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Report on the Examination

Physics
Specification A

- Advanced Subsidiary
- Advanced

Advanced Subsidiary – 5451
Advanced - 6451

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Advanced Subsidiary Examination

The Advanced Subsidiary examination is now well established and candidates have become familiar with the type of questions and the format of the papers.

All the principal examiners were satisfied that the papers had been fair and of a similar standard to the June 2001 papers. It is pleasing to report that the practical paper PHA3/P produced a wider distribution of marks than the corresponding paper last year. This was due to the design question being more accessible and the paper as a whole allowed candidates at all levels to demonstrate their skills. The principal examiners were also of the opinion that the coursework now achieved comparabilty with the practical examination.

There was no evidence in any of the papers to suggest that candidates had been short of time and apart from one topic in paper PA01 (see detailed report) there was no strong evidence that any particular topic had not been covered.

Many of the examiners made reference in their reports to the continuing incorrect use of significant figures and, to a lesser extent, the use of incorrect units. Candidates are penalised for such errors and it is felt that more attention should be drawn to them during the course of the teaching year.

There was general consensus that the quality of the written communication had improved and very few candidates failed to gain any of the two allocated marks.

Unit 1 : PA01 : Particles, Radiation and Quantum Phenomena

General

A majority of candidates found the paper relatively straightforward and a significant number of excellent scripts were seen, but for most candidates there was at least one area of the Specification in which their knowledge was insufficient to give a good answer. The purpose of the inside coating in the fluorescent tube in question 4(b) was the least well understood topic, followed equally by the optics question and the photoelectric effect. At the lower end of the mark spectrum there was a noticeable tail of low marks and a significant number of single figure scores were noted.

Question 1

Part (a) usually gave a good start to the majority of candidates. In part (b) there was an even split between candidates who gave the answer as +2 and those who gave the correct answer in coulombs. The final answer was also sometimes given a negative value. The results in part (c) were, in general, correct.

In part (d) only the better candidates completed the calculation. The usual errors involved using the wrong number of electrons or nucleons or not using consistent mass units. In recent examinations it has been quite common for candidates to make errors when calculating percentages but in this question this error was not often seen.

Question 2

Difficulties occurred in this question because it required some care in the candidate's choice of words and also required the candidate to think carefully about the drawing in part (b). In part (a) the simple fact that air absorbs or deflects α particles was frequently not stated and words like diffraction appeared in the answers. The conclusions concerning the nucleus also lacked sufficient detail in some cases to gain marks. Such examples were: 'the nucleus has a big charge' rather than a positive charge and 'the atom is mainly open space' when the question was specifically about the nucleus and not the atom. In the final section of part (a) the strong nuclear force and the weak interaction both featured as possible answers, both being incorrect.

In part (b) the path of α particle 3 in particular was poorly done because candidates did not address the physics of the situation before drawing the path. Some thought should have been given to the following: the force is repulsive so which way does the path curve, where does the path curve the most, how much curvature is there compared to path 2 and how close does the path come to the nucleus.

Question 3

Only a minority of candidates tackled this question satisfactorily. In part (a) about 50% of the scripts showed incorrect refraction at the surface, with the angle of incidence being less than the angle of refraction and also did not show the angle of reflection to be equal to the angle of incidence at the boundary between the two media. A worrying number of candidates failed to use a ruler when completing the diagram and a penalty was applied to freehand drawings.

Again, in part (b), only about 50% of the candidates could use Snell's law correctly when calculating the angle of incidence and refraction. Part (c) on the other hand, was well understood and answered correctly by most candidates. Although many candidates encountered difficulties with this question, the examiners were of the opinion that, in general, the answers did show a slight improvement to those in previous years on the optics question.

Question 4

Candidates, generally, did not performed well in parts (a) and (b), both of which required descriptions and explanations. In part (a) the description of an excited mercury atom very often contained far too much detail e.g. the description often included a discussion of the subsequent relaxation of the atom. Alternatively, too little information was often the problem, e.g. statements such as 'the atom is given extra energy'. Other candidates referred to a change in orbit without giving the direction of the change. However, on balance, candidates did seem to know what an excited atom was. Part (a)(ii) discriminated well. Many candidates simply repeated the answer to part (a)(i) using different words rather than describe how excitation takes place in a particular environment.

Answers to part (b) included all sorts of reasons, ranging from 'it keeps the heat in', 'it keeps mercury safe' and 'it reflects electrons', to the correct answer. On the positive side almost all candidates attempted parts (a) and (b) but it was obvious to the examiners that this section of the Specification had, in general, not been taught to any depth.

The majority of candidates performed well in part (c) and calculated the correct frequency. The usual error was omitting the powers of 10 when transferring the values of the energies. Also, many candidates failed to draw the arrow in the correct position in part (c)(ii).

Question 5

Certain parts of question 5 discriminated well. In part (a) it was usual to gain only two out of the three available marks because candidates did not realise that the particle in part (a)(i) was an anti particle and in part (a)(ii) were not aware of the π^0 hadron.

In part (b) about 75% of the candidates knew the quark structure of the K^+ muon and about 50% gave the antiparticle corresponding to the positive muon. The other sections of part (b) caused very few difficulties. Only the better candidates completed the Feynman diagram without error in part (c). The majority drew the familiar H pattern and randomly mixed up electrons and neutrinos on the right hand side of the diagram.

Question 6

In part (a)(i) it was quite common to find candidates simply reiterating the question without presenting any further information. This meant that the usual error in this type of question of not distinguishing between intensity and frequency was seen less often than in previous examinations, but unfortunately this was not due to an improvement in the understanding of the topic. In part (a)(ii) only the better candidates considered more photons per second rather than just more photons, and of these candidates only a fraction discussed the nature of the interaction being that of one photon interacting with one electron.

The calculations in part (b) were generally well done and caused problems only for the weaker candidates. Many candidates however, in parts (b)(ii) and (b)(iii), used the approximate value for the frequency, given in part (b)(i), rather than the more accurate calculated value. This incurred a penalty. There was also considerable incorrect use of significant figures at this point. Although the calculations were generally correct the interpretation of the data obtained, which was necessary for (b)(iv), was not of the same standard.

Question 7

Most candidates showed that they could perform these types of calculations with ease. A number of candidates however did pick up a significant figure penalty. Part (ii) did show more physics errors than part (i), the most common being using the electron speed rather than the speed of light in the equation $c = f\lambda$.

Unit 2 : PA02 : Mechanics and Molecular Theory

General

The examination paper produced good discrimination with a full range of marks. There proved to be no inaccessible questions although some marks were hard to come by and were only secured by the most able candidates. The more descriptive questions were answered in greater detail than was the case last year and it appears that candidates are getting better at this type of question. The quality of written communication was definitely an improvement on last year and most candidates were awarded either 1 or 2 for this skill. There was no evidence that candidates were short of time or that there were areas of the specification in which candidates were less well prepared.

Question 1

Candidates found this question quite straightforward and full marks were not uncommon, but the idea of the magnitude of velocity increasing with negative acceleration did tax some. In part (c) a significant number of candidates did have trouble explaining clearly why the distance travelled was different to the displacement. There was a tendency to offer vague answers without focusing on the fact that displacement is a vector quantity whereas distance is scalar.

Question 2

Weaker candidates experienced considerable problems with this question. In part (a) these candidates found it difficult to explain what the symbols in the equation represented and errors such as stating that p represented momentum and that c was the speed of light or the specific heat capacity were quite common.

Answers to part (b) were much better and it was clear that candidates were well prepared for this type of question. Part (c) however, caused more problems and although most candidates scored some marks the descriptions were generally vague.

Question 3

Plotting the graph in part (a) was, by and large, well done and the majority of candidates were able to gain the allocated three marks. Again, calculating the gradient of the graph in part (b) was satisfactorily done although a minority of candidates found the inverse of the gradient.

Parts (c) and (d) proved to be very good discriminators. The better candidates tackled the calculations impressively, but weaker candidates seemed unsure as to where to begin. The unit for specific heat capacity did cause a lot of problems to even the best candidates.

Question 4

This question was generally well answered throughout although it was clear that a significant number of candidates were unsure how light gates are used to determine velocity. Ideas for minimising friction were many and varied but very few candidates seemed aware of the concept of a friction compensated slope.

Question 5

Candidates found parts (a) and (c) quite straightforward and usually gained the allocated marks. There were problems with part (b) and of the two sections only the better candidates obtained the correct value for the driving force. Far more candidates were able to calculate the power delivered to the wheels, as they were not penalised for using an incorrect value of the driving force.

Question 6

Most candidates found this question difficult. In general, the candidates had some idea about the independence of horizontal and vertical motion but they found it difficult to express their ideas clearly. This difficulty was even more evident in part (b) when they were asked to consider the effects of air resistance. A common mistake was to state that air resistance decreased the vertical velocity as it caused deceleration. This type of question, which has been set in previous examinations and which also posed difficulties, does seem to highlight candidates' conceptual difficulties.

Question 7

The calculations in parts (a) and (b) were well done although the unit for momentum produced the usual problems. Explaining the crumple zone in part (c) was often well answered although some candidates' answers did tend to lack focus. The idea that the time duration of the collision was increased and that this was important, seemed to be well understood.

Unit 3 : PHA3/P : Practical

General

There was an entry in excess of 3000 candidates for this paper. The work seen showed considerable variation in quality: the better examples (of which there were many), compared favourably with the best work seen in recent years and there were several instances of candidates obtaining the maximum mark of 30. As ever, some weaker candidates were unable to demonstrate any significant progression beyond moderate GCSE standard.

