OCR
RECOGNISING ACHIEVEMENT

GCE

Physics B (Advancing Physics)

Advanced GCE **A2 7888**

Advanced Subsidiary GCE **AS 3888**

Report on the Units

June 2006

3888/7888/MS/R/06

Oxford Cambridge and RSA Examinations

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REPORT ON THE UNITS

2860 - Physics (B) (Advancing Physics)

Physics in Action

General

The paper was of an appropriate standard of difficulty providing a high mean mark with good discrimination. Section A was generally well answered but sections B and C showed more differentiation. There was evidence this summer that a significant proportion of candidates ran out of time; several did not attempt all of section C. Other candidates showed in section C pre-prepared answers that were inappropriately adapted to the particular requirements of the question. It was apparent from the papers of several candidates, from long multiplication and division working, that they had attempted the examination without the use of a calculator! It was also apparent that on coded answer type question 3, some otherwise good candidates felt that each of the three letter codes A, B, C had to be used once. Candidates should be warned that there is no such limitation on their choice. (The correct code order was C A A, but a significant proportion chose C A B).

Overall Performance

The range of marks ran from single figure scores out of 90 up to marks in the high 80's.
The mean mark was pleasingly high with a good standard deviation spreading out the candidates who could show off a wide variety of their physics skills and a broad knowledge.

Comments on the responses to individual questions:

Section A

1 This was an easy starter question on the units of Young modulus and density. Most candidates scored 2; the majority of errors were on the units of density.

2 **(a)** Many candidates recognised that the phenomenon described was due to the polarisation of radio waves. Candidates who did not name the correct phenomenon had to give a clear description in their own words to score the mark.

(b) The first part predicting the return of the signal to full strength was generally answered well. Many candidates ignored / lost the second mark by not giving a good explanation about the return of the aerial to the plane of polarisation / oscillation of the wave.

3 It was apparent that on coded answer type question 3, some otherwise good candidates felt that each of the three letter codes A, B, C had to be used once. Candidates should be warned that there is no such limitation on their choice. (The correct code order was C A A, but a significant proportion chose C A B).

4 Pleasingly most candidates could multiply the number of electrons per by second the quantum of charge to get the current 3.2 pA ($I = n e$) in the STM.

5 This question was a straightforward calculation of atomic diameter from a STM image. Most candidates scored well: some ignored the 2 S.F. instructions, or put an extra power of ten into their calculator to lose a mark. Candidates who made the gross error of dividing the distance of 2.1 nm by the total 34 atoms in the image lost both marks.

6 **(a)** This question first asked for the calculation of electrical conductivity, from the given resistivity of magnesium. Most candidates easily computed this reciprocal value. A few did not record their value clearly.

(b) They then went on to correctly plot the data for magnesium on the graph, which was judged to a precision of + ½ graph square. The few candidates who had small transcription errors in their value from (a) were allowed ecf.

(c) Because of the spread in the data around a proportional relationship, a wide variety of answers describing the data trend was also accepted: positive correlation, linear and as thermal conductivity rises so does electrical conductivity. Some weaker candidates thought the data showed the temperature variation of conductivity. The final mark was for mention of free or de-localised electrons accounting for the trend; metallic bonding was not rewarded the mark.

7 This question about sampling an analogue signal was quite discriminating. In (a) many sampled at the wrong times, or sampled at the signal value rather than at the nearest level, as instructed and lost a mark. Most got the correct bit-stream in (b) and went on to correctly describe a difference in a reconstructed signal. Many otherwise sharp candidates quoted aliasing, but this was not credited on this occasion because the frequency picked up by the sampling was present in the original waveform, and was not a construct of the sampling.

Section B

8 This question was about possible circuits for a car heated front windscreen, and as usual with electricity questions was a good discriminator. Part (a) required simple GCSE calculations of current $I = P / V$ and resistance $R = V / I$ from the data supplied, and found some weaker candidates lacking. In (b) many reasonably good candidates stopped at the calculation of x-sectional area and gave it as the answer for the diameter of the resistance wire, this lost them two of the four marks available. Only the better candidates went on to the second part of the composite calculation. In (c) the better candidates calculated that the **very low resistance** required by the series connection of heating elements would need a conductor of diameter about 1 cm; here only quantitative reasoning was accepted for the second A grade mark.

9 This question was about a suspension bridge. Part (a) saw some poor definitions of strong, stiff and tough, as properties required of the vertical support cables. The concepts were often confused, or several were quoted rather than one as a cover-all for misconception; which was penalised a mark. In (b) weaker candidates did not make proper allowance for the doubling of the x-sectional area of two cables (or halving of the force per cable) and lost one mark. Those that realised that they were out by a factor of two, and applied it as an afterthought, were not penalised. The calculation in (b)(ii) was performed by most candidates in two parts; first find the strain then the extension, rather than manipulating the Young modulus definition to find extension directly. Weaker candidates dropped out altogether, or only got as far as the strain. In (c) there were good explanations for the varying tension in the vertical hung cable under the load of its own weight. A popular distractor in (c)(ii) was answer **A** rather than **C**, from those candidates who did not read the information **stress before the bridge section is added**.

10 This question was about the sound absorption properties of a panel and about handling logarithms. Many candidates made a good attempt at explaining a mechanism for sound absorption by the acoustic wool: from many reflections, large surface area, to dissipation by the friction between fibres. Weaker candidates went round in circles and effectively just reworded the root of the question. In (b)(i) many referred incorrectly to the shape of the graph or to k (kilo multiplier) as being indicative of a logarithmic plot, rather than the doubling in value for each equal scale increment. In (b)(ii) most students made the link between the frequency range plotted and the range of human hearing; weaker candidates discussed the intensity range of humans or the sounds in the home and were not credited the mark. There were many pleasing response to (b)(iii) which required a clear statement of the trend shown by the graph, and links between the bass drum at low frequencies and vocal sounds at higher frequencies. In (c) a substantial proportion were not familiar with logarithms (a mathematical requirement of the specification), and made $10 \log_{10} (100) = 1000$, but they still scored one of the marks by setting up the correct method of calculation.

