RECOGNISING ACHIEVEMENT

GCE

Mathematics (MEI)

Advanced GCE **A2 7895-8**

Advanced Subsidiary GCE **AS 3895-8**

Report on the Units

January 2008

3895-8/7895-8/MS/R/08J

Oxford Cambridge and RSA Examinations

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REPORT ON THE UNITS

GCE Mathematics and Further Mathematics Certification

From the January 2008 Examination session, there are important changes to the certification rules for GCE Mathematics and Further Mathematics.

1 In previous sessions, GCE Mathematics and Further Mathematics have been aggregated using 'least-best' i.e. the candidate was awarded the highest possible grade in their GCE Mathematics using the lowest possible number of uniform marks. The intention of this was to allow the greatest number of uniform marks to be available to grade Further Mathematics.

From January 2008 QCA have decided that this will no longer be the case. Candidates certificating for AS and/or GCE Mathematics will be awarded the highest grade with the highest uniform mark. For candidates entering for Further Mathematics, both Mathematics and Further Mathematics will be initially graded using 'least-best' to obtain the best pair of grades available. Allowable combinations of units will then be considered, in order to give the candidate the highest uniform mark possible for the GCE Mathematics that allows this pre-determined pair of grades. See page 2 for an example.

As before, the maximisation process will award a grade combination of AU above, say, BE. Where a candidate's grade combination includes a U grade a request from centres to change to an aggregation will be granted. No other requests to change grading combinations will be accepted. e.g. A candidate who has been awarded a grade combination of AD cannot request a grading change that would result in BC.

2 In common with other subjects, candidates are no longer permitted to decline AS and GCE grades. Once a grade has been issued for a certification title, the units used in that certification are locked into that qualification. Candidates wishing to improve their grades by retaking units, or who have aggregated GCE Mathematics or AS Further Mathematics in a previous session should re-enter the certification codes in order to ensure that all units are unlocked and so available for use. For example, a candidate who has certificated AS Mathematics and AS Further Mathematics at the end of Year 12, and who is certificating for GCE Mathematics at the end of Year 13, should put in certification entries for AS Mathematics and AS Further Mathematics in addition to the GCE Mathematics.

Grading Example

A candidate is entered for Mathematics and Further Mathematics with the following units and uniform marks.

Unit	Uniform marks	Unit	Uniform marks
C1	90	M1	80
C2	90	M2	100
C3	90	M3	90
C4	80	S1	70
FP1	100	S2	70
FP2	80	D1	60

Grading this candidate using least-best gives the following unit combinations:

Mathematics		Further Mathematics	
Unit	Uniform marks	Unit	Uniform marks
C1	90	FP1	100
C2	90	FP2	80
C3	90	M1	80
C4	80	M2	100
S1	70	M3	90
D1	60	S2	70
Total	480 (Grade A)	Total	520 (Grade A)

Under the new system, having fixed the best pair of grades as two As, the mark for the Mathematics would be increased by combining the units in a more advantageous manner. The table below shows the allowable combination of units.

Option	Applied units used for Maths	Total uniform marks for Mathematics	Applied units used for Mathematics	Total uniform marks for Further Mathematics
1	M1, S1	500	M2, M3, S2, D1	500
2	M1, D1	490	M2, M3, S1, S2	510
3	S1, D1	480	M1, M2, M3, S2	520
4	M1, M2	530	M3, S1, S2, D1	470
5	S1, S2	490	M1, M2, M3, D1	510

Option 4 gives the highest uniform mark for Mathematics. However, this would only give a grade B in the Further Mathematics, and so is discarded. Option 1 is the next highest uniform mark for Mathematics and gives an A in Further Mathematics, and so this is the combination of units that would be used.

4751: Introduction to Advanced Mathematics (C1)

General Comments

Many of the candidates were able to make a strong start in the first few questions of this paper, with some of the weaker candidates scoring over half their marks on questions 1 to 5. This resulted in fewer scores under 10 marks on the paper compared with last January. At the other end of the scale, the examiners were pleased to see the strong candidates gaining some very high marks, although a few question parts remained challenging for such candidates, with relatively few candidates realising that two conditions needed to be shown in question 12(iii), for example.

Errors in basic arithmetic were common in some questions, including from the able candidates, such as $3.4 - 5 = 1.6$ or -2.4 in question 4, $25 + 8 = 32$ in question 11(iv) and errors in the method for adding fractions in question 8. In this non-calculator paper, it is always sad to see marks lost needlessly for low-level work.

The use of graph paper remains a problem for the candidates of some centres who still issue this. Where it is issued, candidates tend to use it, and spend time drawing accurate graphs when a sketch is what is required. One candidate who drew a sketch in the body of the script and gained marks for it commented 'I have done this again on graph paper in case I need to, but I don't think I do', evidence of the confusion caused to candidates by supplying the graph paper. The examiners are grateful to the many centres who do not issue it.

There was some evidence of the paper being a little long, with a few examiners feeling that there were some rushed attempts at question 12. This was sometimes due to long methods being used earlier.

Comments on Individual Questions

Section A

1) Many candidates earned full marks here. A few weaker candidates used addition/subtraction instead of multiplication/division as their first step but then usually earned the last mark for a correct follow through from their v^2.

2) Stronger candidates usually had no problem here and there were many wholly correct answers. Some spoiled their efforts by attempting to simplify further after having achieved the right expression. Factors of $x^2 - 1$ seemed to elude quite a number of candidates, especially the weaker ones, with $x(x - 1)$ being a common error. Many were able to factorise the numerator correctly. Some of the weaker candidates attempted to use the quadratic formula to help them factorise the numerator.

3) Most knew $\left(\frac{1}{4}\right)^0 = 1$, although a few, as expected, thought it was 0. In the second part, there were many correct answers and of those who did not earn all three marks, many were able to deal correctly with at least one aspect of the powers.

4) Many were able to find x correctly but there were errors in finding y, as noted in the general comments. Direct substitution for y was not always the preferred method, many candidates opting to manipulate the equations and go for a method of elimination which, in the main, led to correct answers. In some cases, however, this resulted in marks lost because of sign or arithmetic errors, especially when dealing with double negatives.

5) Better candidates had no problem determining the correct gradient. Quite a few candidates “lost” the negative sign and some weaker candidates merely stated the coefficient of *x* in the given equation as the gradient. In the second part, most successful attempts started from using $y = mx + c$ with the same gradient and stating or finding that $c = 12$, although a few used the condition for perpendicular lines in error. Relatively few candidates attempted the $4x + 5y = K$ argument or a step method using the gradient. Quite a few of those candidates who failed to score, fully or at all, in part (i) were able to benefit from the two method marks in this part by following through with their gradient and using $y = 0$ in their equation. The final mark was again an opportunity for poor arithmetic and algebraic manipulation: many candidates who started correctly from an equation such as $\frac{4}{5}x = 12$ did not proceed easily and correctly to $4x = 60$ or $\frac{x}{3} = 5$ and hence $x = 15$ but rather to statements such as $0.8x = 12$ so $x = 12/0.8$ and then did not know how to proceed or made errors in doing so.

6) Most candidates correctly attempted to use f(2) = 3 and many of these successfully found the correct value of *k*. Those who attempted long division were usually less successful, often only gaining one method mark.

7) The first part was poorly answered. Of those who were familiar with the notation and knew what to do, a disappointing number correctly cancelled to find $\frac{8\times7\times6}{3\times2\times1}$ but then worked it out as $\frac{336}{6}$, with long calculations clearly seen. They often reached the correct answer, but clearly much time had been wasted. Many started again in the second part, even those who had successfully calculated 56 earlier. Full expansions were seen from some. Many reached $56 \times 1^5 \times (-\tfrac{1}{2}x)^3$ but then did not cube ½ or lost the negative sign.