For the majority of candidates, both questions proved accessible and marks were gained in each of the four areas of assessment. Question 1, assessing AO3a, proved to be within the scope of most and the changes to the marking scheme introduced in the January examination proved once again to be of assistance to the candidates. A trend still exists among many candidates to approach this question as a GCSE investigation with much time and effort being wasted in supplying details that are not required. There were encouraging signs however that increasing numbers of candidates are following the guidance given at the end of the question in the way they structure their answers. By doing so they present a far easier task to the examiner in the comprehension of their answers.

Candidates should be reminded that the space provided in the answer book is intended to indicate the length of answer expected, but a significant number (although less than in 2001) continue to use supplementary sheets. Candidates should also realise that the diagram they are prompted to supply can contain details that gain credit for explaining a suitable strategy and appropriate measuring methods, for deducing relevant control factors and for identifying and overcoming potential difficulties. The question provided little opportunity to give generalised and bland statements about procedures: there were few examples of statements such as 'repeat the experiment to reduce error' for example. Despite frequent instances in which sensible and appropriate procedures were identified in the answers, there remains a reluctance among most candidates to link these to a specific difficulty.

Question 2, assessing AO3b, c and d, managed to be accessible to all but the weakest candidates but there were a number of points that discriminated well in favour of the better candidates. Those who arranged their results in table form were at a strong advantage and there were few who could not produce sensible readings of current values. Many candidates needlessly truncated their derived data, thereby compromising the graphical work that followed. Some failed to transfer the full six sets of data to the graph but most proved capable of measuring the gradient properly. There were fewer instances of graphs with difficult or non-linear scales than in the Spring examinations.

Relatively few candidates realised that using combinations of three 100 Ω resistors could produce seven different combinations but credit was earned if the candidates showed six possible arrangements. Candidates who used only combinations involving the simultaneous use of three resistors were not penalised.

Candidates generated marks across almost the entire mark range and it is encouraging to note that even some of those who one might suspect will not continue to A2 with the subject were able to demonstrate sound practical physics work.

Question 1

Candidates were presented with a problem involving the transfer of heat from a lamp to a bicycle wheel in which the spokes were made of rubber bands. The contraction produced in the spokes causes the wheel to rotate.

In contrast to the 2001 paper, nearly all candidates could make a start and in most cases went on to earn at least four of the maximum eight marks that could be awarded. Far too many accounts were overlong but an encouraging number of candidates were able to score the maximum mark; in many instances the answers included more than the maximum eight points for which credit was given. Centres are reminded that this question is now marked as 12 max 8.

Most candidates realised that the rate of rotation of the wheel would vary according to the heat provided and that this could be varied by either changing the power transformed in the lamp or by changing the position of the lamp/reflector relative to the wheel. The overwhelming majority chose the former strategy and correctly specified the need for an ammeter and voltmeter to make the necessary measurements to find the power. Credit was given where candidates stated that they would produce a graph to show how the rate of rotation of the wheel varied with the power transformed in the lamp. Suggestions to draw a graph of period against power gained credit but suggested graphs of rate against voltage did not. Even when a candidate could not describe a worthwhile strategy marks were still available for suggesting suitable measurements, control factors or difficulties.

A mark was awarded for explaining how the power transformed in the lamp would be measured. It was often possible to give credit for the use of a voltmeter and an ammeter where a suitable circuit diagram had been drawn. However the general quality of circuit diagrams was poor: there was considerable variation in the way that the lamp was represented and the means to vary the pd across the lamp was often omitted. Other diagrams were based on the view of the apparatus given in the question paper: these gained credit if static and moving reference marks were shown as aids in accurately finding the rate of rotation of the wheel.

Many candidates ignored the phrase 'rate of rotation', although this was specified in the question. A significant number of those that did refer to 'rate' then described a method involving counting rotations in a fixed time; this gained no credit. Some candidates interpreted rate of rotation as tangential speed: it was common in such cases to see a 'computer' used to measure the speed. Most candidates specified a stopwatch to measure the period of rotation although for those that forgot to mention it, the (pictorial) inclusion in the diagram came to the rescue.

Very few correctly identified the key control variable: for those intending to vary the power transformed in the lamp, the factor to be controlled was the relative positions of the lamp, reflector and wheel.

When discussing difficulties and suitable procedures to overcome them, most neglected to specify the difficulty a certain procedure was intended to overcome. Candidates were given credit for any two procedures that were linked to an anticipated difficulty. Examiners will not give full credit where no difficulty is identified for the procedure outlined. Typical procedures given included maintaining the ambient temperature of the room and waiting until the wheel was rotating at a constant rate before starting timing. Many candidates wrote about repeating experiments to reduce uncertainty but candidates should understand that such vague answers will not gain credit. As ever, there were spurious comments about rejecting anomalous results.

Question 2

Candidates investigated the characteristics of a circuit containing a resistor network.

The initial marks were almost universally gained, although some candidates (wrongly) gave a unit for the initial value for the ratio k. The tabulation of data was mostly satisfactory except in instances where insufficient care had been taken or units had been wrongly given for current. The uncertainty given for the current readings was almost always satisfactory but there was some variation in the consistency with which the derived data was recorded.
As with most simple circuit problems of this type, theory and practice tend to agree well. The graphs produced almost always yielded a straight line but some candidates at this level continue to make rudimentary errors. Several instances were seen in which the horizontal scale contained equal intervals on the $\frac{1-k}{R}$ axis for unequal steps, e.g. those between 0.3, 0.2 and 0.1 were the same as between 0.09, 0.08 etc. This led to a graph with a kink as $\frac{1-k}{R}$ became less than 0.1. It was rare to find (any) correct unit with this axis. Most candidates managed the gradient calculation and obtained an answer of approximately 100 Ω as expected.

The first of two questions addressing AO3d concentrated on what the candidate could deduce about the relationship between variables by looking at the graph. Many candidates still assume that a straight-line graph is proof of proportion between the variables: there is no qualification to be made between ‘proportion’ and ‘direct proportion’ as some insist. Candidates should describe the relationship between two variables as linear when a straight line with an intercept is produced.

In part (e)(ii) comparatively few candidates realised that there would be seven possible combinations of the three 100 Ω resistors although many gave six arrangements and thus gained some credit. It was expected that evidence should be provided for statements about the number of possible arrangements but it was common to find the limiting values of 300 Ω and 33 Ω to be correctly identified. A small number of candidates assumed that the question meant that three resistors should be used simultaneously and deduced that only four arrangements could be produced. Providing clear evidence was given that this assumption had been made, full credit could be earned and these candidates were thus not disadvantaged.

Unit 3 : PHA3/C : Coursework

The general comments on the presentation of coursework are the same as those made on the A2 coursework and the reader is referred to the more detailed comments which appear on pages 18 - 21 of this report.

Unit 3: PHA3/W: Current Electricity and Elastic Properties of Solids

General

Candidates were awarded a wide range of marks in this paper, with some gaining very high marks and comparatively few having very low (below 10) marks. The number of significant figure errors was surprisingly large and examiners felt that candidates should pay more attention to this aspect of the calculations. Similarly, a considerable number of unit errors occurred, especially in question 5 where the unit of the Young modulus, the Pa, seemed unfamiliar to many candidates. The quality of the written communication was of a good standard and many candidates gained the two marks allocated.

Question 1

Part (a) provided the candidates with a reasonably easy four marks, and very few failed completely on the calculation. Usual errors such as units and arithmetic errors occurred but, in general, the candidates knew how to proceed with the calculation.
Part (b) required clear, logical thinking and sadly, the majority of candidates failed to gain the full three marks. Having been told in the question that the resistance of the sensor decreased with increasing temperature, many candidates simply wrote that the reading of the voltmeter would increase. Such a statement, although in itself correct, without any reasoning did not gain marks. Many candidate realised that the current in the circuit would decrease, but failed to go any further. The best approach seemed to be using the potential divider equation and candidates who tackled the question from this angle were usually awarded two or three marks.

Question 2

Although the large majority of candidates gained marks on part (a), the examiners felt that the basic physics which accounted for the form of the characteristic was not fully understood and certain errors and omissions occurred regularly in the explanation. For example, candidates knew that the filament heats up, but it was not made clear that this was due to the current in the filament. Again, most candidates realised that the resistance of the filament increased with increasing temperature, but very few related this increase to the inverse of the gradient of the characteristic. A significant number of candidates thought that the resistance equalled the gradient, not realising that the characteristic had current on the y axis and voltage on the x axis. There were many correct references to the rate of increase of current decreasing, but a surprising number stated that the current decreased with increasing voltage. This last statement was felt to be a failure of expression rather than a lack of understanding, but no marks could be awarded for such a statement. A large number of candidates attempted to give an explanation of the increase in resistance in terms of molecular collisions. Such accounts, although interesting, gained no credit since this depth of understanding is not required for this Unit by the Specification.

The straightforward calculation in part (b) caused a great deal of trouble and the majority of candidates only gained one mark, that being for using the correct expression for power. Errors occurred in converting the mA to A, but the greatest error lay in the correct use of significant figures, many candidates quoting the answer to four significant figures.

Question 3

A descriptive question invariably gains high marks and part (a) of this question was no exception. The circuit diagrams were usually drawn correctly, even though a good variety of possible circuits were produced. The usual error in these circuits was connecting the voltmeter across the variable resistor and omitting the resistance wire altogether. Not only did such a circuit gain no marks but it also affected the description in part (ii) since the measurements described by the candidates would not produce the required reading. The description of the measurements taken with the correct circuit were usually clear except that a large number of candidates wasted time on describing how the area of cross-section of the wire was obtained. In part (iii), when describing how a value for the resistivity was obtained from the readings, the most common error that occurred was not taking a mean value of the resistance of the wire from readings of I and V. It was pleasing to see how many candidates adopted the alternative method of plotting a graph of V vs I to obtain the resistance.