11 This question was about data from a lens experiment to form a real image. In (a) most candidates could plot the data point correctly and add the + uncertainty (error bar). Some more marks were lost for poor plotting of the curve of best fit; here multiple curves, or curves not passing through the uncertainty bars were the most common errors. For a practical difficulty in (b)(i) weak candidates usually blamed poor measuring equipment and "use better ruler" was given as a solution (despite data being given to the nearest 0.001 m). These answers were not credited. Better candidates discussed the difficulty of judging when an image is in “best” focus, and suggested a variety of sensible solutions e.g. use a separate magnifying glass, coloured filters or repeated readings to eliminate random error. Part (c) was also discriminating, there being lots of scope with sign errors and difference values for students to make silly slips in calculating the curvature added to the wavefronts by the lens. The discussion by most students of an estimate of uncertainty in the focal length of the lens started promisingly, from the uncertainty in the image distance values, but many answers were too woolly to gain the second mark. This required a good explanation of what to do with the extreme values to calculate an uncertainty (absolute or %) or range of f values.

Section C

12 a) Nearly all candidates could state an example of a suitable transducer to measure a physical property of their choice. A common error this year was for candidates to state that they were measuring light intensity with an LDR, whereas the real physical variable they were measuring in their experiment was distance (related to the reflected light intensity from a surface). They would lose some credit for this later in the question. In (a)(ii) Voltmeters in series and Ammeters in parallel, poor knowledge of standard circuit symbols were common errors, which lost a mark for each error. However, many circuits and descriptions of how they operated in (b) were very good indeed. Weaker students here lose marks by talking about a change of resistance when a physical property increases, rather than specifying whether it increases or decreases, and its subsequent effect on the size of the output voltage. Another problem candidates make for themselves is by choosing, for example, the turning on/off of a light or a heater rather than having a continuously measurable output. In (c) there was much confusion over sensitivity (change in output / change in input) and resolution (smallest detectable change in input OR smallest detectable change in output/sensitivity). Units did not often agree with their quantity in (a) for say sensitivity. Even when the unit was correct, some used light intensity to measure distance (which would be fine), but referred first to intensity and then later to distance. Credit was allowed ecf where estimates and units agreed with either their stated quantity or the definition that they had given in (i). Measurements of sensitivity were better described on the whole than measurements of resolution or response time. Stopwatch methods can work to measure the response time of "slow" thermistors, but are not really appropriate for LDRs where fast data-logging techniques would be more suitable. Many candidates also missed the point about stopping timing when the sensor has settled to its new steady value, which should have been pre-determined.

13 This question about describing an experimental technique of their own choice to measure refractive index of a material such as glass brought a good crop of good marks for many students. Certainly some weaker students seemed to be running out of time on this last question.

(a) A significant proportion did not label the angles *i* and *r* (or the critical angle *c*) properly or at all despite later reference to them. (this was penalised in (b) by a maximum of 2/3 marks). Most scored the 2/3 marks for a working diagram, despite many being rather scruffy.

(b) Descriptions of the method of the experiment were generally quite acceptable.

(c) One shot measurements of refractive index were credited one mark; methods involving repeat readings were credited 2/3 and better graphical methods scored full marks.

(d) (i) Many candidates made the link between speed of light and refractive index for the first mark, but were not explicit enough about the reciprocal relationship to generate the second mark. Simply quoting the formula from the sheet was not felt to be worthy of the second mark.

(d) (ii) Only the direction of the refracted was credited not the small size of the deviation of the blue light from the red ray given. Many weak candidates contradicted what they had written in (ii) but the mark was stand-alone. In (d)(iii) in trying to describe the image woolly answers such as distorted image were not credited, but discussion of blurred images or coloured edges to the image were given the mark.

2861 - Understanding Processes

The paper was of an appropriate standard and provided candidates with opportunities to demonstrate their knowledge and understanding across a range of phenomena. The variety of question styles examined candidates' abilities in calculation, deduction and explanation. There were parts of questions specifically designed to test the more able and provide differentiation at the higher levels of performance. It was pleasing to see so many candidates prepared to show their reasoning clearly and to carry out calculations in a systematic and orderly manner. The mean mark on this paper was 55 and the distribution of marks about the mean had a standard deviation of 17.2. The mark required for an A grade on this paper was 68 and the E grade threshold was 38. Most scripts were fully worked indicating that the candidates were able to complete the paper in the 90 minutes allocated. Sections A and B were generally well answered and the quality of many answers in Section C was impressively good, covering an interesting range of contexts that had been studied.

Section A

In this part of the paper, which contained the shorter questions, performances ranged widely across the mark range, but it was pleasing to see the number who scored the maximum 20 marks available. In general, clear working was shown and gained credit. Questions 1 and 2 were done well by a majority of candidates, though question 1 proved to be a searching test of the ability of many to translate information from one form into another. Good, clear calculations were shown in question 3(a), but part (b) confounded all but the stronger candidates. There were many pleasing answers to question 4 but a common error in part (a) was to give the answer to 3 decimal places rather than 3 significant figures as specified in the question. The most commonly occurring error in part (b) was to fail to use the time <u>difference</u> (Δt) in calculating the velocity of sound in the well from $v = 6.80 / \Delta t$. Question 5 was discriminating, as expected, but question 6 proved to be accessible to all but the weakest candidates.