8) There was a varied response to the first part, with strong candidates quickly reaching the correct answer but weaker candidates getting muddled in their attempts to simplify $\sqrt{48}$, as expected. A correct stage of $4\sqrt{3} + \sqrt{3}$ was sometimes followed by $4 + 2\sqrt{3}$. In the second part, most had some idea of what to do, but weaker candidates often made errors in their method for adding fractions, such as adding numerators and denominators, perhaps having first found a common denominator, so that answers such as $\frac{1}{23}$, $\frac{10}{46}$ and $\frac{1}{10}$ were seen, as well as the usual arithmetic errors in working out $5^2 - \left(\sqrt{2}\right)^2$. Some rationalised the denominator of just one fraction, or of each fraction separately before adding them. Stronger candidates usually had no problem.

9) In the first part, those who used $n = 2k$ were able elegantly to gain their three marks, but few candidates used this approach. Some worked with $3n(n + 2)$ or the given expression and used odd and even number arguments whilst others divided by 12 and showed that $\frac{n^2}{4} + \frac{n}{2}$ was an integer when *n* was even. However, many simply substituted some even numbers and jumped to the conclusion, gaining no marks, with some claiming proof by exhaustion! The marks in the second part were more easily gained, and weaker candidates were often able to use a counterexample correctly here. There was considerable confusion of factors and multiples in explanations throughout the question.

Section B

10) (i) This part was done poorly - only a minority of candidates appreciated that a translation 2 to the right was what was required, although some successfully found (0, −0.5) as the y-intercept independently.

(ii) Many candidates solved this equation successfully, although some made algebraic or arithmetic errors.

(iii) Most candidates equated the two expressions for y and made some progress towards solving the resulting equation. Knowledge of the quadratic formula was better than last time, with fewer candidates making errors in remembering it. As expected, many did not simplify the final answer correctly, but the correct answer was seen encouragingly often. Candidates who sensibly drew the line $y = x$ on their part (i) sketch and identified the intersections as the points required obtained the final mark in this section for doing so; those who omitted the $y = x$ line needed to show that the x and y coordinates were the same and often did not.

11) This question was accessible to most candidates, even if they were not able to do the first part. There were some centres who were clearly well versed in completing the square – others less so but they were still able to proceed with parts (ii) to (iv).

(i) Most candidates were able to earn at least the first method mark here. Further progress was limited for many candidates by their inability to find 2.5^2. For those who at least showed that they were trying to do this calculation, there was the possibility of the next method mark; but many showed no working, so were not able to gain credit. The most common error was to believe 2.5^2 to be 4.25 and so a very common wrong answer was $(x – 2.5)^2 + 3.75$. It was surprising that so many candidates did not use their result to explain why the graph was above the axis, or attempted it and failed to explain clearly. Many resorted to the algebraic technique of considering the discriminant of the equation where $y = 0$.

(ii) This part was attempted quite well, but a large number of candidates failed to make the intercept on the y-axis and the position of the turning point clear. A few candidates answered the final stage of part (i) here, without realising it. Some did not realise the relevance of the work they had done in part (i) and started again, using symmetry or calculus to find the coordinates of the turning point.

(iii) Most candidates successfully rearranged the inequality to produce $x^2 − 5x − 6 > 0$.The majority of these managed to arrive at the values of 6 and −1 . However it was all too common to see final answers of $−1 < x < 6$ or $−1 > x > 6$. A very small number of candidates produced factors involving 3 and 2 and some were able to pick up the final mark on a follow through basis. A few candidates tried a numerical approach which rarely reached a conclusion, though one or two candidates did conclude that $x > 6$.

(iv) A variety of methods were applied here with varying degrees of success. Having written down an expression for $f(x) −10$, a number of candidates spotted that the graph would now cut the y-axis at (0 , 2) - a method requiring little working. Others tried to show that the minimum of the new graph had a negative y coordinate, too often hampered by their inability to subtract 10 from a number involving fractions! Once again many candidates used the discriminant method, and in this part seemed more secure in their conclusion. A few candidates used sketch graph, but not all of them quantified a strategic point. One or two candidates used the straightforward approach of showing that there were some points on the curve above the axis, and some below.

12) (i) Many candidates failed to have a systematic approach to changing the form of the equation to show that it was a circle. Those completing the square, did not often realise where the 9 fitted in. Candidates who started from the given equation and completed the square were mostly successful. Those who started from $(x - 4)^2 + (y - 2)^2$ often got in a muddle with the signs of the constant terms and many only obtained one mark. Many of the weaker candidates thought that the radius was 9 or 3. A few candidates used the *g f* version of the general equation – with mixed results, depending on how much information was quoted.

(ii) This was the least well done part of the question; some candidates made no attempt at it. Others gained a method mark for working out $4^2 + 2^2$, although some were unable to complete the argument from this, with some not knowing what to do and others having used a wrong radius such as 3. Those who put (0, 0) into the original given equation often did not appreciate what they were doing, ended up with 0 = 9 and did nothing further, gaining no credit. A small number of candidates successfully showed that the origin was on a chord within the circle (usually by finding $x = -1$ or 9 when $y = 0$).

(iii) The modal score was 2 out of the 4 marks, with most candidates showing one of the two criteria necessary for AB to be a diameter, and few realising that two were required. The most popular method was to try to show that the length of AB was double the radius, which caused problems if they had the radius wrong, although many got as far as the length being $\sqrt{116}$. A large number of candidates showed that the midpoint of AB was C, with a few using vector methods to do this. Those who started by showing that both A and B were on the circle generally realised that something else was needed. Some candidates with the wrong radius in part (i), having found answers in (iii) such as AB = $\sqrt{116}$, or AC = $\sqrt{29}$, were able to go back to part (i) and find their errors there.

(iv) Many candidates were able to handle the coordinate geometry of straight lines, including a good proportion of those who had proved weak elsewhere. Sign errors were common in finding the gradient of AB, but most knew the rule for perpendicular gradients and used it well. A few candidates tried to differentiate the circle equation, but were rarely successful. There were many arithmetic errors in simplifying the equation of the line and some did not give an answer in the requested $y = mx + c$ form, so that loss of the final accuracy mark was common.

4752: Concepts for Advanced Mathematics (C2)

General Comments

Most candidates found this paper accessible, but there was enough challenging material to stretch the best candidates. There was a full range of achievement, but there were fewer very poor scripts than usual, and fewer candidates scored full marks. Section A was generally better received than section B. Many candidates set their work out clearly. Nevertheless, many marks were lost by failing to show sufficient detail of the method or by failing to annotate diagrams adequately.

Comments on Individual Questions

Section A

1) An overwhelming majority of candidates scored full marks here. A minority lost a mark by including an extra term. A few made careless errors and gave the answer as $40x$ or $30x^3$.

2) Part (i) was very well done, with nearly everyone presenting the correct answer.

Part (ii) proved more challenging, although a significant minority scored both marks. Common errors were: "9.6×15", "9×15 + 3" and "8×15 + 1 + 2 + 3".

3) This question elicited a variety of approaches. Generally speaking only the better candidates scored well. The usual method was a right angled triangle with θ clearly marked and Pythagoras used to find the hypotenuse. Some candidates lost marks by failing to show enough detail in their working, although they may have fully understood what they were doing. There was some excellent work seen based on substituting $\sin\theta = ½\cos\theta$ or $\sin\theta = \cos\theta\tan\theta$ in the identity $\sin^2\theta + \cos^2\theta = 1$. Some weaker candidates used their calculator to find $\tan^{-1}½$, and then find $\cos\theta$ and square the answer, in spite of the clear instruction in the question. This approach invariably scored zero.

4) Part (i) was often done well by stronger candidates, but many thought the transformation was an enlargement, or a translation of $\begin{pmatrix} 0 \\ 2 \end{pmatrix}$.

Part (ii) was very well done by most candidates, although some translated to the right by 3 units, or vertically upwards by 3 units, thus scoring no marks. In both parts, far too many candidates lost marks either by incorrect labelling of the points, or by ambiguous labelling.

5) Most candidates scored 4 or 5 marks on this question. A fully simplified answer was required, so answers such as $\frac{12}{6}x^6$ were penalised. A few candidates omitted "+ c" or gave the third term as $\frac{7^2}{2}$. However, the most common error was failing to deal with $\sqrt[3]{x}$. Some simply integrated √x – often correctly – but lost two marks. Others failed to simplify the fraction, and a few candidates gave the answer as

$$\frac{(\sqrt[3]{x})^2}{\frac{2}{3}}.$$

6) Part (i) was accessible to most. Nearly all candidates were able to draw the correct sine shape over one period. However, many lost the second mark by omitting some indication of scale (in radians) or some indication of the amplitude.