The calculation in part (b) proved to be more troublesome than anticipated with candidates using the length of one of the sides as the thickness of the plastic. Very few candidates drew a simple freehand sketch, which the examiners felt would have eliminated this particular error. The units of resistivity appeared to be well known.

Part (c) enabled the large majority of candidates to gain two marks quite easily, especially since the value of R from part (b) (even if incorrect) was carried forward into part (c). Some candidates thought that the four units were connected in parallel, but this was practically the only error which occurred.

Question 4

It was pleasing to see that a large number of candidates analysed the oscilloscope trace correctly in part (a) and obtained the correct value for the time elapsing between the initial pulse and the reflected pulse. There were some errors, as expected, in taking the reading from the trace, some candidates for example, taking the start of the second pulse as the relevant point, thus giving a total time of 8.0 ms. A significant number of candidates did not realise that the pulse travelled back to the microphone, i.e. a total distance of 3 m.. This calculation again incurred many significant figure penalties.

The answers to part (b) were, in general, slightly disappointing. The main problem was due to candidates not reading the question properly and consequently not describing how the source was connected to the oscilloscope (or Y plates). Many candidates did not describe how the oscilloscope was set up, i.e. adjusting the voltage sensitivity and time base to give a trace, but assumed that this had already been done. Some very neat traces were drawn but others were sketched very casually and did not gain the allocated mark. The majority of candidates described correctly how the period of the wave and hence the frequency was obtained from the trace.

Question 5

High marks were gained for this question on the Young modulus. The definitions in part (a) were usually correct, although it is worth reminding candidates that when defining the Young modulus it is essential to use tensile stress and tensile strain and not just stress and strain. The description of elastic limit was sometimes vague, but the examiners sensed that the candidates knew what it was, even if their wording was not perfectly clear. It should be emphasised however that the wire can only regain its original length when the load or force is removed. A large number of candidates referred to the wire regaining its original shape rather than length; the shape of a wire does conjure up a different picture to the length of a wire.

The graph in part (b) was usually well drawn, although a significant number of candidates did omit the zero point, which was an important point to plot. Surprisingly in part (iii), although candidates had indicated correctly on the graph the extent of Hooke's law, they used a load of 10N in the calculation. This load extended the wire well beyond the region of Hooke's law. Many candidates not only omitted the units in the calculation, but also used incorrect units, N m^2 being a popular alternative.

In part (c), because the expression for the energy stored was given in the question, showing that the work done in stretching the wire = ½*Fe* proved to be more difficult than expected. In the calculation in part (ii) the usual error encountered was not converting the 4 mm to metres.

Advanced Examination

Although there was an A2 examination in January 2002 this was the first time that all A2 papers, including the Synoptic paper, had been available.

A comparison with the performance in January would not be meaningful since there was only a low entry at that time. All the principal examiners were satisfied that the papers had been fair and the questions accessible to all candidates.

In the Synoptic paper, all questions performed well and the examiners were very satisfied with the standard of work produced, even at the lower end of the range of marks. It was felt that even the weaker candidates were able to demonstrate what they had learnt over two years.

Unit 4 : PA04 : Section A : Objective Test Questions

The keys to the objective test questions were:
1-B; **2**-B; **3**-D; **4**- C; **5**-A; **6**-C; 7-B; **8**-B; **9**-D; **10**-A; **11**-C; **12**-C; **13**-D; **14**-A; **15**-C.

The *facility* of a question is a measure of all candidates attempting a question who choose the correct option. The mean facility of the paper was 61%, compared to a mean facility of 70% in January. The facility for individual questions ranged from a maximum of 75% for question 5 to a minimum of 33% for question 14. The examiners were of the opinion that, in general, candidates had not performed as well on this section as they had on section B of Unit 4.

The *point biserial index*of a question is a measure of the discriminating power of that question. The mean point biserial of the paper was 0.44, this being approximately the same as that for January.

Question 1 involved a calculation on the oscillation of a mass on a spring. Surprisingly, for the first question on the paper, the facility of 54% was 4% less than that in the pre-examination test. Almost 30% of the candidates had opted for distractor A, which gave a period of half that of the correct answer.

Questions 2 - 3, also on oscillations and waves, performed more in line with the pre-examination statistics, but in question 3, on shm, almost 25% of the candidates opted for a distractor which stated that the acceleration and velocity in shm are always in opposite directions.

Question 4 involved a graphical representation of a stationary wave. As in question 1, the facility of 70% (although high) showed a 6% decrease on the pre-examination facility.

Candidates were obviously more familiar with the phenomena of interference and diffraction, which were tested in ***questions 5 and 6***. Both realised high facilities of over 70%. Question 6 produced a good discrimination of 0.50

Question 7 involved a calculation on the energy stored in, and the pd across a charged capacitor. Although the facility was 51%, the discrimination was only 0.35 and the statistics showed that almost half the candidates were guessing at the answer.

Questions 8 - 11 were based on uniform motion in a circle and gravitational field strength. It is pleasing to record that all performed well, with facilities ranging from 64% to 70%. It is worth noting however, that in question 9, almost 25% of the candidates thought that the gravitational force between two masses bore a linear relationship with r^2, rather than with $1/r^2$.

Question 12 investigated the relationship between electric field strength and electric potential, a topic which has caused problems for many candidates. It is therefore pleasing to report that the facility for this question was 62%. The remaining candidates appeared to choose at random from the other three distractors.

Questions 13 and 14 were set on the force on a current carrying wire in a magnetic field and motion of an electron in a magnetic field respectively. Question 14 produced the lowest facility, 33%, of all the questions. The statistics showed that the candidates were not familiar with this type of question and that they were guessing almost equally between the four distractors.

Question 15, on the relation between of mass and energy, performed reasonably well, with a facility of 55%, although this was slightly lower than the pre-examination facility.

Unit 4 : PA04 : Section B : Waves, Fields and Nuclear Energy

General

The performance of candidates on this test paper was appreciably better than on the corresponding one in January 2002. Undoubtedly a major factor in this improvement was the greater maturity and experience of the candidates. The summer cohort had twice as much time to study and reflect on the subject matter contained in the Unit 4 specification. Therefore more candidates achieved high marks, fewer candidates were awarded really low marks, and the mean mark for the test was higher.

Large numbers of the students continued to have difficulty in knowing how to deal with significant figures, and penalties were regularly imposed for excessive figures in final answers. This was most frequent in Question 4 (b).

On the whole, more of the candidates seemed to recognise that the quality of their written communication was going to be assessed. Part (b) of Question 1 and part (a) of Question 4 were used for this purpose. However, many of the candidates still failed to organise their work in coherent sentences which convey some knowledge of spelling, punctuation and grammar.

All of the questions proved to be rewarding for good candidates. The examination paper gave candidates a fair test of what they had learnt, and the majority of them were able to show good familiarity with the content of Module 4.

Question 1

Candidates' knowledge of forced vibrations, resonance and damping was rather better than might have been anticipated when this question was set. Consequently most candidates achieved high marks.

The Millennium footbridge has turned out to be a most complex structure, somewhat removed from the temporary "advancing army" type of footbridge traditionally considered in text books. When it was first opened, walkers on the bridge subconsciously adjusted their steps so that they were synchronised with lateral vibrations of the bridge span. In effect this was a feedback phenomenon in which the bridge vibrations were being passed back to the driving forces when there were a large number of people relative to the mass of the bridge and where the level of damping was low. Candidates could not be expected to be familiar with the full detail of this, and consequently the examiners took the view that "resonance" was an acceptable alternative to "forced vibrations" as an answer to part (a).

Part (b) was usually very rewarding. Clear reference to the frequency of the driving force was not always made, however. The examiners were also looking for mention of the amplitude of vibrations, rather than just the size of them. Many good, and some ingenious, answers were seen in part (c). The need for engineers to make the changes was not always appreciated. For example, some candidates suggested that the pedestrians should walk out of step. Neither were the limitations on the materials available to build a bridge readily recognised by some candidates; changing the natural frequency of the material of the bridge would not be a very practical solution. There were also candidates who thought that shortening the bridge would be an acceptable strategy! Despite these unsatisfactory responses, the majority of the candidates knew enough to suggest measures such as improved damping and a stiffer structure.

Question 2

It was satisfying to see so many excellent answers to a question on a subject area that has caused problems in the recent past, and also on those sections testing parts of the specification dealing with the mathematics of exponential discharge, which have been re-introduced at A level. Part (a) only seemed to trouble those candidates who had not learnt $Q = CV$, together with those who did not know that 1 μF = 10^{-6} F. When finding the stored energy in part (b), many more candidates realised that $E = ½CV^2$ is a safer approach than $E = ½QV$, but the latter equation also provided a large number of correct answers.

Three alternative routes were possible when answering part (c). Most candidates preferred to start from the exponential decay equation (either in terms of V or in terms of Q), substituted values, took logs and proceeded to a solution. It was pleasing that so many succeeded. The most elegant solutions came from the candidates who knew that the charge stored falls to (1/e) of the initial charge in a time equal to the time constant. Solutions that made use of the gradient of the initial section of the graph were exceedingly rare. Part (d) was usually well rewarded in most scripts, with candidates working from their knowledge of the time constant as RC.

Question 3

Attempts at part (a) revealed huge uncertainty in the minds of many of the candidates, with 0^o and 90^o repeatedly crossed out before arriving at a considered decision. In the end, more than half of the candidates seemed to get a correct answer.

After the examination it was decided that part (b) should be removed and the answers were not marked by the examiners.