Section B

Question 7: This question was about a guitar created using nanotechnology. Generally speaking, this question was well answered by a majority of candidates. In part (a) it was encouraging to see the relevant data being selected and the confident use of the multiplying factor in converting from nanometre to the S.I. unit. Commonly occurring errors in part (b) were to draw a standing wave of higher frequency than the fundamental in (b)(i), and to interchange the positions of displacement nodes (**N**) and antinodes (**A**). In (b)(ii) the link between internodal distance and wavelength λ is not at all obvious to all candidates, and in (b)(iii) the problem of using an incorrect relationship between velocity, wavelength and frequency persists for those for whom rearranging formulae is a dark art.

Question 8: This question concerned the forces acting on a moving vehicle and the power required from the engine under different conditions. A majority of candidates made a very confident start to this question. Part (a)(i) provided a straightforward introduction, and was well done, and answers were encouragingly good to (a)(ii) where the demand was significantly higher. Perhaps the familiar context gave candidates a feel for how to proceed and a wide range of valid approaches to a solution were seen. The most common error in part (b)(i) was to state that the forward thrust must be greater than the drag force, in order for the car to be able to move forwards at constant velocity; a forward thrust of 260 N seemed to be a popular incorrect value to choose. Most candidates picked up both marks in (b)(ii) (error carried forward being allowed from (b)(i) but only the strongest candidates were able to successfully provide the convincing discursive argument required to secure the marks in (b)(iii).

Question 9: This question was about water waves in a large wave tank. The beginning of this question was intended to provide candidates with the opportunity to carry out two routine calculations and to establish the velocity and frequency of the water waves travelling down the first 50 m of the tank. In general, candidates did not disappoint and they were then set up to proceed to consider the effects of a changing water depth on the waves in the tank. In (b)(i), a surprisingly large proportion of candidates wrongly stated the water depth at point **C** to be 0.7 m, which led to a value for the velocity of 2.6 m s^{-1} at **C**. Most were able to correctly calculate a velocity of 2.0 m s^{-1} at **D**. In (b)(ii) many appreciated that a decreasing velocity would have the effect of decreasing the wavelength, but few knew that the frequency would be unchanged. There were many good, carefully constructed diagrams produced in answer to (b)(iii), and the better answers reflected a fine appreciation of the elements of physics at work here.

Question 10: This question was about the quantum behaviour of photons. There was very little evidence of candidates being unable to recognise the area of physics involved, and this was extremely gratifying. Better candidates, armed with a useful level of understanding of the relevant part of the course, went about reasoning their way through the question to produce some good answers. Examiners could see, through the written word, the thought processes of these candidates at work as they dealt with these esoteric points of physics.

In (a)(i) and (b)(i) the diagrammatic representation of the combination of phasors in, and out of phase was tested. In (a)(ii), which proved to be quite discriminating, the specific connection between the probability of arrival of photons at B and the resultant phasor amplitude for the paths considered was required. In (b)(ii) candidates were required to synthesise the ideas established in earlier parts into a coherent argument to answer the question. This proved too demanding for many, but it was good to read some outstandingly authoritative answers to this part of the question. As before in this question, there were some excellent answers to part (c) in terms of equal trip times (or equal path lengths), but a significant minority ignored the prompt in the stem of the question to answer in terms of the quantum behaviour of photons, and framed an answer in terms of geometrical optics.

Section C

In these two questions candidates were given a choice of the situations that they described. In question 11 they were asked to choose and write about an effect caused by wave superposition, and in question 12 to describe and explain a method to measure the distance to some remote or inaccessible object of interest. Answers to section C questions are improving for candidates who prepare well and take the trouble to organise their responses to match the sub-sections of the questions. That said, there were scripts where the quality of the written work and diagrams was disappointing.

2862 - Physics in Practice (Coursework))

General Comments

The vast majority of centres should be congratulated on the professional manner in which the marking and completion of relevant paperwork was carried out. Also, in the way in which virtually all of the work was delivered within the time scale required. Unfortunately there are still a few centres where the addition of totals for each task and the transfer of this mark to their MS1 form led to mistakes, these errors can inevitably lead to delays in the moderation process.

As in recent years, very few centres were adjusted and where adjustments were necessary they appeared to be following similar patterns and it is to be hoped that the following notes will help those centres in the future.

Instrumentation Task

The majority of centres are now following advice given in previous moderator reports and their candidates are using potential divider circuits with LEDs, thermistors or variable potentiometers. It was noticeable that candidates who used more ‘complex’ circuits involving, say, transistors as amplifiers or Wheatstone bridge networks often scored considerably less marks than those who used more traditional AS equipment. Those using transistor circuits often finished with circuits in which the only observation was a bulb being on or off and those using a Wheastone bridge circuit could rarely explain the Physics behind the circuit. Conversely, candidates who used very simple circuits such as a thermocouple connected across a multimeter should not expect to score highly in use of resources. Good candidates give a clear understanding, with relevant equations, of the Physics of a potential divider. Candidates who include an ammeter in their circuit and proceed to measure both the p.d. and current to calculate the resistance appear to miss the point that the p.d. is a measure of the input variable.

In Skill A, two specific points that were often missing from candidate’s reports were proof of planning and a statement about safety. If there is no plan then a candidate should not gain full marks in (a)(i) and similarly if there is no statement on safety written by the candidate, then full marks cannot be awarded in (a)(ii) even if the procedure is inherently safe.

It is in Skill D ‘Analysis’ where there is the greatest misunderstanding of what is required. Under ‘Systematic Measurement’, candidates are expected to take at least three sets of readings for high marks and these readings should all be to the same number of significant figures. It is then perplexing to see candidates making no comment about significant differences between sets of readings and just averaging whatever has been taken instead of pointing out obvious anomalies and taking steps to minimise their effect. There also seems little point in plotting graphs for each individual set of readings as well as a graph of the average; it is the average one that is important and the others are little more than page filling and a waste of time and effort. The ‘Fitness of Purpose’ section of this skill is not just a discussion on whether the particular sensor will fulfil a particular job, it is aimed at quantitatively calculating at least two of the properties listed in the mark grids, e.g. sensitivity, response time, resolution etc.

