of these sensors, including possible sampling rates. However, the plan is supposed to be based on the use of standard equipment found in a School or College laboratory, and the straightforward ultrasonic sensor should have sufficed here. A surprising number lost one or both ‘Reference’ marks by omitting references altogether or omitting page numbers.

Nearly all candidates earned the two quality marks. However, one or both of these marks could be lost by rambling and poorly organised material, or by not following instructions, i.e. writing far too much (well over the stipulated 500 words), or by not leaving a right hand margin for the examiner's use. Fortunately this very rarely happened, and it was good to see that there were a large number of well presented and word processed accounts.

For future papers, the link which is supposed to exist between the planning exercise and Question one will become more tenuous. This should mean that a wider variety of interesting plans can be set, and yet remain accessible to all candidates.

Question 1

The written examination proved to be of about the same difficulty as in previous years, and few candidates appeared to run out of time. However, some reports from schools stated that candidates who had taken three readings for each amplitude in question 1, for each of the six different values, found it very time-consuming, and were tight for time. Ideally perhaps three readings should be taken, but conditions are not ideal in a timed examination, and two readings were quite acceptable.

Candidates were required in part (a) to determine the area of a given square card, and to calculate the percentage uncertainty in its area. They first had to estimate the uncertainty in the length of the side (± 0.5 mm or ± 1.0 mm), and then use this to find the % uncertainty in the length. The better candidates did this and then correctly doubled it to find the % uncertainty in the area. Only about half got this correct, and those who attempted to find the absolute uncertainty in the area before using the % error formula nearly always got it wrong.

In part (b) (i) they were required to measure the amplitude of vertical oscillations of the card on a spring, and credit was given for repeating readings, either here or later in part (d). Part (b) (ii) asked for difficulties and possible solutions. Most candidates gained credit by saying it was difficult to view the moving card, or by mentioning parallax problems. Use of a video camera to view the oscillations was an acceptable solution, but not a motion sensor unless its positioning was made clear.

The experiment itself, part (d), caused few problems. Tables of results were usually well-presented with units correctly inserted, and very few needed help from invigilators. However, an unaccountably large number of candidates failed to spot the instruction to take logs of the amplitude X, and therefore plotted an incorrect graph of X against area, instead of ln(X) against area. This only lost them two marks (one for calculating ln(X), and the quality mark awarded by inspection of the plotted points), but of course calculations done later on were invalidated, because they had not drawn the ln graph of the given equation.

In general, graphs were drawn well with the plots covering a good area of the graph paper. Axes were well labelled but too many candidates are still choosing awkward scales (i.e. two large squares to 150 cm² on the x-axis). It is not an easy experiment to do under time constraints and examiners only looked at 5 out of the 6 points when assessing quality of the results, and the drawing of the best fit line. Gradients were competently calculated, with nearly all using large triangles, and most spotting that it was a negative gradient. However, a fair proportion of candidates read off their intercepts from the y-axis, failing to notice that they had a false origin on their x-axis.

The calculations in part (f), based on the logarithm equation, proved too difficult for weaker candidates, but the stronger candidates generally got it right. Too many failed to notice that units were also required, and hence lost fairly easy marks. In the final part of the question, (f) (ii), most failed to realise that k in the given equation is not a spring constant but a damping constant, and very few gave one of the two possible answers. These were to count more than 20 oscillations, and to conduct the experiment in a more resistive medium.

Question 2

In this experiment candidates timed the flow of water from a burette tilted at 15° and 65°, and investigated the relationship between the time t for 25 cm^3 to flow and the sine of the angle of tilt (sin θ).

The investigation of proportionality, involving calculations of the ratios of t to sin θ and comparing the ratios for each angle, proved to be a good discriminator, but a reasonable majority scored full marks for this section. There were a few candidates who failed to obtain a correct value for sin θ on their calculators; the calculators appeared to be in 'radian' mode.

This experiment was difficult to do, with unsteady plumblines and protractors, tilted meniscuses, difficult to open taps, etc., and the evaluation of these difficulties, together with possible solutions, turned out to be as challenging as ever for the weaker candidates.

Examiners were looking for a statement of the problem, and suggested solutions for each problem. A difficulty in the past has been that candidates have given the solution (e.g. 'I would take 6 sets of readings of t and θ, and plot a graph of t against sin θ') without stating the problem (e.g. '2 sets of readings are not enough'), and thus losing easy marks. This seemed to happen less often this year. The different problems and solutions are listed in the mark scheme but some points ought to be stressed. Taking repeat readings was not enough to earn a solution mark; the results had to be repeated and averaged. Taking more sets of readings was not enough; a graph had to be plotted.

There is a tendency to rely on electronic/computerised solutions to practical difficulties best solved by more conventional means. The usual glut of light gates, motion sensors, and magic burette taps that opened and closed electronically were all given as possible solutions, and were not generally credited. Most candidates, though, recognised the major limitations of the given procedure.

Most candidates had made a good effort to make their evaluation legible and grammatical in order to earn the two 'quality of written communication'marks. The majority earned these marks.

Advanced GCE Physics A 3883/7883
June 2006 Assessment Series

Unit Threshold Marks

Unit		Maximum Mark	a	b	c	d	e	u
2821	Raw	60	43	37	32	27	22	0
	UMS	90	72	63	54	45	36	0
2822	Raw	60	50	45	40	35	30	0
	UMS	90	72	63	54	45	36	0
2823A	Raw	120	96	85	75	65	55	0
	UMS	120	96	84	72	60	48	0
2823B	Raw	120	96	85	75	65	55	0
	UMS	120	96	84	72	60	48	0
2823C	Raw	120	92	83	74	65	57	0
	UMS	120	96	84	72	60	48	0
2824	Raw	90	60	53	46	40	34	0
	UMS	90	72	63	54	45	36	0
2825A	Raw	90	69	62	56	50	44	0
	UMS	90	72	63	54	45	36	0
2825B	Raw	90	68	61	54	48	42	0
	UMS	90	72	63	54	45	36	0
2825C	Raw	90	65	58	51	45	39	0
	UMS	90	72	63	54	45	36	0
2825D	Raw	90	60	53	47	41	35	0
	UMS	90	72	63	54	45	36	0
2825E	Raw	90	70	63	57	51	45	0
	UMS	90	72	63	54	45	36	0
2826A	Raw	120	88	79	70	61	53	0
	UMS	120	96	84	72	60	48	0
2826B	Raw	120	88	79	70	61	53	0
	UMS	120	96	84	72	60	48	0
2826C	Raw	120	84	77	70	63	56	0
	UMS	120	96	84	72	60	48	0

Specification Aggregation Results

Overall threshold marks in UMS (i.e. 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	19.1	37.6	55.5	70.9	83.3	100.0	6982
7883	26.9	48.7	69.4	85.0	95.9	100.0	5452

For a description of how UMS marks are calculated see;
www.ocr.org.uk/OCR/WebSite/docroot/understand/ums.jsp

Statistics are correct at the time of publication

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