The amplification column of section 13.4.3 of Physics Specification A reads " $\Phi = BA$, B normal to A ". This same entry has appeared in the previous two NEAB syllabuses, stretching back over ten years, out of which the current AQA specification was developed. It was intended by the designers of the specification, and the previous syllabuses, as shorthand for " $\Phi = BA$, where B is normal to A ". "B normal to A" defines the condition under which the equation applies, rather than implying that the 90^o condition is the only case in which magnetic flux may be calculated.

However, it has been pointed out to the examiners that teachers at many centres have interpreted "B normal to A" as defining the only condition under which candidates could be expected to calculate magnetic flux. (This is consistent with the 90º case being a restriction which definitely applies to the equations $F = B\,I\,l$ and $F = B\,Q\,v$ in sections 13.4.1 and 13.4.2 of the specification).

Therefore, in fairness to all candidates taking the test, the two marks for part (b) of Question 3 were discounted from the assessment and the whole paper was marked out of 28 rather than 30.

Part (c) was seldom answered correctly. Very few candidates knew the distinction between flux and flux linkage, and there were considerable difficulties over powers of 10. Many candidates obtained one mark by determining the maximum flux correctly but did not then multiply their result by 650. The correct unit of flux linkage evaded almost all.

Question 4

Candidates usually had a good understanding of fission processes and most were able to make good progress with the calculation on energy release. In a large proportion of the scripts, candidates appreciated that *induced*, *fission*, and *thermal* had to be explained for the three marks in part (a). The explanation of fission itself was not always satisfactory, because candidates referred to atoms decaying rather than large nuclei splitting into two smaller nuclei. Almost inevitably, a significant minority of candidates considered thermal neutrons to be ones that have been heated up rather than ones that have been slowed down.

The calculation in part (b)(iii) produced very many fully correct solutions, even in the work of candidates who had not been able to calculate N correctly in part (b)(i). Significant figure penalties were, however, very common in part (iii). Because mass differences are small, it is conventional to quote atomic masses to a large number of significant figures. Ultimately the data in this question was limited by the three significant figures of 931 MeV, and so examiners were not prepared to accept answers to more than four significant figures.

Units 5 - 9 : PHAP : Practical

General

There was an entry in excess of 2000 candidates for this paper. Although some outstanding work was seen, there was substantial variation in the general quality and the majority showed only a moderate improvement on the standard reached in PHA3/P last summer. The tendency to write more than is necessary, although still prevalent in some instances is less marked than before but this may be because some candidates simply ran out of things to write. The standard of written presentation continues to be very poor among weaker candidates and when this extends to the tabulation of results the subsequent processing usually suffers too.

Despite a more generous marking scheme than previously, the demands of the problem set in question 1 to assess AO3a found significant numbers of candidates lacking in the basic physics knowledge expected at this level. Some candidates had little or no idea how the wavelength of light could be measured: the large numbers that opted for single or double slit methods clearly failed to appreciate that their solution could only work if the filters transmitted monochromatic light which is not the case in this problem. While some did recognise that the limiting values of the wavelengths transmitted by the filters should be measured, relatively few described the use of a diffraction grating. The use of a spectrometer was not expected but many instances were found where candidates described its use in clear and precise detail. There were easy marks to be obtained by describing procedures to overcome difficulties but many got no further than stating the need for subdued lighting or blackout. The evidence seen conveyed the impression that section 13.1.6 of the specification (Interference) was far better understood than 13.1.7 (Diffraction).

Question 2 enabled some easy marks to be gained in AO3b and AO3c but most candidates struggled to score well in all three of the assessment areas. The use of significant figures in the tabulation of raw and derived data found out the weaker candidates and the standard of graphical work was inferior to that seen in the Spring paper. The experiment rewarded careful work and most candidates proved themselves capable of measuring the period of the interrupted pendulum in a satisfactory manner. Few candidates produced evaluations of $\frac{G}{x}$ that could earn full credit: in many cases, the inability to deduce correct units for the quantities plotted on the graph was at the root of the problem. The questions set to assess AO3d discriminated well in favour of those that thought carefully about the issues raised in (e)(ii) and (e)(iii). Although the different types of systematic error described fell outside the range of some candidates' knowledge, the ability of better candidates to think logically worked in their favour. The answers seen in (e)(i) showed the majority are aware of where to observe pendulum motion from, although the correct positioning of the fiducial mark is still a mystery for some.

There is still a fundamental difficulty for some physics candidates in explaining themselves through extended writing. This is more than simply a failure to develop an adequate scientific vocabulary and is exemplified by ambiguity and repetition in the answers given. Weaker candidates will continue to benefit from making sketches of their solutions as these often contain key detail, subsequently omitted in the writing, which can gain credit. The concerning point here though is that as the best candidates continue to get better the weakest seem to get worse. There is a growing number that are simply uncompetitive at this level.

Question 1

Candidates had to explain how to find the range of common wavelengths transmitted by two filters with slightly different characteristics. Marks were awarded for the use of a diffraction grating with known spacing. Candidates were expected to specify two linear measurements capable of yielding the diffraction angle with some suitable measuring instrument specified. If a spectrometer method was described, it was sufficient to explain that an angular measurement was expected. The use of a protractor to measure the diffraction angle was not accepted. For the purposes of this question the term diffraction grating was seen as being distinct from a double-slit system. Suggested double slit methods could not gain full credit since the diffraction pattern obtained would not generate fringes from which a range of wavelengths could be found. Some accounts tended to stray between double slit and conventional diffraction grating methods: inclusion of $\lambda = \frac{ws}{D}$ was usually enough to guarantee that the marks for identifying and making measurements could not be given.

Regardless of how the diffraction was achieved, marks could be awarded if the general solution described was sensible. Examiners gave credit if a sensible test of the transmitted light was suggested, using either each filter in turn or both filters in series. The diagram drawn often provided useful evidence for which credit could be given. Some candidates produced a variation on the two - slit method by placing each filter in front of a different slit: this gained no credit. A mark was awarded if a quantitative explanation was given for explaining the range as the difference between the longest wavelength transmitted by the dark red filter and the shortest wavelength transmitted by the deep red filter. However some accounts did little more than restate the information contained in the diagram. Further credit could be gained for quoting $n\lambda = d\sin\theta$ provided the meaning of d was made clear. Numerous instances were seen where d was given as the distance between the grating and the screen.

Some novel, but impractical, solutions were suggested involving the use of prisms or variable frequency light sources. Other candidates hopefully suggested the use of LDR circuits to test whether light was transmitted or not. In a few desperate cases an oscilloscope was suggested as a means of measuring the light frequency.

Candidates offering the double slit method could still earn marks for other parts of their answer. Many seemed to have a good grasp of Young's experiment and might have been expected to give details about the need for collimation of the beam and use of a white screen, but too often these accounts petered out or became repetitive.

There was widespread misunderstanding of the term monochromatic in relation to the light source: several cases were seen in which lasers were shown in the diagram. The control factor expected was that a white light source should be used, a key detail that most overlooked. It was sometimes possible to give credit for this when included in the labelling of the diagram: no marks were specifically given in the scheme for a diagram but examiners will give credit for any relevant detail included. This came to the rescue of numerous candidates. Among the common misconceptions given for control factors was that the intensity of the source should be kept constant. The need to keep the distance between the grating and the screen constant was also repeatedly seen.

As described in the PHA3/P report it is now the practice to give a mark for a sensible precaution and an additional mark if the difficulty it is intended to overcome is correctly identified. These marks can be awarded for two different difficulty-procedure combinations. For those candidates describing the diffraction grating technique some of these marks came easily and several candidates earned marks in excess of the maximum eight that could be awarded. Ideas such as measuring spectra to the left and right or measuring second or third order spectra to reduce uncertainty were acceptable. Those candidates who proposed two - slit methods seldom gave procedures to overcome difficulties associated with accurately determining diffraction angles but tended instead to detail procedures involving variations in some physical dimension such as slit separation, so that a graph could be produced.

The most frequently quoted precaution was the use of blackout although most claimed this was to cut out interference due to other light sources: it was expected that this precaution was justified as a means of ensuring the spectra could be seen clearly. The use of a white screen could be justified using the same argument.

The fact that large numbers of candidates could only earn 1 or 2 marks rests with a general failure to appreciate the significant advantage to be gained by using a diffraction grating when compared with a two - slit system. However there were ample opportunities here for candidates to obtain marks whether the method suggested involved a diffraction grating or not. Additionally, far too many candidates did not keep their explanations simple and concise. In the best scripts seen, the majority of marks were awarded for relatively short answers.

Question 2

Candidates were required to measure the period of an interrupted pendulum.

The initial measurement was almost universally acceptable and a further mark was usually awarded for tabulating the raw data. Some candidates failed to use a sufficiently large range of l

values (>30.0 cm was expected) and it was even more common to find that these data were not given to the nearest millimetre, as required. Most candidates were able to generate values of T from at least 20 cycles, as was expected.

The derived data sets should have been consistently recorded to either 3 or 4 significant figures although many gave $\frac{1}{T}$ data to 2 significant figures.

A minority failed to appreciate that a unit was required on the vertical axis of their graph: this had implications later for the gradient and evaluation of $\frac{G}{x}$. The marking of graph axes should use the solidus to separate the quantity from its unit and it is expected that the correct power notation be provided in the case of a quotient or product. For example, the vertical axis should have been marked

$\left(\sqrt{l+x}+\sqrt{l}\right)/\,m^{1/2}$ with the horizontal axis marked T/s^{-1}. Several candidates gave $\sqrt{m}$ and Hz as the units on the axes of their graph.

Many graphs were given reasonable scales although marks are withheld when these have been contrived to maximise space in a way that makes interpretation difficult. Some scales were compressed to include an origin and the use of two significant figure data tended to increase the scatter on the graph and forfeit the quality mark. The marking of points and line was generally good and most seem to appreciate the need to use a large triangle to calculate the gradient.