Material Research Presentation

This task produced some excellent work that must have helped candidates not only in their understanding of a particular material but also in the Key Skill of Communication. Candidates whose title includes a material and its use in a particular context e.g. 'Silicon and its use in semiconductor chips' automatically start to score in both the focus and the context boxes. A few other useful points are as follows:

It was with concern that it became apparent that a few candidates did not do an actual presentation of any type; if this is the situation then they should be heavily penalised in both (c)(ii) and (d)(ii).

(a) (i) Candidates are required to submit a written plan, otherwise they cannot score more than three marks in this section, a pro-forma for a plan can be found on the Advancing Physics website.

(a) (ii) Candidates must provide a list of their sources and if this list includes page references from books and webpage addresses from the internet then this will also act as proof of doing research in (d)(ii). These references should then be linked into the presentation. Without the original list of sources candidates cannot score any marks in (a) (ii) and also penalise themselves in (d) (ii).

(c) (ii) The illustrations used should enhance the Physics e.g. by showing the structure of the material.

(d) (ii) The paper record should include talk notes as well as power point slides and bibliography.

Making Sense of Data

As with the other two tasks the general standard of work produced is improving. Centres are advised that it is the interpretation of the data that is important within this task and not its collection. Therefore, it is probably better to show candidates the required experiment, and by all means let them use the apparatus, but to then provide one common data set for the whole class. This should make marking easier and should also avoid individual candidates getting a spurious set of results.

The greatest area of concern in this task is the production of computer generated graphs. If a computer package is used then candidates are still required to produce graphs to the same standard as those that may be hand drawn. Thus graphs should be of a reasonable size, at least half an A4 page, say, must have both horizontal and vertical grid lines, small points whose values on the x and y axes can be read from a suitable scale and have labelled axes with both quantities and units. Lines of best fit, whether hand drawn or computer drawn should be genuine straight lines or smooth curves, not dot to dot. Failure to follow these guidelines should lead to penalties in (a)(ii), Use of ICT, as well as the sections particularly relating to graph drawing. This advice for graphs also applies to the Instrumentation task.

Another concern in this task applies to only a minority of centres: this is the manner in which all candidates, from these centres, follow exactly the same steps in the analysis of their data and are then awarded high marks for the independence of their work. It is, of course, expected that centres will give certain guidelines before candidates start on their analysis but if this is so prescriptive that all the work is virtually the same then the independence of the work must be brought into question.

2863 - Rise and Fall of the Clockwork Universe

General Comments

The paper proved accessible to the majority although a small but significant proportion of the candidates failed to complete all parts. In some cases this was clearly due to running out of time. However, it was also noticeable that some candidates simply did not attempt parts of the paper. This may have contributed to a mean mark of 43 out of 70, a little lower than in June 2005.

It was noticeable that questions covering areas of the course met for the first time at A2 level such as the Boltzmann factor and the physics of the ideal gas elicited stronger responses than those questions that drew on ideas first developed at GCSE level. Candidates often fell back on GCSE knowledge when the examination required a deeper understanding. Specific examples of this will be considered below.

Once again, questions requiring explanatory answers were often the clearest differentiators between ability levels.

Comments on Individual Questions

Section A

1 Most candidates coped well with the standard calculations required in this question.

2 Although the equation for the acceleration of a simple harmonic oscillator is given in the formula and relationship sheet many candidates did not attempt this question. Other responses included attempts to apply the equations of uniformly accelerated motion to the situation – showing a lack of understanding of simple harmonic motion.

3 Weaker candidates found this question inaccessible, perhaps because the data were presented in a table. This led to some answers suggesting a velocity of approach greater than the speed of light.

4 Candidates have memorised the necessary equation and drew sensible curves for the graph. This is part of the course that seems well covered in all centres.

5 It is most encouraging that very few candidates now consider redshift synonymous with the Doppler effect. The second part of the question elicited some surprising though reasonable answers. The expected answer was that the Universe was formed before the galaxies whereas many candidates correctly suggested that the value of the Hubble constant was somewhat uncertain and could give an incorrectly small time interval from the formation of galaxies.

6 The simple calculation *RC* calculation caused little difficulty for any but the weakest candidates. However, the responses to the second part of the question were less convincing. Many did not answer in terms of a model and assumed that an experiment was being performed. This led to statements such as ‘take readings more often’ in order to improve the model.

Section B

7 This question was about using the decay of a potassium radionuclide to date rocks. It was the most accessible of the Section B questions.

a These standard calculations caused few problems

b The major difficulty in (b)(ii) was getting the ratio the correct way round. Those candidates who correctly identified that the potassium argon ratio would fall if argon escaped successfully worked through to the end of the argument.

8 This question tested understanding of the model of an ideal gas and basic ideas of momentum. Many candidates did not seem to have read the question sufficiently carefully to gain full credit.

a The majority of responses in (a)(i) scored 1 out of 2 in this part of the question because the calculation was rather vaguely worked through without careful use of signs. (a)(ii) proved rather more obvious. (a)(iii) revealed a great deal of misunderstanding about forces. A sizeable proportion of the responses suggested that the force on the wall was much less than the force on the ball. Other weak responses merely stated that the forces were 'equal' – an answer which was not given credit on the mark scheme.

b Weak answers tended to fall back on half-remembered GCSE ideas. Some candidates did not read the instruction to 'use ideas about force and momentum' and thus failed to gain marks. Other weak candidates wrote in rather unconvincing terms about the molecules hitting the walls 'harder'. This was disappointing as the equation given at the beginning of the question should have led them through the explanation. However, many responses were more encouraging and showed a good understanding of force as rate of change of momentum.

c This was a straightforward calculation that most candidates succeeding in working through.

d This was another area in which some candidates gave low-level answers. The weakest answers seemed to be made up on the spot. Once again, the better answers showed a good grasp of the relevant principles and the question proved to be differentiating.