There were some excellent answers to part (ii) However, many chose to work in degrees, in spite a clear request for radians, and a good number failed to give the answer in the required form. A surprising number of candidates supplied only one answer, and a few gave answers such as 2π – 30, which scored zero.

7) Many good candidates scored full marks on this question. However, there were a number of common errors. In part (i) an extra term was often included – usually 64, but sometimes 2. Some candidates calculated 5×2^2 and others evaluated $2^2 + 3^2 + 4^2 + 5^2$. In part (ii) some candidates used logarithms, and ended up working with rounded decimals, giving their answer as -5.99, which scored zero. In part (iii) the most common error was the omission of the y-intercept, but a minority of candidates only sketched the curve in one quadrant. Some candidates wasted valuable time on an accurate plot on graph paper.

8) Most were able to score well on this question, with many candidates obtaining full marks. The decreasing geometrical progression caused some problems, and those who thought *r* =3 could make no progress with the sum to infinity. A small number of candidates seemed unfamiliar with the appropriate formula, and used their calculators to sum a large number of terms, usually giving an answer close to 81.

9) Most candidates obtained the correct answers to parts (i) and (ii). However, parts (iii) and (iv) defeated many. Common errors were $(3x + 2)^4$ for part (iii) and e^{3x+2} in part (iv)

Section B

10) (i) There were many very good answers to this question, but a significant number of candidates could not progress beyond stating an expression for h, and some even failed to do this. A number of candidates showed insufficient working to obtain all three marks.

(ii) Many candidates scored full marks on this section. There were, however, some common errors. Most notable of these was $\frac{dy}{dx} = 4x + 480$, but some weaker candidates gave the answer as $\frac{dy}{dx} = 4x + x^{-480}$ and a few made slips with the signs in either the first or the second derivatives.

(iii) Surprisingly few candidates took the hint and attempted to solve $\frac{\mathrm{d}y}{\mathrm{d}x}$ = 0. Of those who did, solving the equation caused problems, with many obtaining an extra root x = 0. Very few candidates used the second derivative appropriately, and substituting the x-value in the formula for A often led to arithmetical slips. A common error was to attempt to solve $\frac{\mathrm{d}^2y}{\mathrm{d}x^2}$ = 0 or $\frac{\mathrm{d}^2y}{\mathrm{d}x^2}$ > 0.

11) (i) Most candidates scored full marks for this part. Candidates were clearly familiar with the Cosine Rule, but a disappointingly large number evaluated $(b^2 + c^2 - 2bc)\cos A$. Even some good candidates omitted to give the total length of the course.

(ii) Most knew to use the Sine Rule to find angle B – or occasionally angle C – but a surprising number seemed unfamiliar with bearings, and this was sometimes left unanswered. Many simply calculated 360 – "B".

(iii) Most candidates successfully found the length of the chord PQ, but far too many candidates simply calculated $r\theta$, with θ as 224 (or 136) and did not appreciate that this answer was simply ridiculous. Surprisingly few of the successful candidates adopted the expected approach – more often they converted the angle to radians and then used s = $r\theta$.

12) (i) Part (*A*) was generally done very well indeed, although some candidates gave an extra root of – 2.

Part (*B*) was also very well done, although some candidates substituted an upper limit of 16 instead of 2.

(ii) *(A)* Those who used the Binomial expansion generally obtained both marks in this part. Those who expanded the brackets longhand often made slips.

(B) Many went on to obtain both marks with this part, too. However, many candidates simply ignored their previous answer and manipulated $\frac{\mathrm{f}(x+h)-\mathrm{f}(x)}{h}$, often submitting the answer f. It seemed clear that many candidates were unfamiliar with differentiation from first principles.

(C) Only a few candidates connected this part with its immediate predecessors. Consequently it was often not answered. However, some candidates gave the correct answer, but had been unable to cope with the algebra in parts *A* and *B*.

(D) This elicited a wide variety of incorrect answers, some of which were clearly flippant. More often it was left blank, a correct response occurring only rarely.

4753: Methods for Advanced Mathematics (C3) (Written Examination)

General Comments

The paper proved to be a fair test of students' ability. There were plenty of accessible marks, and even weak candidates managed to score around 20 marks. There were also many excellent scripts over 60 marks. The scripts suggested signs of improvement on some topics which have caused problems in the past, such as implicit differentiation and inverse trigonometric functions. Although virtually all candidates attempted all the questions, there were signs in question 8 of a few candidates running out of time. The standard of presentation was variable.

Algebraic immaturity is a common source of problems. For example, the inability to eliminate variables from pairs of simultaneous equations in question 3 and errors in simplification of expressions in questions 1 and 7(ii), were common sources of weakness. Another general point is candidates' sensitivity to command words such as 'show' and 'verify', for example using 'verification' in question 3(i) and 'showing' in 7(i).

Comments on Individual Questions

Section A

1) This was a straightforward test of the chain rule, in which most competent candidates scored full marks. Sources of error were using the wrong index for the cube root, derivative formula errors, and faulty simplification of the final result.

2) This question was well done, with nearly all candidates applying f and g in the correct order for each composite function, and sketching the resulting quadratic functions. In the sketch, only the *x*-intercept for fg and *y*-intercept for gf were required, though some 'burned their boats' by getting the other intercept wrong.

3) Weaker candidates made heavy weather of eliminating *A* and establishing $e^b = 1.6$ – many substituted the given result prematurely. However, nearly all candidates scored B1 for $A = 6250$ and $b = 0.470$, and the 2 easy marks for part (ii). The answers to part (ii) were often written to improbable degrees of accuracy, though this was not penalised.

4) This question was less successfully answered. Part (i) was a gift of a mark for everyone, but the easy derivative in part (ii) was disappointingly done, the main errors being $(v-k)/v^2$ and k lnv. The use of the chain rule in part (iii) was less secure, with many candidates thinking that the rate of change of *P* was d*P*/d*V*.

5) This little 4-mark question rarely achieved full marks. In part (i), we penalised those who tested $p = 1$ – clearly many candidates classify 1 as a prime. In part (ii), although most candidates showed that $2^{11} - 1 = 2047$ for M1, many failed to complete the proof convincingly by pointing out that 11 is prime, and 2047 is not.

6) The implicit differentiation in part (i) was usually either 0 marks or 4 marks, with many candidates scoring full marks. Part (ii) was less well done, with numerator = 0, or numerator = denominator, common errors. A fair number of candidates lost an accuracy mark by writing $x = 0.92$ instead of 0.920.

Section B

7) Most candidates scored over half marks for this question, but a lot of marks were lost if they failed to find the correct derivative of $\ln(1 + x)$.

(i) The product rule was well known, though the derivative of ln(1 + x) was occasionally wrong – 1/x a common error. It is important that candidates understand the meaning of command words such as 'verify': having found dy/dx, a significant number of students tried to solve dy/dx = 0 instead of verifying that x=0 is a solution.

(ii) Some candidates lost their way with the second derivative by combining the fractions instead of differentiating them separately, then using the quotient rule on the more complicated expression. The quotient rule was generally well done. The second derivative rule was also well known, though the final 'E' mark was reserved for better candidates who had managed the algebra securely.

(iii) This was a fairly easy integration by substitution, with the result given. However, candidates needed to show $du = dx$, and to expand $(u - 1)^2$, to gain the 'E' mark. Integration errors were usually from the $1/u$ term, and some candidates got the limits for u and x mixed up.

(iv) There were plenty of correct applications of integration by parts, but occasionally flawed notation led to the substitution of the answer from part (iii) incorrectly – for example, it was included inside the brackets with the limits resulting in it being added and subtracted.

8) This question tested a variety of topics, and rarely gained full marks. Some attempts showed evidence of rushing through lack of time.

(i) To gain full marks, we wanted the transformations described correctly as 'translation' and 'stretch', and the directions clearly indicated. Getting the directions mixed up was quite a common error.