Careful working led to results for $\frac{G}{x}$ that fell within the expected range of (0.95 – 1.05 s m$^{-½}$) but carelessness with units was widespread. Many instances were seen with answers in units given as or in unresolved expressions such as ($\sqrt{m}\,/\,s$) or in unresolved expressions such as $\frac{m^{1/2}s}{m}$.

The questions addressing AO3d dealt with techniques for measuring the period of the pendulum and identifying different types of systematic errors. Most candidates provided a labelled sketch showing the pendulum motion in the same plane as the page, as required. The labelling expected included the pendulum, the 'knife edge' and the fiducial mark. Full credit was given if the fiducial mark was shown at the centre of oscillation: this could not be given if the fiducial mark was shown above the 'knife edge'. It was sometimes possible to give some credit if the drawing showed the view from above the pendulum providing the fiducial mark was correctly positioned directly below the equilibrium position.

Oddly, in the context of what followed in (e)(iii), significant numbers saw the error outlined in (e)(ii) as one that affected the values of $\frac{1}{T}$ incrementally (in the manner of a zero systematic error). For full credit, candidates were expected to state that the error causes a proportional decrease in T which leads to a reduction in the gradient of the graph. In (e)(iii) candidates were expected to explain why a zero systematic error was easier to spot than a percentage systematic error once a graph had been drawn. Relatively few linked a zero systematic error with the production of an intercept and many stated that a percentage systematic error would lead to the production of a curve or anomalous results.

While there was some scope for the weaker candidates to gain marks, this question discriminated well in favour of those that worked carefully and thought about what they would write before committing pen to paper.

Units 5 - 9 : PHAC : Coursework

More centres than in previous examinations produced well-annotated scripts with the investigation being appropriate to the level being assessed.
However, many adjustments to the marks had to be made. This could generally be put down to one of two reasons; either the centre failed to apply the hierarchical nature of the scheme or the centre did not act on the guidance given via the training meetings. Failure to apply the hierarchical system resulted in about 75% of the adjustments.

Following the guidance given at training meetings, centres failed to

- (i) show a dimension to be measured on the diagram, resulting in the loss of A4c;
- (ii) show Δx and Δy on the graph, resulting in the loss of C6b;
- (iii) comment on the spread of repeat readings, resulting in the loss of D2c;
- (iv) use the resolution of the measuring instrument, rather than the spread of repeat readings, to determine the uncertainty in the measurement, resulting in the loss of D4b.

On a more general note, centres are advised to consider carefully the criteria for awarding A8b, B6b, and D6a.

In A8b it was obvious that some candidates were not awarded this mark even when their script demonstrated a sound theoretical background to the design. In B6b, when taking measurements of length, it was not uncommon for this to be awarded for values quoted to as little as one significant figure. This obviously was penalised. In D6a, some centres failed to appreciate the difference between random and systematic errors. This resulted in both penalties for the candidates and the reinforcement of 'incorrect' physics.

A small number of inappropriate investigations were again seen. These can be classed under three types.

- (i) an investigation which is too simple to allow access to the full range of marks across four skills e.g. Hooke's law for a simple spring,

- (ii) an investigation for which the theoretical background is beyond the Specification, e.g. the rotation of the plane of polarisation of light,

- (iii) an investigation which was based on theoretical considerations beyond the scope of the large majority of candidates, e.g. the angle through which a bottle can be tilted before tipping, as a function of the depth of water in the bottle.

Units 5 - 9 : PHA5/W - PHA9/W : Section A : Nuclear Instability

The question on nuclear instability performed well on the whole and many candidates gained high marks. Most of the answers to part (a) had the α radiation correct, but the answer to part (ii) seemed to be guesswork between β radiation and γ radiation.

In part (b) most candidates scored at least one mark and the majority, two marks, but very few were awarded all three. The main problem seemed to be part (i) which asked why a γ source was used. A large number of answers to this were disregarded when candidates referred to the source and not to the radiation being able to pass through the body. In general the answers to parts (ii) and (iii) were sensible and overall the majority of candidates seemed to have good understanding of this part of the course.

The calculation in part (c) provided an accessible five marks, but many candidates forfeited two marks by not taking into account the mean background radiation. A surprising number corrected one count only, usually the 2550 count, but failed to apply a correction to the other count rate. The majority of candidates applied the inverse square law correctly, even if sometimes the calculation became long winded, but it usually ended with the correct answer. The examiners were concerned for those candidates who thought that the constant k in the equation was the Boltzmann constant, and also for those candidates who used the corrected count rate as I and the uncorrected count rate as I_0. Both these fundamental errors indicated complete misunderstanding of the equation.

Unit 5 : PHA5/W : Section B : Astrophysics Option

General

Whilst it was pleasing to acknowledge the large number of candidates who were clearly well prepared for the examination and scored very highly on all questions, a significant number appeared to have attempted the examination with little relevant knowledge or understanding of the subject. None of the questions were considered to have been particularly difficult, or, on the other hand, particularly easy, but there were several common misconceptions or gaps in knowledge which are worthy of comment. Also even some of the better performing candidates occasionally missed marks by not reading the question carefully.

Question 2

Part (a) was considered to be a fairly straightforward exercise but it was not answered as well as had been hoped for. Common errors included: failing to label the focal points, or labelling the point where the top ray crossed the principal axis as a focal point. Also, although many candidates did not draw a construction ray, the better answers showed clearly the rays emerging from the eyepiece parallel to an imaginary construction ray. Several candidates drew the bottom ray parallel to the principal axis as though it had passed through the focal point of the objective. This method of drawing the diagram was not penalised provided the central ray appeared to go straight through the objective lens.

Many candidates in part (b) were aware of the relationships between the two focal lengths and could derive the correct answer, but very few realised that the length of the telescope could be approximated to the focal length of the objective. In part (ii) many candidates correctly calculated the diameter for Titan based on the given data but a few candidates included the magnification of the telescope in their calculation. Use of trigonometric functions meant that some candidates confused radians and degrees.

Confusion arose in part (c) between optical advantage and the explanation. For example, a large diameter was not accepted as an advantage, although it was accepted as the explanation for better resolution or brighter images. Answers to do with the heating of the atmosphere were not accepted.

Question 3

The calculation in part (a)(i) was performed correctly by many candidates although there was some confusion with the unit of m in Stefan's constant, a significant number assuming it represented milli. It was pleasing to note that most candidates were aware that the calculated wavelength was the peak value in the black body radiation curve, and not the maximum value on the wavelength axis. Many candidates did not spot that the peak wavelength did not coincide with the first required value on the wavelength axis in part (ii), or else ignored the zero at the start of the axis. The black body curve for Arcuturus was well drawn, even by the weaker candidates.

In part (b) many candidates understood the relationship between brightness and the absolute magnitude scale, both in general terms and using the mathematical relationship. Any mention of temperature was penalised and candidates were also not rewarded for simply repeating the information in the table. Whilst many candidates calculated the surface area of both the Sun and Arcturus, several did not make their answer explicit by dividing these values to give the correct ratio of 207.

Question 4

This question was well answered by the majority of candidates who had clearly been taught the CCD in great detail. Weaker answers implied that quantum efficiency is based on the output of the object, rather than being equal to the ratio of number of photons which produce a signal to the number of photons incident on the device. The action of a CCD was best described by candidates who followed the process in logical steps from the incident photons to the production of the image on the screen.

Question 5

In part (a) the terms supernova and neutron star were generally understood, although pulsing was not accepted as a property since this is a property of our observation rather than the star itself.

In part (b) the event horizon was often referred to as a point or radius rather than as a boundary or surface. It was very pleasing to note however that most candidates, even the weakest, could calculate the radius of the event horizon. Some common errors included missing out the factor of 10^6, or, carelessly omitting to square the value of the speed of light.

Unit 6 : PHA6/W : Section B : Medical Physics Option

General

The paper gave almost all candidates an opportunity to present some of their knowledge of Medical Physics and only a few very poor scripts were seen. Some marks were not awarded, even at the top end of the ability range, but no one marking point was elusive to all. Very often, candidates lost marks through imprecision, because statements were phrased casually.

Question 2

Part (a) was well done by a few candidates who gained full marks, but most only gained the first mark for the three colour cones labelled red, green and blue and then failed to gain any other marks by not including a correct scale with units for the wavelength axis.

In part (b) there were good answers in general to part (i), but few candidates gained more than one mark for (ii). In (ii), having stated that the cones were activated in bright light, candidates failed to relate the fine detail to the actual size of the receptors and the angle subtended, but commented on the connection of rods and cones to nerve fibres.

Only a few candidates in part (c)(i) wrote about the use of repeated periodic stimuli leading to a steady image, but many candidates were able to pick up the mark for a practical situation in part (ii). The commonest mistake was to discuss dark adaptation.

Question 3

Part (a) was, in general, well done, the most common error being the labelling of the surround of the X-ray tube as concrete rather than lead. Part (b), on the other hand, was poorly answered with explanations in part (i) merely stating, for example, 'to stop the anode from overheating'. Such answers were not awarded the allocated mark. The use of the bevelled edge in part (ii) was also poorly understood. The most common answer was 'to reflect the X-rays out of the window'. Other candidates suggested that 'it focused the X-ray beam' or 'that it created a narrow beam of X-rays'.

In part (c) there were very few correct definitions of the attenuation coefficient, most of them coming from a handful of centres. Definitions of the half-value thickness were much better, but some candidates lost the mark by relating their answer to reducing energy rather than to intensity. Very few candidates related either the linear attenuation coefficient or the half-value thickness as being specific to a mono-energetic X-ray beam and consequently the usual mark for part (c) was one.