9 This question was about gravitational field and potential, an area of difficulty for many students of Physics at this level.

a The majority of the candidates followed the instructions to use the graph in answering this part of the question and, doing so, scored well.

b This straightforward part of the question caused few difficulties.

c Although the majority of the candidates correctly calculated the kinetic energy of the Earth in orbit around the Sun they seemed to forget that the potential energy of the Earth is negative when they added the two energies together. Reaching an answer in which the total energy of the system was positive did not seem to concern these candidates.

d Good candidates showed an excellent grasp of the situation in this part of the question. Weaker candidates once again fell back on GCSE knowledge and considered gravitational potential energy as mgh rather than $-GMm/r$. Some answers did not follow the instruction to consider energy changes and used an argument from centripetal force.

10 The last question in the paper concerned the ionisation of particles on the Sun's surface and fusion processes within the core. As in previous years, candidates showed confidence in this area of the subject first encountered at A2 level. The best responses gained full marks.

a An easy starter that proved accessible to all.

b (i) and (ii) were correctly answered by nearly all candidates. (iii) was more testing and it was encouraging to read many cogent responses that correctly linked number of collisions per second with the value of the Boltzmann factor as a measure of the probability of a collision having sufficient energy to ionise an hydrogen atom. It is clear that students are well-prepared in this area of the course.

c (c) moved on to a consideration of fusion within the core. (i) was trivial whilst (ii) allowed confident candidates to further show an understanding that unlikely events will occur given sufficient attempts. Once again the best answers showed clarity of thought and understanding of the basic physics of the situation.

2863/02 - Practical Investigation

There were approximately 2800 Candidates from 307 Centres entered for the coursework component in the June session. Moderators noted an increase in the number of administrative errors with both the MS1 and rating sheets. A lack of ticks or any comments on the latter can also make it very difficult to see how the marks given can be justified.

Strand C assesses Communication in the form of data recording, narrative and graphs. Whatever choice is made for the placement of graphs the size should be sufficient for the data plotting to be checked, (a lower limit of A5 is suggested). For access to the higher ratings in C(ii) graphs should have horizontal and vertical grid lines, the axes labelled with both quantity and unit, a trend line and be suitably referenced from the source data table. A well structured report will have clear referencing between the text and the graphs/tables so that the reader can follow the narrative. In addition the report should be paginated so that a reader can identify and refer to particular points made by the author; a valuable aid to Moderators giving feedback to Centres. On a practical level each report should be stapled through at the top left hand corner or treasury tags used. The various spines, decorated files and plastic wallets are not necessary and only a slight improvement on those Centres that send 567 loose pages for the Moderator to put into some sort of order.

The choice of topic is secondary to what the Candidate does. Although the ideal is for the Candidate to make the choice it is increasingly clear that many Centres give Candidates a limited list from which to choose. Frequently this results in several Candidates investigating the same topic and the independence of the work done is compromised to some extent. There is clear evidence of collusion when Candidates present tables with the same values for both the dependent and independent variables and the only difference in the graphs is the colour of the background shading. The specification for this component suggests a Candidate may typically spend about ten hours on practical work and a similar time on other aspects. The work presented by many Centres suggests a much shorter time involvement and level of demand of the task which has not moved on from GCSE or AS level. Frequently much of the work appears to be driven by haste and economy of effort. Similarly Candidates who have searched the course CD for ideas present work with no development beyond the detail on the CD.

To give a practical illustration of the above points, consider what has become, by virtue of the numbers of Candidates doing it, almost a standard investigation: the falling sphere viscometer or Stokes' Law for the determination of fluid viscosity. It is expected that an A2 Candidate will appreciate the uncertainty in the measurement of the drop time. If manual timing, using a stopwatch, is employed with recorded drop times in the region of a couple of seconds, then large percentage errors will be involved. These errors will affect the ratings in the assessment strands other than just strand (c) (i). In particular the marks available in strand D, Evaluating evidence and drawing conclusions, will be very limited on the rubbish in equals rubbish out principle. Fully appreciating the limitations of the timing method used does not score a five in (d) (i). To gain access to the higher ratings it is also expected that there will be clear evidence that terminal velocity has been checked for, the upthrust provided by the fluid has been considered and the Candidate appreciates the importance of the relative diameters of the falling sphere and the fluid container. Dropping a ¼ inch steel ball bearing through glycerol in a 6 inch test tube will not yield results worthy of analysis or discussion. The values determined for the dynamic viscosity of the fluid used should have the correct units (Nsm-2) and be compared with the accepted values from referenced sources of known integrity (not Wikipedia). However determining the viscosity of engine oil, or any other fluid, is not what good Physics B practical investigations are all about. Far better to pose the question: "Does Stokes' Law apply to the fall of a party balloon in still air?" There is no standard textbook answer at this level and finding out should encompass all the physics mentioned above. It is not a secret that the short answer is "no" but finding out what laws do govern the motion and why is a real challenge. It is also much more fun.

2864/01 - Field and Particle Pictures

General Comments

This year, for a change, Section A was straightforward throughout, allowing many candidates to earn full marks. However, Section B offered fewer easy marks than usual, so the outcome was broadly the same as previous years, with the paper providing good discrimination. Some candidates were able to earn full marks, others only a handful.

It was good to find that so many candidates were able to demonstrate a good understanding of the whole range of topics covered by this module. The physics involved with Field and Particle Pictures is not always easy, and most candidates are already tired when they start the exam, so their performance does them credit.