(ii) A surprising number of candidates, even competent ones, thought that the limits of this integral were from 0 (rather than $-\pi/4$) to $\pi/4$, and integration errors were quite common.

(iii) The first three marks were very straightforward, though mixing derivative and integral results for trigonometric functions is quite common. The derivative of the inverse function as the reciprocal was often not known – some candidates tried to derive the inverse function, and others confused this with the perpendicular gradient result, giving the answer as − ½ instead of ½ .

(iv) Domains and ranges often cause problems, and correct domains here were relatively rare. Most candidates attempted a reflection in $y = x$ and gained M1, but few showed the correct domain for the inverse function for the A1.

(v) Many candidates got these two marks, and even weaker ones usually got M1 for attempts to invert. The most common error was confusing the inverse with the reciprocal of the function.

4754: Applications of Advanced Mathematics (C4)

General Comments

There is always a comparatively small entry for this examination in the January session compared to that in June. The overall standard of work in January has generally been higher than in the summer and this paper proved to be no exception.
The papers proved to be very straightforward. All questions were answered well by most candidates- both in Paper A and the Comprehension - and high scores were achieved by a large number of candidates.
Candidates should however be advised that when an answer is given in the question, a full explanation of how that answer is established **must** be given. The omission of brackets was also a disappointingly common failure which leads to subsequent errors and the loss of marks.

Comments on Individual Questions

Paper A

Section A

1) This proved to be a relatively straightforward application of the method for solving equations of the type $3\cos\theta + 4\sin\theta = 2$. There were two common errors. The first was the use of degrees rather than the required radians. The other was either to only find one solution in the final part or to give ± the same solution e.g. +2.087 and – 2.087. Otherwise, this question was usually answered correctly.

2) (i) Binomial expansions with n= ½ or -1 were sometimes seen but the expansions were usually correct. The powers of $-2x$ caused some errors, particularly among those who failed to use brackets. The most common errors involved the set of values for the validity. This was either omitted or equality signs were included in the statement or in some cases, only one end point was given.

(ii) Most candidates correctly used their expansion from part (i) in part (ii).

3) There were many completely correct solutions for this volume of revolution. However, some candidates gave confused answers. Those who integrated a function of y wrt y and between y limits were usually successful. Too many substituted y limits into an expression in x. Trying to integrate $(1+x^2)^2$ wrt y was common.

4) This was generally well answered. Weaker candidates failed to collect terms but the majority obtained full marks in both parts (i) and (ii).

5) This was well answered by the many candidates that started with the correct form of the partial fractions. However, $\frac{4}{x(x^2+4)} = \frac{A}{x} + \frac{B}{x^2+4}$ or $\frac{A}{x} + \frac{Bx}{x^2+4}$ were too often incorrectly seen as the starting points.

6) This question was usually correctly answered. Occasionally $1/\text{cosec}\theta = \cos\theta$ was incorrectly used, or only one solution was found.

Section B

7) (i) The vectors were almost always right.

(ii) The method and answer for finding the length was usually correct.

(iii) Some candidates failed to show sufficient working that the two vectors were perpendicular.

$\begin{pmatrix}-6\\6\\24\end{pmatrix}.\begin{pmatrix}4\\0\\1\end{pmatrix}=0$ is not enough –working needs to be shown.

The cartesian equation of the plane was sometimes omitted or possibly overlooked. Starting from the vector equation of the plane and then converting to cartesian form was seen, but most used the easier $4x+z = c$ as their starting point.

(iv) The vector equations were usually correct but many candidates did not clearly establish that (5,10,40) was on both lines. A common error was to use the same parameter, usually λ, for both of the vector equations and then solve to find the value of the parameter. For those that solved equations correctly to find both their parameters, many failed to show that the point lay on both lines or failed to make it clear that their solutions for their parameters satisfied all three equations.

(v) The volume of the ornament was often well done-even by weaker candidates.

The most frequent error was failing to realise that the perpendicular height of POABC was 40cm. Some candidates used a slant height and others assumed, incorrectly, that the pyramid was a right pyramid and used Pythagoras to calculate the height.

8) (i) The verification was almost always correct. In some cases $\cos^2\theta+\sin^2\theta=1$ was not clearly stated.

(ii) The differentiation was usually correct. Most differentiated the parameters and then divided but the use of implicit differentiation was also fairly common and successful.

(iii) $k=2$ was usually found. $k=\sqrt{8}$ was the most common error.

(iv) The graphs were well answered-often with a great deal of detail for a sketch. The most common error was failing to give a scale on the y axis.

(v) Although most candidates understood the idea that these gradients were the negative reciprocals of one another, their explanations were sometimes incomplete. References to the 'inverse' or the 'normal' were seen. There were, however, many good answers.

(vi) Few candidates obtained full marks in this part. Although most candidates separated the variables correctly and integrated there were many errors. $\int \frac{1}{4y} dy = \ln 4y$ was a common error. Candidates still fail to perform log rules correctly. For example, ln$y$ = 4ln$x$ +c $\Rightarrow$ $y = x^4 + c$ is still often seen. Also, $\frac{1}{4}$ ln 4y = ln 4$y^{\frac{1}{4}}$ without the use of brackets often lead to 4x$y^{\frac{1}{4}}$ instead of $(4y)^{\frac{1}{4}}$ causing subsequent errors. Some candidates still failed to include a constant of integration.

Paper B: The Comprehension

1) The values 4,1,….11,17 were almost always correct.

2) This was usually correct although explanations were not always clear. Some gave good algebraic reasons based on the 3n+1 th term. Most spotted the pattern of odd and even terms. There were incorrect answers and explanations such as every fourth term is even.

3) 8φ+5 was usually correct.

4) The method was often correct but poor use of brackets often lead to the answer being incorrectly given as (3+√5)/2. Although most candidates approached from 2-φ there were equally good answers from different starting points-often (φ-1)/φ.

5) (i) These gradients were often correct.

(ii) There were some good explanations showing why these lines were perpendicular. Some used a variety of equations in terms of φ and many substituted (1+√5)/2 and worked in surds. There were many other cases where the justification was poor.

6) The substitution was usually correct but the rationalisation of the denominator was not always clear. The answer was given in the question and so justification of $\frac{3+\sqrt{5}}{2\sqrt{5}} = \frac{5+3\sqrt{5}}{10}$ was needed.

7) There were some good solutions here but some did not really understand what was required. Some found 2a+d=a+2d and then equated terms or just stated a=d=0 and others made algebraic errors.

4755: Further Concepts for Advanced Mathematics (FP1)

General Comments

The overall standard of the candidates was high, with the majority clearly well prepared for this paper. There were, however, a very small number of centres where the candidates scored few marks; perhaps they had been entered too early.

Although there were many high marks, relatively few candidates scored in the upper 60s or higher; certain part-questions, particularly the end of question 8, were found very difficult.

A large number of avoidable errors were made by candidates failing to read the questions sufficiently carefully.

Marks were lost by some candidates who failed to label diagrams clearly, or who showed insufficient workings in their solutions.

Comments on Individual Questions

1) **Matrices**

Usually well answered. In (i) a few multiplied **AB** instead of **BA**. In (ii) the most common error was to multiply 3 by either det **A** or det **B**, but not both. More candidates who did this correctly seemed to use det **A** and det **B** rather than det **BA**. A very few tried to transform a square or rectangle of area 3 but this method was very rarely successful.

2) **Complex numbers and modulus-argument form**

Almost all candidates got part (i) right; there were just a few careless mistakes.

In part (ii) many candidates did not obtain the correct argument of the angle; it was often the case that they did not know which angle was required. Those candidates who sketched -3+4j on an Argand diagram were nearly always successful. Other common errors were giving the modulus as 25 rather than 5, and not knowing the meaning of modulus-argument form.

3) **Complex numbers and the roots of a cubic**

Almost all candidates were successful in showing that 3 is one root of the equation and most found the other two roots, although there were a few careless mistakes.

In part (ii) the complex roots were usually shown correctly on the Argand diagram but many lost a mark by omitting the real root.