Part (d) was done well by those candidates who knew the relationship between the attenuation coefficient and the half-value thickness, whilst others worked from first principles and obtained the correct answer. However, many candidates failed to even start the calculation.

Question 4

The stem of the question in part (a) stated very clearly that for a given medium the acoustic impedance was equal to the product of the density and the speed of sound. It was therefore very disturbing to find a lack of understanding by some candidates that the answer was obtained by multiplying two quantities together. Other candidates lost the mark in part (i) for using an incorrect unit, and many lost the mark in part (ii) for the incorrect use of significant figures. In part (iii) most candidates were awarded the mark for correct substitution of their answers from (i) and (ii) into the equation, and a consequent correct calculation. But even here, the occasional candidate lost the mark for using the figures as for a tissue / air boundary.

Answers to part (b) were often poorly worded and failed to explain fully what was required by the question. Many candidates failed to state that without gel, air was trapped between the probe and the skin, but with gel this air was removed and that it was this layer of trapped air which caused almost 100% reflection of the initial incident pulse. A very common error was to suggest that the gel should have an acoustic impedance half way between those of air and tissue, suggesting that the ultrasound travelled from air into gel into tissue.

Because candidates, in general, failed to direct their answers to the actual question asked, part (c) was marked as a whole rather than as two separate parts. Many candidates described an ultrasound probe rather that its use in an A-scan. Again many candidates failed to say that the pulses were short and that the same probe acted as transmitter and receiver. Many accounts lost a mark for not stating clearly that only some of the ultrasound was reflected at a boundary and that the rest was transmitted, thus allowing another reflected pulse to be obtained from the next boundary. In explaining how the results were used to find the size of the organ, many candidates lost a mark for failing to realise that the measured time obtained from the trace is the time taken for the pulse to travel there and back and thus had to be halved before being used in the calculation.

Unit 7 : PHA7/W : Section B : Applied Physics Option

General

Candidates on the whole seemed ill-prepared for the Applied Physics questions: most of them did not realise that temperatures have to be converted from centigrade to Kelvin to work out the efficiency of a heat engine; many of them were unaware of using the area under a pV graph to estimate work done; very few could interpret the speed-time graph in question 3; the use of units was not good and the great majority of candidates was penalised for a significant figure error somewhere, most notably in the estimated answer of question 4.

The examiners gained the impression that many, or even most, of the centres were entering candidates for the first time and were not using the considerable bank of past Applied Physics papers and their reports for guidance; that the centres were probably suffering considerably in operating their scheme of work during this first year and consequently skimped on the option teaching or left it too late.

The large majority of candidates attempted every question and there was no evidence of a shortage of time on the paper. With few exceptions, the standard of English and the presentation were acceptable and there were the usual few scripts which were immaculate. It may be that the mathematics in this paper was less demanding than usual, but candidates made very few arithmetic errors, apart from the conversion from km h^{-1} to m s^{-1} and the curiously prevalent one of forgetting to square the speed in the kinetic energy calculation.

Question 2

Most candidates made a reasonable attempt at part (a) of this question, using the appropriate formulae and transposing them correctly. Many did not attempt to convert 60 km h^{-1} into m s^{-1} or were unable to do so correctly. Of those who succeeded, a significant number then forgot to square the speed to calculate the kinetic energy either in section (i) or section (ii). Most candidates gave the correct unit for moment of inertia but some did not, despite its appearance in the stem of question 3, part (a).

Very few candidates answered part (b) correctly. The design of flywheel B was commonly thought to lead to an increase in moment of inertia, an increase in stored energy, a reduction in friction at the axle, reduced windage or increased storage space for goods in the concave area of the wheel. Good candidates explained the smaller mass of flywheel B in terms of $I = mr^2$ or suggested the advantages this reduced mass might have in terms of the performance of the van.

Question 3

Most candidates in part (a) used the gradient of the straight-line portion of the graph to find the angular acceleration or used two pairs of values in the appropriate formula. Many mistakes were made in reading the time axis of the graph. Weaker candidates tended to read values from the curved portion of the graph or forget to express the time interval in seconds rather than milliseconds. Very few candidates knew that the unit of torque is N m.

Only a small minority of candidates answered part (b)(i) correctly. Most thought that the spring was 'running down' or 'fighting a losing battle against the inertia of the fly'. The better candidates recognised the shape of the velocity-time graph as similar to that seen in the motion of a parachutist or a car and were able to produce very good explanations. Sections (ii) and (iii) were correctly answered by almost all candidates.

Question 4

In part (a), it was apparent that a significant number of candidates had not come across the method of estimating the work done by measuring the area under the graph. Many, perhaps the majority, of those who did know this procedure, chose a wrong area to measure or used a wrong scaling factor. Most estimates, whether 'correct' or not, were expressed to 3 or 4 significant figures and consequently incurred a penalty.

Parts (b), (c) and (d) of this question were answered correctly by the great majority of candidates.

Question 5

Rather few candidates arrived at the correct answer to part (a)(i); most failed to convert temperature to Kelvin. Section (ii) was answered well, allowing for any error in the previous section, but section (iii) was almost always wrong. A very small minority of candidates achieved full marks for part (a) of the question.

Part (b) was much more successful, with most candidates achieving at least one of the two marks. Heat loss in the transfer from the hot rocks to the heat engine, or during the process, was widely recognised as a factor in the reduction of efficiency. Several other losses were commonly suggested, including the need to pump water into and out of the hot rocks, electrical resistance in the generator windings and the rise of temperature of the heat sink.

In part (c), credit was given for answers based on reduced running costs, local availability of the energy source or the absence of waste-product disposal problems. Many answers took the form of a bald reference to 'renewable' energy sources and were not awarded the mark.

Unit 8 : PHA8/W : Section B : Turning Points in Physics Option

General

The examiners were well please with the performance of candidates in this paper and all questions were tackled confidently by the better candidates. The weaker candidates however found difficulty in scoring on questions 2 and 3 on and these questions discriminated well.

Question 2

In part (a) many candidates considered the work function to be a property of the light incident on the metal surface rather than an intrinsic property of the metal, but the majority were able to calculate the correct answer for the threshold wavelength. The usual problem for those candidates who failed in the calculation was the inability to convert the value of the work function from eV to joules.
Many candidates failed to score marks in part (b)(i) as a result of omitting basic points or else expressing their answers in too general a form. For example, frequency comparisons were given without reference to the expression for photon energy and many candidates failed to mention that a single photon is absorbed by a single electron which therefore gains energy hf. In part (b)(ii) few candidates were able to give an adequate answer, often providing a confused reference to wave particle duality.

Question 3

Most candidates knew in part (a) that the wave nature of the electron was the key property here, although few were able to relate this adequately to the STM. In part (a)(ii), most candidates failed to address the question asked, and usually provided a non-specific answer which could have been applied to almost any situation where there is an electric current.

A large majority of candidates scored full marks in part (b). However, some candidates failed to score at all because they attempted to use an expression relating the wavelength to the potential difference V, which they considered to be the speed of the electron.

Question 4

There were many accurate descriptions of the process of thermionic emission in part (a). but a lack of reference to the kinetic energy of the electrons did cause some candidates to lose a mark. Quite a few candidates failed to read the question properly and wrote about how a beam of electrons was produced. The high voltage supply was sometimes thought to be necessary to produce the filament current. In part (ii), candidates often confused the filament current with the emission current.

The calculations in part (b) were usually carried out correctly and very few candidates failed to score some marks.

Question 5

In part (a) most candidates correctly calculated the speed of the particles, although a significant number incorrectly interpreted μ as 10^{-3}. Many clear and correct answers were also seen in part (a)(ii) although some candidates failed to score on this calculation because they confused the proper length with the length in the particles' reference frame.

There were some very clear and correct answers in part (b). These answers demonstrated clarity of thought and the ability to write with coherence and precision. These particular candidates clearly knew how to apply the time dilation formula and in some cases they used their own values in order to amplify what they had already written. Candidates who did not score well often gave contradictory or ambiguous statements, with little or no reference to the time dilation expression.

Unit 9 : PHA9/W : Section B : Electronics Option

General

The response to the paper was slightly disappointing in that, although the full range of marks were gained, there were a significant number of candidates who were awarded very low marks. The question that comes to mind is whether these candidates had been fully prepared for the examination. Significant figure errors were very much in evidence in the calculations. There was also some misuse of units especially in the calculation of voltage gain in question 4.

Question 2

Answers to this question were, in general, very poor. The calculation in part (a) was meant as a lead in to the next part and to get the candidates thinking in terms of reactance. The majority of candidates calculated the correct frequency in part (i), although there were many instances of significant figure errors. However, in part (ii) the same candidates seemed to forget about reactance and attempted an answer in terms of a high pass filter rather than in terms of the reactance at low frequencies and considering the circuit as a form of potential divider.

The answers to part (b) were, if anything, worse than part (a) and the majority of candidates merely described the shape of the curve without any explanation. As an alternatively to this form of answer many candidates again discussed high pass filters simply stating that a certain range of frequencies were either blocked or allowed through.

Question 3

Part (a) produced some good answers with many candidates gaining full marks. The majority of candidates were able to read the log-log graph correctly, which was pleasing, and consequently deduced the correct transistor base voltage. Similarly in part (ii), the majority of candidates treated the arrangement of resistor and LDR as a potential divider and correctly calculated the value of the LDR resistance necessary for the lamp to change its state. Again the conversion from resistance to lux was usually correct.