The poor standard of presentation of algebra and calculations has been mentioned in previous reports. The situation is unchanged. Too many candidates lose marks because examiners cannot follow their logic. It would help if candidates were trained to start at the top and work their way down to the bottom, with some indication of the flow of the argument. Many weak candidates do not write down every step in a calculation, making it impossible for any marks to be awarded for valid steps towards a wrong answer.

Candidates are no better than previous years at retaining the context of a question in their mind's eye. It is distressing to find halfway through a question about generators that the candidate clearly thinks that it is a motor!

Comments on Individual Questions

Section A

1 This is the traditional start to the paper. Although the vast majority of candidates knew the correct units for electric potential and field strength, many weak candidates got them in the wrong order.

2 The symbol E in the expression $E = mc^2$ represents the rest energy of a particle. Answers which invoked the energy E required to create a mass m (and vice versa) were accepted. Weak candidates typically related E to binding energy, probably confusing the universality of the mass-energy relationship with their most recent application of it.

3 Although the vast majority of candidates worked out the value of the missing nucleon number (90), many failed to earn the second mark, often because they assumed the beta particle has positive charge or no charge at all.

4 This was a straightforward two-part calculation which many candidates were able to perform correctly. Sadly, many weak students did not realise that they had to calculate the decay constant first.

5 This was the first time that a poem has appeared on this paper. The vast majority of candidates correctly stated that the particle was a neutrino (both neutron and photon were popular wrong answers). Most candidates completed the charge column correctly, but made mistakes in the interaction column. They were expected to recognise that neutrinos interact much, much more weakly with matter than electrons, neutrons or photons; many candidates clearly did not.

6 This question arose from candidates' general inability to draw these scattering curves correctly in previous year's papers. It was pleasing to find that many candidates were able to recognise the correct path, even though experience suggests that many of them would not have been able to sketch it. Some candidates were unaware that the alpha particle does not lose much kinetic energy when it is scattered.

7 This was another two-part calculation which defeated weak candidates. They needed to calculate the total dose equivalent first (4.0 mSv) before calculating the risk. Too often they tried to do it all in one calculation, forgetting to take account of the 40 years or the units (mSv). As always, the need to calculate a percentage defeated many weak candidates, often offering answers which were 100 times too large or too small.

8 The overwhelming majority of candidates knew that the emf across the coil is proportional to the speed of rotation of the magnet. It was interesting to see how many candidates couldn't keep the context in their heads as they tackled part (b), providing answers more appropriate to a motor than a generator.

9 This question about binding energy was well answered by most candidates. Not only could they correctly identify the region of the graph where the most stable nuclei are to be found, they were also able to correctly sequence the statements arguing why binding energy is always negative. Experience from previous years suggests that very few candidates can write anything sensible about binding energy, so it is good to see that so many can demonstrate some understanding of what is going on.

Section B

The last four questions always ask candidates to demonstrate their understanding through a realistic context, with hard questions lurking between easier ones. Good candidates are able to assimilate the information provided and use it to answer the questions. Weak candidates often treat each section of a question as a stand-alone item, and get lost because they haven't remembered what the context is. The four marks for quality of written communication appear to be ignored by many candidates. They cannot expect to gain all of them if they do not use capital letters and full stops at the start and end of sentences, and give no indication of the order of their algebra.

10 This is not the first time that a mass spectrometer has had a whole question to itself on this paper. Nevertheless, it discriminated well. Many good candidates earned full marks, but weak candidates often scored very few. Although most candidates knew that the field lines had to point from left to right, they failed to draw them so that they appeared to be equally spaced. Too many candidates lost a mark through careless sketching of these lines. The two-part calculation of the momentum of the particles leaving the accelerator defeated many weak candidates, with some confusing potential difference V with velocity v. As ever, candidates who wrote down a wrong answer and failed to help the examiner identify the train of their argument earned no marks at all. Simply writing down the formula, followed by the substitution before doing the calculation earns two marks. It also gives the candidate a chance to check their calculation. Careless sketching (again) of the force on the particle in the magnetic field lost many candidates a mark. Drawing a line which crosses the path is not enough. It must look as though it is at right angles to the tangent at that point. The calculation of the radius of the path has been asked many times before, and many candidates earned all three marks. Weak candidates who tried to equate IlB to mv^2/r got nowhere. The final part of the question was, as expected, the hardest, with only the best candidates able to explain why increasing the mass of the particle increased the radius of the path.

11 It was good to see how many candidates were able to explain why the decay products could not be just alpha particles. Weak candidates who could not remember the nucleon and proton numbers of an alpha particle tended to earn nothing, but those who confused nucleon and neutron number could often gain a mark or two. Similarly, many candidates were able to earn full marks for explaining how the amount of lead-206 increases with time. Weak candidates who forgot about (a) and assumed that the amount of lead-206 decreases as time goes on earned nothing. The graph was well sketched by the majority of candidates, although many of them will not have seen it before. Showing that $R = e^{\lambda t} - 1$ was beyond many candidates. Too often they would write down the expression $N = N_0e^{-\lambda t}$ from the formula book and then do things to it seemingly at random until it became the desired expression. Finally, many candidates were able to do a difficult calculation involving logarithms, suggesting that many centres have taken trouble to equip their students with the mathematical tools required for this module.