4) **Using standard results to prove the formula for the sum of a series**

Nearly all candidates knew how to answer this question but many of them made the mistake of writing $\sum 2 = 2$ instead of $\sum 2 = 2n$.

While most candidates scored fairly well on this question, a significant few seemed totally unprepared for a question of this type. A small number tried to prove the result by induction.

5) **Relationships between the roots of a cubic equation**

Most candidates knew what to do in this question but there were plenty of careless mistakes, many of them because of sign errors. Another common error was to omit the 2 in the expansion $(\alpha+\beta+\gamma)^2 = \alpha^2+\beta^2+\gamma^2+2(\alpha\beta+\beta\gamma+\gamma\alpha)$.

6) **Proof by induction**

Most candidates knew what to do in part (i), applying an inductive definition, and obtained the right answer. There were, however, a few careless arithmetical mistakes.

In part (ii), candidates were asked to prove a result by induction. The question asked for proof of the formula for the general term of a sequence, rather than for the sum of the sequence. Many candidates did not appreciate this and tried to find the sum instead. However, many others did realise what was required and obtained full marks on this question.

In attempting to prove the inductive step, a few candidates made the error $7 \times 7^{k-1} = 49^{k-1}$.

Some candidates were not good at explaining the implication of their workings; 'therefore by induction the result is true for all *n*' is not sufficient to earn the final 2 marks unless the candidate convincingly explains why this is the case – see the mark scheme.

7) **Graph**

This question was very well answered. Many candidates obtained full marks, or nearly so.

(i) This was well answered, but some candidates omitted one or other of the two points, usually the intersection with the *y*-axis.

(ii) Almost all candidates scored full marks but a few either omitted the horizontal asymptote or gave an incorrect answer.

(iii) Most drew the correct shape but many lost a mark by failing to write the co-ordinates of the points of intersection of the curve with the axes on their sketches.

(iv) Most candidates obtained the required regions but many did not give strict inequalities where they were required and so lost marks.

8) **Loci on the Argand diagram**

This was the least well answered question on the paper.

(i) Many candidates ignored the instruction to draw the two loci on a single Argand diagram.

Many candidates drew the circle with centre (0, -3j) instead of (0, 3j), and the half-line beginning at (1, 0) instead of (-1, 0). Those who made this error ended up with no obvious intersection for part (ii).

(ii) In a large number of scripts the instruction regarding the inequalities was misinterpreted as "either … or…" , rather than "and". This was often the case even with correctly drawn sketches.

(iii) Few candidates made much progress on part (iii). Many of those who drew the tangent from the origin to the circle assumed it made an angle of $\frac{\pi}{4}$ with the real axis. Most failed to indicate the required point. It was only the very strongest candidates who obtained the correct answer to this part.

9) **Matrix transformations**

Many answers were fully correct. There was a very small number of candidates who worked with row vectors rather than columns, but very few of these were consistent throughout their answers.

(i) Almost all candidates got this right.

(ii) Almost all candidates got this right.

(iii) The large majority of candidates got this right.

(iv) Whilst most got this right, many gave incomplete descriptions, most commonly omitting either the centre or the direction of the rotation.

(v) **TM** was quite commonly calculated instead of **MT**.

(vi) Those who obtained the correct answer to part (v) usually went on to obtain the correct answer to part (vi).

4756: Further Methods for Advanced Mathematics (FP2)

General Comments

This paper was found to be rather more straightforward than the recent past papers, and most candidates performed well on it. They displayed well-developed skills in manipulative algebra and calculus, and handled new topics such as eigenvalues and hyperbolic functions with confidence. Only a few candidates seemed to have any difficulty completing the paper in the time allowed. There was nevertheless a wide range of marks, with about one third of the candidates scoring 60 marks or more (out of 72), and about one fifth scoring fewer than half marks.
In Section A, Q1 (on calculus) and Q3 (on matrices) were answered rather better than Q2 (on complex numbers). In Section B, almost every candidate chose the hyperbolic functions option.

Comments on Individual Questions

1) This question (on polar coordinates and Maclaurin series) was generally answered well. About 20% of candidates scored full marks, and the average mark was about 14 (out of 18).

(a) Most candidates set about finding the area enclosed by the curve confidently and efficiently, and there were very many fully correct solutions. The great majority wrote down a correct integral expression for the area, although the factor ½ or the a^2 was sometimes missing. A few forgot to square the expression for r, even when they had previously written $\int \frac{1}{2} r^2 \mathrm{d}\theta$. The method for integrating $\cos^2 2\theta$ by using the double angle formula was well known, although there were many errors with signs and coefficients.

(b) In part (i), the first derivative of $\arctan(\sqrt{3}+x)$ was given accurately by the great majority of candidates. Finding the second derivative proved to be slightly more of a challenge, with sign errors, and forgetting to square the denominator, occurring quite frequently.
In part (ii), most candidates demonstrated that they knew exactly how to produce a Maclaurin series; although the constant term was sometimes left as arctan $\sqrt{3}$, and the 2! was sometimes missing from the x^2 term.
In part (iii), most candidates knew what to do, and carried it out accurately. Some forgot to multiply through by x, and there were often careless errors in the integration or the evaluation. As the answer was given, this needed to be correct in every detail to earn full marks. There were a few attempts to integrate by parts.

2) About 15% of candidates scored full marks on this question (on complex numbers), and the average mark was about 11.

(a) Most candidates knew how to find the 4th roots, and very many did so correctly. Common errors were taking the modulus of 16j to be 4 instead of 16, and giving the arguments of the 4th roots as $\frac{\pi}{2}+\frac{2k\pi}{4}$ instead of $\frac{\pi}{8}+\frac{2k\pi}{4}$. It was very pleasing to see that almost all candidates took care to give the arguments in the required range. The Argand diagram was frequently drawn on separate graph paper, which was unnecessary.

(b) The identity in part (i) caused very little difficulty.
In part (ii), almost all candidates knew that they should consider C + jS, but some made no progress beyond this. The series was usually recognised to be geometric, and an attempt made to sum it, although many considered the sum to infinity instead of the sum of n terms. In the sum to n terms, r^n was quite often written as $2\mathrm{e}^{\mathrm{j}n\theta}$ instead of $2^n\mathrm{e}^{\mathrm{j}n\theta}$. Using part (i) to obtain a real denominator, and considering the real and imaginary parts, was quite well done, although the expression for S often included an extra −4 in the numerator.

3) About one third of candidates scored full marks on this question (on matrices), and the average mark was about 13. Most candidates showed a high degree of confidence and skill with matrices.
In part (i), almost every candidate understood the methods for finding eigenvalues and eigenvectors. The eigenvalues were usually found correctly, but a fairly common error with the eigenvectors was, after correctly obtaining, say, $y = -2x$, to give $\begin{pmatrix} -2 \\ 1 \end{pmatrix}$ instead of $\begin{pmatrix} 1 \\ -2 \end{pmatrix}$.
In part (ii), most candidates knew how to find the matrices P and D, and indeed there were very few cases of candidates giving the columns of the two matrices in an inconsistent order.
Some candidates omitted part (iii) altogether, some tried to apply the Cayley-Hamilton theorem, and some tried evaluating $\mathbf{M}^2$, $\mathbf{M}^3$ and so on. However, most candidates proceeded by evaluating $\mathbf{PD}^n\mathbf{P}^{-1}$ (although some did have $\mathbf{P}^{-1}\mathbf{D}^n\mathbf{P}$) and on the whole the manipulation was carried out accurately. Failure to obtain the correct results was usually due to incorrect eigenvectors rather than errors made in this part of the question. A few candidates had the annoying habit of making corrections by writing over their previous figures, which sometimes made their work almost illegible.