Answers to part (b) were disappointing. A large number of candidates were penalised for incorrect number of significant figures. This usually occurred when correcting the calculated answer of 52 mA to 5.0×10^{-3} A. Another serious error was calculating the peak current in the heater rather than the rms current. The large number of candidates who made this error caused the examiners some concern and gave the impression that candidates did not really understood what the rms value meant. In part (iii), most candidates seemed oblivious of the role of the relay in isolating one circuit from the other and of its necessity due to the greater voltage or power required by the heater. Very few candidates seemed aware that the transistor cannot work on ac.

Question 4

This was a straighforward question and high marks were scored consistently. Part (a) generally realised maximum marks, although there were many candidates who gave a unit of voltage to the voltage gain and were consequently penalised. The sketch graph was usually drawn correctly with the correct peak value.

Part (b) did not fare as well as part (a) since many candidates did not seem to be aware that the output saturated at approximately 15 V and drew the curve with a maximum at 20 V. Other candidates drew the full sinusoidal curve, with a maximum voltage at 15 V, but no clipping was indicated.

Question 5

Part (a) usually provided two marks with candidates showing that the capacitor's 50 V maximum voltage was less than the peak value of the ac supply.

Part (b) seemed, to a large extent, to be a matter of guesswork, although there were numerous answers which listed the correct advantage and disadvantages. Many candidate stated that the electrolytic capacitor would work at a higher voltage than the mica capacitor. This is not so. When listing the disadvantages, many candidates simply wrote high tolerance or low tolerance. A mark could not be awarded for such an answer since it was not clear what this statement meant. A phrase such as 'poor tolerance', or quoting a figure, such as ± 50 %, for example, would have indicated clearly what the candidate meant.

Unit 10 : PA10 : The Synoptic Unit

General

Most candidates were able to score marks in every question. Some of the weaker candidates lacked knowledge and were unable to answer some questions but the best candidates were able to make good progress on every question. There was no evidence that the candidates ran out of time. Most candidates were able to provide coherent answers to descriptive questions and to provide appropriate explanations in the calculations. Numerical answers were usually accompanied by the correct units and given to an appropriate number of significant figures.

Candidates experienced very little difficulty in relating together knowledge and understanding from different modules where necessary and were generally able to use skills developed throughout the course. The best candidates showed a good awareness of how to work through structured questions, using information given in the questions together with their own knowledge and understanding to provide effective and concise answers. Weaker candidates often performed well in this respect on one or two questions but usually failed to extend their performance across the paper.

On the quality of written communication, more care needs to be taken with descriptive answers and in particular, candidates need to realise the crucial importance of correct spelling, particularly where technical terms are being used.

An unfortunate printing error occurred in questions 4 and 5, where a × sign appeared as ↔. In these questions the examiners accepted all interpretations of this sign and no candidate suffered as a consequence of the printing error.

Question 1

Most candidates were able to complete the equation in part (a) correctly, although a few lost marks by adding an extra particle to the right hand side of the equation.

In part (b)(i) the majority of candidates were aware of the correct conversions from MeV to J and from u to kg although some candidates used the proton/neutron rest mass of 1.67×10^{-27} kg instead of 1.66×10^{-27} kg to convert u to kg. The expression for kinetic energy was generally correctly used. In part (b)(ii) most candidates gave a complete and correct calculation. The conservation of momentum was generally applied correctly although a significant number of candidates incorrectly used 210 u as the mass of the recoil nucleus. Other candidates attempted to calculate the mass of the nucleus from the combined mass of its protons, neutrons and electrons. Some candidates unnecessarily converted the correct masses to kilograms.

Question 2

In part (i), a significant number of candidates obtained a value of 200 Ω or 300 Ω for the resistor through not using the correct pd across it. In part (ii), the same candidates usually proceeded with an incorrect calculation of power in the diode by using in the expression I^2R the resistance calculated in part (i). Some candidates were not aware of the correct value of the prefix m in mA.

The energy of the photon was usually calculated correctly in part (iii), but a small minority wrongly considered $1/\lambda$ as the frequency or used an incorrect equation. In part (iv), most candidates knew how to proceed and gave a correct calculation. In the final part most candidates gave a correct assumption made in the previous estimation. Those candidates who were not specific in stating the assumption were not awarded this mark.

Question 3

Question 3 was a long question worth 15 marks and it is pleasing to report that almost all candidates were able to gain a reasonable mark, with some gaining high marks.

In part (a)(i) most candidates knew that light was diffracted from each of the pair of narrow slits and that interference fringes were produced and could be seen in the overlap area. Some candidates referred to coherence in terms of waves being emitted in phase rather than with a constant phase difference. Most candidates were able to explain how a bright fringe or a dark fringe was formed and were able to relate their statements correctly to the path difference or phase difference. A significant number of candidates did not make it clear that a phase difference of 180° is necessary for cancellation of two waves, and often just stated that the waves were out of phase.

In part (a)(ii), it was clear that many candidates did not know the meaning of 'opaque' and thought that some light would pass through the opaque object. Few candidates realised that the fringes seen in (a)(i) would no longer be seen, but a small minority knew that single slit diffraction would take place and were thus able to give a satisfactory description.

Most candidates were aware in part (b)(i) that the fringes would be closer but few were able to give an adequate explanation of why this was so and only the best candidates were able to quote and use the appropriate expression to justify their answer. In part (ii) most candidates gave a correct calculation without any difficulty, but some candidates were unable to make any progress because they calculated the critical angle for a boundary with air. In part (iii) many candidates scored all three marks with a clear, correct diagram. The main reason for not scoring full marks was usually a failure to give the correct point of incidence.

Question 4

The majority of candidates were able to give the correct quark composition of the proton in part (a), but many were unable to give the correct quark composition of the positive pion, usually as a result of stating that the antiquark was strange.

In part (b) the calculation of the radius of curvature was usually correct although some candidates did not use the correct mass value for the proton. In part (ii) the majority of candidates knew the pion path was more curved and were thus able to score full marks. In the final part candidates often failed to state that the radius of curvature would be less for both types of particles.

Question 5

In part (a) most candidates were able to use the given data correctly to obtain the required volume of gas. In part (b) however, although many correctly calculated the answer to part (i) they were unable to make progress in part (ii), often as a result of confusion between moles and molecules. A significant number of candidates incorrectly divided the molar mass by the mass of gas rather than divide the mass of gas by the molar mass to obtain the number of moles.

Many candidates scored full marks in part (c) although a significant number incorrectly considered 39 MJ to be the energy used, rather than the energy obtained in the calculation in part (a). Some candidates gave the answer as the mass per second, while others just failed to complete the answer calculation.

In part (d) many candidates produced a correct calculation, thereby gaining a mark, but very few scored both marks, mostly as a result of failure to state clearly that a fuse would blow or a trip switch would operate if such a heater was to be operated from the mains supply. Those who did score both marks usually worked out the current needed for the heater and realised that this was greater than the current that could be supplied.

Question 6

Part (a) was quite straightforward and the majority of candidates gained both marks, although some marks were withheld due to candidates referring carelessly to time rather than distance.

The columns of data in part (b) were usually completed correctly, but some candidates lost marks as a result of using too many or too few significant figures. Again in part (c) many candidates scored full marks but a significant minority were unable to choose appropriate scales for their chosen graph. Others were unable to plot a suitable graph, mostly as a result of plotting s against v or v against s rather than s/v against v.

Most of candidates who plotted a straight line graph knew how to determine the value of t_b in part (d). Some however failed to score this mark as a result of lack of care in plotting the graph in the previous section. In part (ii) , most candidates were able to obtain a correct value for the gradient of their straight line graph. In addition, these candidates were able to relate the gradient to the acceleration and obtained a correct value for the acceleration. On the other hand, many of the weaker candidates had plotted an unsuitable graph (e.g. s vs v) and were unable to make progress with the calculations. They were clearly unaware of the necessity of choosing variables that would produce a straight line graph.

Question 7

In part (a) the large majority of candidates knew that the force on the satellite acted towards the centre of the Earth and that the direction of motion or velocity of the satellite was at right angles to the force. However, few of them were able to use these facts to explain adequately why the speed remained constant. Little or no reference was made to the absence of work done or zero change in potential or kinetic energy.

There were many correct calculations in parts (b)(i) and (ii), but some candidates did confuse the two components when calculating the angle in part (ii). In the final part, correct explanations for the induced emf were usually given in terms of the rod cutting the non-radial component of the Earth's magnetic field.

Question 8

In part (a)(i) most candidates were aware that there was a time delay between the sound pulse being transmitted and received and were then able to relate this time delay to the oscilloscope display. Candidates who gave the correct answer in part (i) were usually able to give a correct explanation in part (ii) as well. However, in part (iii) a significant number of candidates, instead of using distance/time to give the speed of sound, attempted to use $c = f\lambda$, with $\lambda = 20$ cm and $f = 1/0.6$ ms. A common fault among those who used the correct expression was to interpret the time base prefix incorrectly.

Only a minority of candidates were awarded both marks in part (b)(i). Many candidates failed to explain correctly why there is a force on the coil and few realised that an alternating current causes an alternating force. In part (ii) again only a few candidates realised that the mass of the magnet rather than its weight was the key factor if the magnet were attached to the diaphragm and the coil were fixed. Many realised that the diaphragm would vibrate less but very few stated that this would be so if the current or pd remained the same.