12 There is always a long question about an electromagnetic machine in Section B. For a change, this one did not require candidates to sketch any flux loops. The transformer calculation was done correctly by most candidates, but their explanation of transformer action was too often significantly weak. They still do not appreciate that the flux from one coil has to **change** in the other to generate an emf. Only a minority of candidates realised that the lack of a good magnetic circuit linking the two coils meant that the emf was significantly lower than the calculated value. The many answers invoking the high resistance of the skin or the loss of energy through eddy currents earned no marks. Candidates have been able to do good sketches of sine curves for a number of years now. There were few instances of carelessly drawn curves with variable amplitudes of incorrect phases. The last part of the question required candidates to calculate the peak flux linkage from the emf-time graph. A common error was to use the gradient instead of the area, and candidates who had the correct rule $\varepsilon = \frac{d(N\Phi)}{dt}$ often chose an inappropriate value for dt from the graph. Only a minority of candidates correctly chose to use a quarter of a cycle. Answers which treated the area as rectangle earned just as many marks as those which treated the area as a triangle or managed to do the integration correctly. As always, electromagnetism appears to be a foreign field for many candidates.

13 Most of this question was well answered by many candidates, suggesting that they understand this type of modelling. The vast majority of candidates could sketch the standing wave correctly and then go on to prove the required expression. The layout of their answers often left much to be desired, with the ordering of the expressions often not flowing down the page or from left to right. The first calculation required three steps. Many weak candidates forgot the question and stopped after they had calculated the energy of the photon. Most of the rest divided the energy by 9 instead of 8, even though they had just successfully drawn an upwards arrow from E_0 to $9E_0$ on the energy level diagram. The final part of the question was poorly answered by many candidates, showing their poor grasp of the context. Too often they suggested that energy was transferred to heat, and were too vague about how the photons were different. Only a minority invoked the energy level diagram and explained how lower energy photons could be emitted.

2864/02 - Research Report Coursework

In May 2006 over 420 Centres returned the marks of nearly 5000 candidates for this coursework component of the Advancing Physics course. Most Centres managed to meet the May 15th deadline and quite a few submitted coursework well in advance of it. It is both acceptable and desirable for centres to send all of the scripts when the number of candidates is small. With entries up to about 15 it makes sense to submit the whole sample without waiting for the request from the moderator as this avoids unnecessary extra administration for the centre assessors. There were a number instances this year where the marks on the MS1 (OMR Mark sheet) could not be read. Centres had not ensured that the scores were indicated as a number as well as the usual series of blobs. As it is the duty of the moderator to ensure that the marks have been correctly transcribed from the assessment grids to the MS1 this created significant extra work for a number of them. A photocopy of the front of the MS1 should be provided where the clarity is in doubt. A few centres did not provide a CCS160 (centre authentication form) which might have resulted in a delay to the publication of their grades this summer. A number of Centres made good use of the electronic versions of the forms from the OCR website. There are several that need to be completed in connection with this work and pre-heading the electronic versions with your centre details obviates the need for much tedious replication.

The most successful centres had instilled in even their weakest candidates the need to make an explicit link between their bibliography and the text they had written. Embedded references are becoming common currency in the best reports as are wide ranging and detailed bibliographies. The number of reports lacking a clear focus based on a topic rooted firmly in the Advancing Physics course is certainly diminishing but some candidates still seem to evade the best advice of their teachers and produce ‘physics free’ work. It cannot be overemphasised that this is a piece of A2 coursework and as such needs to be built around a physics topic of appropriate demand. A number of students still insist on tackling subjects with a somewhat tenuous link to the course. Although the most talented individuals are able to write impressive pieces on almost any topic you can think of the weaker candidates do need focus. Chaos, time travel and supercomputers seem to feature regularly as some of the least well tackled topics. Students clearly set out with enthusiasm for the fundamental ideas but find the going tougher than they expected and that source material at the appropriate depth is difficult to obtain. The end result can be rather descriptive and contain little or no physics at all. It is not the intention of the specification to encourage students always to play safe but teachers are well advised to guide their students towards topics that are appropriate for them. The Report title chosen must enable the student to demonstrate a good grasp of the A level physics that it might reasonably be expected to contain.

There were a handful of centres in this session who submitted reports where substantial plagiarism had been overlooked. All students use source material to some extent but the best rework it appropriately, sifting and selecting to give the original words their own spin and to stress their chosen theme. What is not acceptable is the simple inclusion of material verbatim only changing the font in an attempt to pass off the source text as their own. In such cases high marks awarded in Strand A for Interest & Independence and B for Analysis & Interpretation of the physics cannot be justified compromising the centre’s rank order and making a moderating adjustment to the whole centre impossible. The Moderators task is made significantly easier by those centres that mark the scripts assiduously. A number of centres are still submitting scripts for moderation that show no signs of marking at all. Although the comments given on the assessment grids demonstrate that the scripts have been accurately assessed it is essential that they have annotations within them. Where such annotations indicating errors are omitted it will be assumed that they have been missed and the centre risks a downward adjustment. The more evidence that the centre provides in support of the assessments that they make the less likely the moderator is to consider such an adjustment. The majority of the changes recommended in this session occurred where little or no evidence was provided in support of the marks.

Large centres need to be aware of the need to moderate internally to ensure consistency of assessment across their entry. Moderators are instructed to sample across the sets as well as across the mark range in order to confirm that such consistency is maintained. Some evidence needs to be provided to the external moderator that this process has been carried out and a short note explaining the details is expected.

There was another healthy batch of scripts scoring full marks (40/40) that were recommended for coursework prizes. The topics on offer included A History of Timepieces, The Physics of Football, Optical tweezers, The Earth's Magnetic Field, General Relativity, Roller Coasters and Superconductors plus many more. Centres can be rightly proud of the high quality of work that they elicit from their best students in executing this piece of coursework.

Centres that are concerned about their understanding of the criteria for the assessment of this task might consider attending one of OCR's Training sessions usually held in the Autumn term. Another way that Centres can seek reassurance that their interpretation of the criteria is sound is by using the Consultancy Service. This is provided free of charge and allows centres to submit a sample of a few marked scripts for detailed analysis and feedback from an expert moderator. It should be noted that a 6 week lead time is involved so the onus is on the school to submit the work early in the assessment cycle. Details of this consultancy service and dates for the training sessions can be found on the OCR website.