4) Most candidates demonstrated competence in the handling of hyperbolic functions, but very few managed to score full marks. The average mark was about 10.
Part (i) was the hardest item on the question paper, judging by the percentage of candidates who answered it correctly. Most candidates could obtain $x = \ln(k \pm \sqrt{k^2-1})$, but the majority just stopped here, or boldly asserted that the given result followed from this. Only a few could show that $\ln(k - \sqrt{k^2-1}) = -\ln(k + \sqrt{k^2-1})$; almost all the successful candidates did this algebraically, by first showing that $(k - \sqrt{k^2-1})(k + \sqrt{k^2-1}) = 1$. Several candidates stated that $\cosh x$ was an even function, or drew a sketch of the graph of $y = \cosh x$, but usually did not explain how the given result follows from this. As the result is given on the question paper, a complete and convincing explanation was required in order to earn full marks.
The integral in part (ii) was very often evaluated correctly, by going either via ½ arcosh $2x$ or straight to the logarithmic form. By far the most common error was omission of the factor ½.
In part (iii), those who rewrote the equation in terms of exponentials were rarely able to deal with the resulting quartic equation. Success was usually dependent on using sinh $2x$ = 2sinh $x$cosh x, leading quickly to sinh x = 0 or cosh x = 3. It was pleasing that only a few candidates missed the solution x = 0; but it was surprising, given the presence of part (i), how many candidates gave only one

solution for cosh x = 3.
Part (iv) was quite often answered correctly, with most successful solutions rearranging $\frac{dy}{dx}$ = 5 as a quadratic equation in cosh x and showing that the discriminant was negative. Quite a number gave the derivative of sinh $2x$ as ½cosh $2x$ instead of 2cosh $2x$.

5) There were only seven attempts at this question (on investigation of curves). One of these was substantially correct, but most consisted of just a few fragments.

4758: Differential Equations (Written paper)

General Comments

Many candidates demonstrated a good understanding of the specification and high levels of algebraic competency. Questions 1 and 4 proved to be the most popular choices.
When sketching graphs, if candidates use a graphic calculator, merely copying the screen may not be enough if it does not identify the key features of the solution. However, detailed analysis is not required in sketch graphs unless specifically requested in the question.
When a differential equation and conditions are given, a request to find the solution implies that the conditions should be used. (ie in these circumstances, find the particular solution unless the specific term ‘general solution’ is used.)

Comments on Individual Questions

Section A

1) (i) This was generally done very well, although a few candidates did not use the given conditions to calculate the arbitrary constants.

(ii) Although there were some excellent answers, most candidates struggled to explain why the given expressions could not form a particular integral. They were required to say more than just identify them as terms in the complementary function, but to remark that they would give zero in the left hand side of the differential equation.

(iii) This was often done well, although some candidates found the value of t at the maximum, rather than the value of y. It was expected that the maximum value was marked on the sketch graph.

2) (i) This was often done very well, although some candidates made errors when dividing or multiplying the equation through by an appropriate expression. For example, when dividing through by (1 + t), some candidates did not divide the –3 term.

(ii) This was also often done well, although some candidates wrongly used the same integrating factor as before.

(iii) Completely correct answers were not common. Many candidates made errors in differentiating their velocity expressions. A few described the velocity rather than the acceleration.

3) (i) A surprising number of candidates did not use the condition to calculate the arbitrary constant. Note that the question did not ask for the general solution and so the condition should have been used.

(ii) This was often done well, although algebraic errors when calculating the coefficients were common.

(iii) The particular solution was usually well answered.

(iv) The numerical solution was often done well, although a sizeable minority made numerical errors in the second step.

(v) Finding the limiting value was sometimes well done, although many did not realise that this must correspond with a zero derivative. Finding the population when the growth rate is greatest was rarely completed. A number of candidates differentiated the expression, but few were able to solve the resulting equation.

4) (i) Most candidates completed this correctly, but a few did not seem to know how to do the elimination.

(ii) This was often correct, but some candidates assumed that the particular integral was 6.

(iii) Many candidates gave correct answers by using their solution for x in the first of the displayed differential equations. Pleasingly few candidates attempted to construct a differential equation for y.

(iv) Many correct solutions were seen.

(v) The sketches were often done well, but some candidates omitted to identify the key features, in particular the initial conditions and the asymptotes.

4761: Mechanics 1

General Comments

Many of the candidates obtained high scores and many scored full marks to several of the questions. Most of the candidates could make a good start to every question and the only questions where very low scores were seen were Q2 (on the application of Newton's second law and constant acceleration formulae in a vector setting) and Q3 (on statics). Far fewer candidates scored full marks on Section B than on Section A; many strong candidates lost marks in Section B because of their lack of detail when establishing given answers.

Most of the candidates seemed to know what each question required of them and knew the appropriate techniques.

The presentation of the solutions was generally good but, as always, some candidates produced confused working where it was not even clear which part of the question was being attempted.

Candidates should always re-read a question when they think they have finished it to be sure they really have done so. In Qs 6 (i) and 7 (i), there were two requests and quite a few candidates attempted only one of them.

Comments on Individual Questions

Section A

1) **Drawing and using a velocity-time graph**

Most candidates scored full marks on this question with most of the errors being slips. The only common error was to think that the question said that the constant speed was maintained up to 20 s after the start instead of it being maintained for 20 s. Most candidates found the distance travelled by calculating the area under the graph and did this by considering three regions instead of treating it as a single trapezium.

2) **Newton's second law and kinematics in vector form**

A considerable number of candidates did not know how to deal with vectors but many others scored full marks.

(i) Most candidates applied **F** = *m***a** and did so accurately.

(ii) Being given a direction as that of the vector $\begin{pmatrix} 0 \\ 1 \end{pmatrix}$ threw some candidates who tried to combine this with their acceleration before finding the angle. Pleasingly few candidates found the complementary angle to the one required.

(iii) Many candidates knew what to do but others, who had used vectors successfully in part (i), now produced wrong scalar attempts or expressions containing both vector and scalar terms 'added'. The most common error made by those who used the vector form of the constant acceleration formulae was (surprisingly) to use $\mathbf{s} = t\mathbf{v} - \frac{1}{2}t^2\mathbf{a}$ with **v** taken to be the initial velocity. The most common error made by those who integrated was (less surprisingly) to integrate the given initial velocity once instead of integrating the constant acceleration twice.

3) **A statics problem**

While many candidates scored full marks with apparent ease, a few candidates showed they had some fundamental misconceptions. Most of the major errors stemmed from candidates not realising that they should separately consider the block and the sphere or that the tension of 58.8 N is common to the whole of the string; these candidates usually introduced some component of the weight of the block into the tension or included the weight of the sphere in calculations about the block. It was not uncommon for candidates to get part (i) wrong but the rest of the question completely correct. The comments below refer to candidates who did not make these mistakes.

(i) Most candidates managed this correctly.

(ii) Most candidates knew exactly what to do and did it accurately. It was pleasing to see fewer candidates than in the recent past confusing sine and cosine in this part and in part (iii).

(iii) A lot of accurate answers but many candidates wrongly believe that the normal reaction of a plane on a block is the component of the weight perpendicular to the plane and so these were not attempting the right calculation.

4) **Three component vectors and an equilibrium problem.**

Questions of this type set in the recent past have usually been answered poorly by all but the strongest candidates. It was very pleasing that most candidates were able to answer this question well with very few indicating that they had no idea what to do.

(i) Most candidates knew what 'resultant' means and found it but a few thought that it was the magnitude that was the resultant. Far more candidates than in the recent past knew how to find the magnitude of this 3 component vector but wrong methods were not uncommonly seen.

(ii) There were many accurate answers to this part, including some from candidates who had failed to deal with the vectors in part (i) and in Q2. It was pleasing that so many candidates correctly attempted to calculate $\mathbf{H} = -\mathbf{F} - 2\mathbf{G}$ instead of $\mathbf{H} = \mathbf{F} + 2\mathbf{G}$ and a little surprising how many slips were seen in the arithmetic.

5) **A kinematics problem requiring calculus**

This problem was unstructured and it was very pleasing to see so many confident, efficient and accurate solutions.

Most candidates differentiated *v* to find an expression for the acceleration and found that the acceleration is zero when *t* = 2. Some candidates then went on wrongly to try to find the displacement as $\frac{1}{2}\left(v(0)+v(2)\right)\times 2$ but most realized that they should integrate.

Quite a few candidates found the displacement between *t* = 0 and *t* = 2 to be 20 m and wrongly thought this was the position but the majority realized that something more was required; about half of these found the displacement and added 3 at the end and the rest instead obtained the appropriate arbitrary constant to give them an expression for the position at any time. Quite a few candidates, having found the position at time *t* = 2 from a general expression then went on to add another 3m.