Mark Ranges and Award of Grades

Unit/Component	Maximum Mark (Raw)	Maximum Mark (Scaled)	Mean Mark (Scaled)	Standard Deviation (Scaled)
PAO1	60	60	36.2	14.0
PAO2	60	60	37.2	12.4
PHA3/W - Written	50	50	30.0	9.7
PHA3/C - Coursework	30	30	21.7	5.7
PA3C	_	80	51.7	13.7
PHA3/W – Written	50	50	31.7	9.3
PHA3/P – Practical	30	30	19.1	5.4
PA3P	_	80	50.8	13.6
PAO4	60	60	37.1	11.8
PHA5/W – Written	40	60	31.6	13.4
PHA5/C - Coursework	30	30	22.5	5.1
PA5C	_	90	54.1	16.5
PHA5/W – Written	40	60	34.5	13.2
PHA5/P – Practical	30	30	15.6	4.7
PA5P	_	90	50.1	16.6
PHA6/W – Written	40	60	29.4	12.0
PHA6/C – Coursework	30	30	23.5	6.3
PA6C	_	90	52.9	15.5
PHA6/W – Written	40	60	29.8	11.3
PHA6/P – Practical	30	30	14.6	3.9
PA6P	_	90	44.4	13.6

PHA7/W – Written	40	60	33.2	12.6
PHA7/C – Coursework	30	30	23.5	5.1
PA7C	_	90	56.7	15.9

PHA7/W – Written	40	60	31.4	13.4
PHA7/P – Practical	30	30	15.4	4.6
PA7C	_	90	46.8	16.5

PHA8/W – Written	40	60	31.8	11.1
PHA8/C – Coursework	30	30	23.4	4.7
PA8C	_	90	55.2	13.8

PHA8/W – Written	40	60	33.1	10.7
PHA8/P – Practical	30	30	15.0	4.5
PA8P	_	90	48.1	13.4

PHA9/W – Written	40	60	29.7	13.4
PHA9/C – Coursework	30	30	23.5	5.2
PA9C	_	90	53.2	16.3

PHA9/W – Written	40	60	32.9	13.4
PHA9/P – Practical	30	30	15.5	4.5
PA9P	_	90	48.4	16.7

PA10	80	80	46.1	16.8

For units which contain only one component, scaled marks are the same as raw marks.

PAO1 Particles, Radiation and Quantum Phenomena

(7199 candidates)

	Max. mark	A	B	C	D	E
Scaled Boundary Mark	60	47	41	35	30	25
Uniform Boundary Mark	90	72	63	54	45	36

PAO2 Mechanics and Molecular Kinetic Theory

(7723 candidates)

	Max. mark	A	B	C	D	E
Scaled Boundary Mark	60	46	41	36	31	26
Uniform Boundary Mark	90	72	63	54	45	36

PA3C Current Elasticity and Elastic Properties of Solids Coursework

(5528 candidates)

		Max. mark	A	B	C	D	E
PHA3/W Boundary Mark	raw	50	40	35	31	27	23
	scaled	50	40	35	31	27	23
PHA3/C Boundary Mark	raw	30	23	22	19	16	13
	scaled	30	23	22	19	16	13
PA3C Scaled Boundary Mark		80	65	57	50	43	36
PA3C Uniform Boundary Mark		120	96	84	72	60	48

PA3P Current Electricity and Elastic Properties of Solids Practical

(3177 candidates)

		Max. mark	A	B	C	D	E
PHA3/W Boundary Mark	raw	50	40	35	31	27	23
	scaled	50	40	35	31	27	23
PHA3/P Boundary Mark	raw	30	23	20	17	15	13
	scaled	30	23	20	17	15	13
PA3P Scaled Boundary Mark		80	63	56	49	42	36
PA3PC Uniform Boundary Mark		120	96	84	72	60	48

PAO4 Waves, Fields and Nuclear Energy

(4280 candidates)

	Max. mark	A	B	C	D	E
Scaled Boundary Mark	60	46	40	35	30	26
Uniform Boundary Mark	90	72	63	54	45	36

PA5C Astrophysics Coursework

(1566 candidates)

		Max. mark	A	B	C	D	E
PHA5/W Boundary Mark	raw	40	30	26	22	19	16
	scaled	60	45	39	34	29	24
PHA5/C Boundary Mark	raw	30	26	23	20	17	14
	scaled	30	26	23	20	17	14
PA5C Scaled Boundary Mark		90	71	62	54	46	38
PA5C Uniform Boundary Mark		90	72	63	54	45	36

PA5P Astrophysics Practical

(342 candidates)

		Max. mark	A	B	C	D	E
PHA5/W Boundary Mark	raw	40	30	26	22	19	16
	scaled	60	45	39	34	29	24
PHA5/P Boundary Mark	raw	30	20	18	16	14	12
	scaled	30	20	18	16	14	12
PA5P Scaled Boundary Mark		90	65	57	50	43	36
PA5P Uniform Boundary Mark		90	72	63	54	45	36

PA6C Medical Physics Coursework

(543 candidates)

		Max. mark	A	B	C	D	E
PHA6/W Boundary Mark	raw	40	28	25	22	19	16
	scaled	60	42	37	32	28	24
PHA6/C Boundary Mark	raw	30	26	23	20	17	14
	scaled	30	26	23	20	17	14
PA6C Scaled Boundary Mark		90	62	55	48	42	36
PA6C Uniform Boundary Mark		90	72	63	54	45	36

PA6P Medical Physics Practical

(227 candidates)

		Max. mark	A	B	C	D	E
PHA6/W Boundary Mark	raw	40	28	25	22	19	16
	scaled	60	42	37	32	28	24
PHA6/P Boundary Mark	raw	30	20	18	16	14	12
	scaled	30	20	18	16	14	12
PA6P Scaled Boundary Mark		90	62	55	48	42	36
PA6P Uniform Boundary Mark		90	72	63	54	45	36

PA7C Applied Physics Coursework

(425 candidates)

		Max. mark	A	B	C	D	E
PHA7/W Boundary Mark	raw	40	30	26	23	20	17
	scaled	60	45	40	35	30	25
PHA7/C Boundary Mark	raw	30	26	23	20	17	14
	scaled	30	26	23	20	17	14
PA7C Scaled Boundary Mark		90	71	63	55	47	39
PA7C Uniform Boundary Mark		90	72	63	54	45	36

PA7P Applied Physics Practical

(245 candidates)

		Max. mark	A	B	C	D	E
PHA7/W Boundary Mark	raw	40	30	26	23	20	17
	scaled	60	45	40	35	30	25
PHA7/P Boundary Mark	raw	30	20	18	16	14	12
	scaled	30	20	18	16	14	12
PA7P Scaled Boundary Mark		90	65	58	51	44	37
PA7P Uniform Boundary Mark		90	72	63	54	45	36

PA8C Turning Points in Physics Coursework

(930 candidates)

		Max. mark	A	B	C	D	E
PHA8/W Boundary Mark	raw	40	29	26	23	20	17
	scaled	60	43	38	33	29	25
PHA8/C Boundary Mark	raw	30	26	23	20	17	14
	scaled	30	26	23	20	17	14
PA8C Scaled Boundary Mark		90	69	61	53	46	39
PA8C Uniform Boundary Mark		90	72	63	54	45	36

PA8P Turning Points in Physics Practical

(957 candidates)

		Max. mark	A	B	C	D	E
PHA8/W Boundary Mark	raw	40	29	26	23	20	17
	scaled	60	43	38	33	29	25
PHA8/P Boundary Mark	raw	30	20	18	16	14	12
	scaled	30	20	18	16	14	12
PA8P Scaled Boundary Mark		90	63	56	49	43	37
PA8P Uniform Boundary Mark		90	72	63	54	45	36

PA9C Electronics Coursework

(273 candidates)

		Max. mark	A	B	C	D	E
PHA9/W Boundary Mark	raw	40	29	26	23	20	17
	scaled	60	43	38	33	29	25
PHA9/C Boundary Mark	raw	30	26	23	20	17	14
	scaled	30	26	23	20	17	14
PA9C Scaled Boundary Mark		90	69	61	53	46	39
PA9C Uniform Boundary Mark		90	72	63	54	45	36

PA9P Electronics Practical

(168 candidates)

		Max. mark	A	B	C	D	E
PHA9/W Boundary Mark	raw	40	29	26	23	20	17
	scaled	60	43	38	33	29	25
PHA9/P Boundary Mark	raw	30	20	18	16	14	12
	scaled	30	20	18	16	14	12
PA9P Scaled Boundary Mark		90	63	56	49	43	37
PA9P Uniform Boundary Mark		90	72	63	54	45	36

PA10 Synoptic Paper

(5884 candidates)

	Max. mark	A	B	C	D	E
Scaled Boundary Mark	80	62	54	47	40	33
Uniform Boundary Mark	120	96	84	72	60	48

Advanced Subsidiary award

Provisional statistics for the award (7389 candidates)

	A	B	C	D	E
Cumulative %	24.0	42.1	59.0	73.1	84.0

Advanced award

Provisional statistics for the award (5882 candidates)

	A	B	C	D	E
Cumulative %	28.2	49.2	67.5	83.9	94.8

Definitions

Boundary Mark: the minimum (scaled) mark required by a candidate to qualify for a given grade.

Mean Mark: is the sum of all candidates' marks divided by the number of candidates. In order to compare mean marks for different components, the mean mark (scaled) should be expressed as a percentage of the maximum mark (scaled).

Standard Deviation: a measure of the spread of candidates' marks. In most components, approximately two-thirds of all candidates lie in a range of plus or minus one standard deviation from the mean, and approximately 95% of all candidates lie in a range of plus or minus two standard deviations from the mean. In order to compare the standard deviations for different components, the standard deviation (scaled) should be expressed as a percentage of the maximum mark (scaled).

Uniform Mark: a score on a standard scale which indicates a candidate's performance. The lowest uniform mark for grade A is always 80% of the maximum uniform mark for the unit, similarly grade B is 70%, grade C is 60%, grade D is 50% and grade E is 40%. A candidate's total scaled mark for each unit is converted to a uniform mark and the uniform marks for the units which count towards the AS or A-level qualification are added in order to determine the candidate's overall grade.