2865 - Advances in Physics

Once again this year, most candidates had been well prepared for the questions based on the Advance Notice Article, and scored highly on Section A. Some of the less successful candidates gave the impression of having been rushed for time to complete the paper, with gaps in the last two questions. A few candidates lost marks, sometimes several on the paper, by not clearly working out an answer to a 'show that' calculation: just writing out the expression to be evaluated and then following by the value given in the question, as for example in the calculation of a gravitational potential difference in question 1(b)(ii),

$GM/R_X = 6.7 \times 10^{-11} \times 2.0 \times 10^{30}/7.0 \times 10^{8} = 2 \times 10^{11}$ J kg^{-1}

does not show that the expression has actually been calculated out. This loses one of the two marks available for the calculation. The recommended approach is to write

$GM/R_X = 6.7 \times 10^{-11} \times 2.0 \times 10^{30}/7.0 \times 10^{8} = 1.9 \times 10^{11}$ J kg^{-1} $\approx 2 \times 10^{11}$ J kg^{-1}.

Extended answers in continuous prose still prove demanding for many, so that marks were lost due to lack of clarity in explanations. Examiners were left with the impression that candidates had the right ideas, but could not express them adequately. If candidates were to write in correct sentences, avoiding too many references to 'it' and 'they' instead of the quantities or entities referred to in the question, it would help them organise their thoughts and tackle the questions better. Many examiners also complained that the poor handwriting and layout of calculations made interpreting some candidates' answers very difficult, and sometimes impossible.

Details of individual questions:

Section A

Question 1 (Sun's energy source - gravitational). This was mostly well done, but only better candidates were able to explain gravitational potential difference and kinetic energy gain in (b)(i) and (iii).

Question 2 (Sun's energy source - nuclear). Most candidates tackled all parts of the question well. Less successful candidates did not appreciate the need for high precision in calculating Δm in (b) (i) and rounded too soon in the calculation.

Question 3 (Orbits) Relatively few candidates recognised that there were two factors which would lead you to expect a period < 1 year for SOHO in (a)(ii) and to explain the inapplicability of $v = \sqrt{GM/R}$ in (a)(ii). Although most candidates were able to find the section of the article dealing with the comet's tail in (c), weaker candidates had difficulty with clear explanation, and frequently answered (c)(i) in the space for (c)(ii) and vice versa – this was credited.

Question 4 (Sunspots) A surprisingly large number of candidates had difficulty in calculating the period of the sunspot cycle from the graph in the article. Most candidates were able to use Stefan's Law to show that sunspots emitted about 20% of the energy emitted by adjacent regions of the photosphere, but many found it difficult to use simple ideas of contrast to explain why sunspots appear dark while mercury appears bright.

Question 5 (Charged particles in Earth's magnetic field). The combination of circular motion and magnetic field made this question difficult for many. Only the best candidates appreciated the significance of the components of velocity perpendicular to and parallel to the magnetic field, and few candidates followed the logical development of the question from protons moving in circles to protons spirally along field lines to the appearance of aurorae near the poles. Many candidates assumed that the appearance of aurorae there was due to attraction by the stronger magnetic field near the poles.

Question 6 (Solar corona). This question was generally well answered, with many candidates explaining clearly why protons can escape from the solar corona in terms of the number with energy in the $15kT$ to $30kT$ range.

Section B

As in previous years, Section B showed more instances of candidates revealing a lack of understanding of the physics involved. This is to be expected, as they will have had ample opportunity to discuss the physics in the article with their teachers.

Question 7 (Sterilizing food). This question, which could not be prepared in advance, proved the most difficult in the paper for many, who could not explain what the term 'ionising radiation' meant without a circular definition, e.g. 'radiation producing ions'. Very few answers to the part asking why gamma rays do not make food radioactive mentioned the nuclei of atoms, or even revealed the GCSE knowledge that radioactive materials have unstable nuclei. As has been noted before, when asked for the physical properties of a material [used to transport gamma ray sources], candidates rarely refer to bulk material properties and quote instead 'thick', 'air-tight' or similar, rather than the expected 'dense', 'tough', 'strong' or even (as was seen in the best scripts) 'low half-thickness'.

Question 8 (High voltage pulses). Those candidates who had not flagged by this stage did well on this question. Good answers were clear in explaining increased induced emf in terms of greater rate of change of flux, while weaker answers confused charge, capacitance and energy in finding the energy stored in a capacitor, and lost a mark for an excessive number of significant figures. Suggested applications for such a circuit were usually good, with cardiac defibrillators, car spark plugs, camera flash units, cattle prods and tasers all receiving mention and being justified in terms of needing high voltage or short duration.

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June 2006 Assessment Series

Unit Threshold Marks

Unit		Maximum Mark	a	b	c	d	e	u
2860	Raw	90	66	59	52	45	38	0
	UMS	100	80	70	60	50	40	0
2861	Raw	90	68	60	52	45	38	0
	UMS	110	88	77	66	55	44	0
2862	Raw	120	97	85	73	62	51	0
	UMS	90	72	63	54	45	36	0
2863A	Raw	127	100	89	78	67	57	0
	UMS	100	80	70	60	50	40	0
2863B	Raw	127	100	89	78	67	57	0
	UMS	100	80	70	60	50	40	0
2864A	Raw	119	91	81	71	61	52	0
	UMS	110	88	77	66	55	44	0
2864B	Raw	119	91	81	71	61	52	0
	UMS	110	88	77	66	55	44	0
2865	Raw	90	71	64	57	51	45	0
	UMS	90	72	63	54	45	36	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
3888	300	240	210	180	150	120	0
7888	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
3888	23.9	45.0	64.0	79.1	90.7	100.0	6498
7888	31.2	53.9	73.4	87.6	96.8	100.0	5057

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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