Section B

6) **Kinematics and Newton's second law applied to vertical motion**

There were many very good answers to this question. There were few candidates who did not know how to use Newton's second law in simple applications but rather more that did not know how to deal with the connected particle situation in part (iv).

(i) Most candidates managed this part correctly but some forgot to find the distance.

(ii) There were many accurate answers to this part with most of the errors stemming from sign errors in the absence of a clear sign convention. A few candidates omitted the weight term and a small number thought that *F* = *mga*.

(iii) Most candidates included the resistance in a calculation using Newton's second law but (usually in the absence of a diagram) some omitted the weight. Many candidates gave their answer as 20 m s^{-2} but did not say whether upwards or downwards. A diagram indicating which direction they had taken to be positive was accepted in place of a statement.

(iv) The majority of candidates could not cope with this part. Quite a few did not realize that the tension in the rope allowed calculation of the acceleration and became stuck. Others made statements of the type, 'I do not know the acceleration, but assuming it is ….'. These (and others who made no statement) variously took the acceleration to be that in part (i) or part (ii) or part (iii) or zero.

Many candidates did not apply Newton's second law and simply juggled with the various forces.

Some of those with the right method made sign errors, again usually in the absence of a diagram showing their sign convention.

Despite these problems, there were many neat and efficient solutions.

7) **Projectile motion**

There were many complete solutions and many other candidates only lost a few marks because they did not fully establish the given answers in parts (i), (ii) and (v). Most candidates seemed to know how to approach the questions but many showed they had not completely understood the scenario as they did not use the correct times in part (iv).

A number of candidates seemed to confuse the horizontal and vertical components (but not consistently); one feels that a clear diagram would have helped them.

(i) There were few mistakes made here except by candidates who did not fully establish the given vertical component of speed. Many candidates did not use the most direct methods.

(ii) Most candidates obtained this mark. Again, the most common error was to write down the given answer without attempting to show how it was derived.

(iii) The explanations often lacked sufficient detail. It is not enough that the two parts have the same acceleration; it also depends on their starting from the same height at the same time with the same speed. Candidates were expected to indicate in some way at least two of these requirements. Very few thought to write down an expression for the height and show it applied to both parts.

Most candidates found an expression for the distance *between* the parts but a few stopped after writing down the positions of the parts at time *t*.

(iv) (A) The most common mistake in this part was to take *t* as being the time from projection from the ground and then use it as the time after the explosion. Otherwise there were few errors. Many candidates obtained the correct answer.

(B) This part presented more difficulties. Some candidates equated the expression for the vertical component of displacement to 10; others, more directly, equated the distance dropped to 40 – 10 = 30. The most common errors were with signs and more often, as in (A), from using the wrong time; very many of the candidates who solved $10 = 49t - 4.9t^2$ found the larger root correctly but then went on wrongly to assume this was the time elapsed after the explosion.

Many candidates produced good, efficient and correct answers.

(v) Unlike in some recent sessions, very many of the candidate knew exactly what to do. The only common error was to give insufficient evidence of working to get from the substituted equation to the given answer.

4762: Mechanics 2

General Comments

Many excellent scripts were seen in response to this paper with the majority of candidates able to make some progress worthy of credit on every question. The majority of candidates seemed to understand the principles being employed. However, some did not clearly identify the principle or process being used and, as has happened in previous sessions, those parts of the questions that were least well done were those that required an explanation or interpretation of results or that required the candidate to show a given answer. In the latter case some candidates failed to include all of the relevant steps in the working. Those candidates who appreciated the value of a good diagram were generally more successful than those who avoided drawing any diagram.

Comments on Individual Questions

1) **Impulse and momentum**
Many candidates understood what to do and did it well. Those that drew diagrams were usually more successful than those who did not.

(a)(i) Few candidates had problems with this part of the question.

(ii) Many candidates did well on this part of the question. The main sources of error were inconsistencies between the equations for the Principle of Conservation of Momentum and Newton's Experimental Law. Candidates who drew a diagram with velocities clearly labelled with arrows to show direction were generally more successful than those candidates who either did not draw a diagram or who failed to label their diagram fully.

(iii) Many candidates gained full credit for this part of the question. However, a small minority wrongly used $v^2 - u^2 = (v - u)^2$ when calculating the change in kinetic energy.

(b)(i) A high proportion of the candidates stated that the linear momentum of A was 72 Ns but failed to give any indication of direction of this vector quantity. Almost all of the candidates could correctly show the given answer for the momentum of B.

(ii) A small minority of candidates did not realise that conservation of momentum was required to solve this part of the question but did realise that they had to equate components in order to obtain values for u and v.

(iii) Most candidates correctly used their answer to the previous part to find the angle requested.

2 **Work – Energy**
It was pleasing to see that the majority of candidates used work-energy methods throughout.

(i) (*A*) This part was well done by almost all of the candidates.
(*B*) Few candidates had difficulties in completing this part of the question.

(ii) Most candidates did well on this part with a large number scoring full marks. Those that did not gain full marks had usually omitted either one of the kinetic energy terms or the work done from their work- energy equation.

(iii) (*A*)The majority of candidates successfully completed this part.
(*B*) Many candidates had problems with this part. The most common error was to omit the resistance term when calculating the force required to produce the given acceleration.

3 **Centres of mass**

Only the last two parts of this question caused any problems to a large majority of candidates. The principles behind the calculation of centres of mass appeared to be well understood and candidates who adopted column vector notation made fewer mistakes than those who calculated co-ordinates separately.

(i) Most candidates obtained full marks for this part. However, some did not refer their answers to the axes requested in the question. Others chose to relabel the axes as x and y but then confused themselves when tackling the next part of the question.

(ii) Few candidates had difficulty in establishing the given x co-ordinate but many failed to explain, or show, that the y- and z co-ordinates should remain the same as in the previous part.

(iii) Few candidates made much progress with this part. While many appreciated that taking moments about AH was required they made mistakes when trying to calculate the necessary lengths. Others did not show (either on a diagram or in a statement) that the normal reaction would act through the line AH and hence have zero moment about this line. Candidates who drew a diagram generally gained more credit than those who did not.

(iv) Many candidates followed through their answer to the previous part and obtained a numerical answer for the coefficient of friction. However, many of them failed to explain that the friction was limiting and failed to establish clearly the inequality. Some candidates attempted to calculate an angle α in the mistaken belief that they could equate the coefficient of friction to tan α

4 **Moments and resolution**

It was very pleasing to see some good answers to this question with many completely correct answers. Those candidates who drew clear diagrams made fewer errors than those who either did not draw a diagram or who drew a poorly labelled one.

(i) Most of the candidates knew what to do and did it well but many failed to show clearly that the distance from D of the line of action of the weight was 0.5 m. Few candidates had difficulty in calculating the normal reaction at C.

(ii) Most candidates established the given answer but quite a few failed to show sufficient working to be awarded all of the marks.

(iii) (*A*) Many excellent responses were seen to this part of the question with errors being arithmetic rather than of concept. However, some candidates tried to take moments about the centre of the beam or about C and then failed to include the reaction at D. Others calculated the moment of the tension about D in the mistaken belief that this was the tension.

(*B*) Candidates, on the whole, did well on this part with the majority choosing to take moments again rather than selecting an approach that used the result from (*A*).

4763: Mechanics 3

General Comments

Most candidates performed well on this paper, and were able to demonstrate a sound working knowledge of the topics being examined. Very few seemed to have any difficulty completing the paper in the time allowed. Nearly half the candidates scored 60 marks or more (out of 72) and very few scored fewer than half marks.

Comments on Individual Questions

1) This question (on dimensional analysis and elasticity) was very well answered. About 40% of candidates scored full marks, and the average mark was about 15 (out of 18).

(a) In part (i), the dimensions of force were almost invariably given correctly, but quite a few candidates gave the wrong dimensions for density.
In part (ii), the dimensions of Young's modulus were usually found correctly, although some thought that $(l - l_0)$ was dimensionless.
In part (iii), the method for finding the powers was well understood and frequently carried out accurately. Previous errors often trivialised the problem, so that follow-through marks could not always be awarded.

(b) Those who wrote down the correct equations from resolving horizontally and vertically were usually able to manipulate these, together with the condition for limiting friction and Hooke's law, to obtain the stiffness of the string correctly. However, a very common error was to assume that the normal reaction was equal to the weight of the particle P.

2) Only about 10% of candidates scored full marks on this question (on circular motion), and the average mark was about 14 (out of 19).

(a) In part (i), the speed of the ball at its highest point was very often found correctly, although the weight often appeared in the equation of motion with the wrong sign, and was sometimes omitted altogether.
Part (ii) caused many difficulties for the candidates. Although the correct methods were seen fairly often, sign errors and other careless slips frequently spoilt the work. Some candidates did not consider energy at all, assuming either that the speed was constant or that the vertical forces were in equilibrium.

(b) Most candidates had no difficulty obtaining the result in part (i), although the deduction that $\omega < 10$ was often missing or incomplete; it was not sufficient just to show that $\omega \to 10$ as $r \to \infty$.
In part (ii), the expression for elastic energy was usually found correctly, although some forgot the factor ½ and some forgot to square the extension. It was quite common for the kinetic energy to be taken as $\frac{1}{2} m\omega^2$ instead of $\frac{1}{2} m(r\omega)^2$. Even when both expressions were correct, many candidates could not show that the kinetic energy was greater than the elastic energy.
In part (iii), most candidates were able to find the tension correctly.

3) About 20% of the candidates scored full marks on this question (on simple harmonic motion), and the average mark was about 12 (out of 17).
Most candidates obtained the result in part (i) correctly.
In part (ii), the values of *A, B* and ω were usually found correctly. The most common error was to obtain *A* = +4.8 instead of *A* = -4.8, resulting from an incorrect sign for the initial velocity.
In part (iii), almost all candidates obtained the given period. The majority also found the amplitude correctly. The most common methods were to use $\sqrt{A^2 + B^2}$ or apply $v^2 = \omega^2(a^2 - x^2)$ to the initial values; a third method, finding the maximum value of x by differentiation, was occasionally used successfully. Some candidates did not seem to know how to find the amplitude, or assumed that it was A.
In part (iv), most candidates evaluated *x* when *t* = 12 and when *t* = 24 (although some were working in degrees instead of radians). However, very many simply subtracted these values to calculate the distance travelled. Those who did consider the change in direction of the particle's motion quite often obtained the correct answer. Some candidates rather strangely integrated the expression for x between *t* = 12 and *t* = 24.

4) This question (on centres of mass) was answered very well, with about 40% of candidates scoring full marks, and an average mark of about 15 (out of 18).
The techniques for finding the centre of mass of a solid of revolution in part (i), and of a lamina in part (ii), were very well understood and usually applied accurately (although there were some errors in integration and evaluation).
In part (iii), most candidates knew how to find the centre of mass of the shaded region obtained by removing a rectangle from the lamina R. However, a very common error here was to take the area of the rectangle to be 4 instead of 3.5. This led to $\bar{y} = 1$, which is very obviously wrong, but the candidates did not appear to be at all concerned.

4766: Statistics 1 (G241 Z1)

General Comments

The level of difficulty and accessibility of the paper seemed appropriate for the majority of candidates. The range of marks was fairly wide although some centres had few high scoring scripts. There were a small number of very weak scripts mainly restricted to those centres with a large number of candidates.

Almost all candidates were able to score some marks throughout the paper although there remain a significant minority who seem unprepared for questions at this level. The better scripts produced answers which were very well presented with methods and working clear. Arithmetic accuracy was generally good although there was little appreciation of the consequences of using rounded answers in subsequent calculations. Some weaker candidates were reluctant to provide reasons to support answers, thus losing valuable marks when a wrong answer appeared.

It does appear that not all centres had covered the specification in sufficient depth or detail as an occasional topic was poorly answered by a majority of the candidates of that centre. Hypothesis testing remains an example of this. Common errors included the use of point probabilities in hypothesis testing, the failure to define the parameter, p explicitly before trying to establish the hypotheses and the lack of full logical reasoning in coming to the final conclusions.

Comments on Individual Questions

Section A

1) A very mixed set of answers except from very good candidates. Almost all candidates identified the mode correctly as 7 or sometimes as 07 but many made errors with the median with 13 or 2.5 (forgetting to add on the stem value of 10) being common mistakes. Some just calculated the location of the median (28 + 1)/2 =14.5, believing this was the median value.

A significant minority of candidates thought that the skewness of the distribution was negative. Most selected the median as the appropriate measure of central tendency although in (iii) part B several candidates referred to an outlier but did not specify what the outlier was, or whether it was a large or small value, preferring to state that the distribution was bimodal, unimodal or had a large range.

Many attempts at the total cost of the messages (even amongst better candidates) failed because of a reluctance to multiply by 28 with popular answers being £1.48 or £1.50. Some omitted the units altogether giving an answer of 4130 whilst a couple of scripts contrived to have a daily mobile text bill of £4130.

2) This question produced the weakest response overall by a wide margin with full marks being scored very rarely. Answers of 4 for part (i) followed by 24 for part (ii) were very frequent. Other errors seen included 3!, ${}^4C_3$ or some multiple of 24 in part (i); 4^4, ${}^4P_3$, or some multiple of ${}^4P_3$; ${}^{12}P_3$ and ${}^{12}C_3$ in part (ii).

3) (i) Virtually all candidates obtained 0.24 as their answer and scored two marks.

(ii) Answers to this part were much less successful with a large number of candidates giving an answer of $0.3 \times 0.8 + 0.2 \times 0.7 = 0.38$, forgetting about the 'both' term of 0.06. Other common wrong answers were $0.3 + 0.2 = 0.5$ and $0.24 + 0.14 + 0.56 = 0.94$ although both were much less frequent than 0.38.

(iii) There were many correct attempts at the conditional probability although the usual error of $(0.06 \times 0.44)/0.44$ was often seen. A small number of candidates quoted a formula for conditional probability correctly but were then confused by the terms included in the formula often resulting in multiplication of 0.06 by 0.44 or similar.

4) (i) Most of the better candidates scored very highly on this question with their likely source of error being arithmetic or a misread of a probability. Weaker candidates were less successful although usually obtaining a correct answer for E(X). Some candidates still insisted in dividing their E(X) by 4 for which a penalty was incurred. Errors for Var(X) included a failure to square E(X) or the quoting of an incorrect formula. A few candidates tried to use $\sum p(X - \mu)^2$ often then making an arithmetic error.

(ii) Many candidates were confused by the expected total cost often writing 4 x £45000 as their answer.

(iii) Most diagrams scored some credit with the most frequent error being a lack of labelling of the axes. A small minority of candidates produced a pie chart or a tree diagram.

5) This question was very well answered with many candidates scoring full marks.

(i) Almost all candidates explained why the sequence **SSJ** was impossible.

(ii) The majority scored well on this part with the most common error being the omission of **SS**.

(iii) Good candidates used the symbolic information given to move directly to the answer of 0.7399; weaker candidates ignored that information and attempted to use Binomial probabilities or a method of subtracting probabilities from 1. The answer of $1 - 0.7^5 = 0.8319$ was common

Section B

6) Most candidates scored some marks on this question although totally correct answers were rare.

(i) A small minority divided by 12 (divisor n) thus finding the RMSD. Most knew the method to find outliers; errors included the use of 1.5s and 3s in place of 2s.

(iii) Some candidates started from scratch and converted all 12 temperatures to °F before calculating mean and standard deviation often correctly, but then possibly finding difficulty in completing all questions in time. Others found the new mean quickly and correctly but wrote 1.8 x 5.95 + 32 = 42.7 for the standard deviation.

(iv) Comments were usually correct although some candidates made no reference to any mean or average temperature. Some weaker candidates believed they could compare ^{0}C with ^{0}F without any conversion.

(v) The cumulative frequency graph, was surprisingly poorly attempted. Only a few managed all 7 marks. The vertical axis was often labelled as frequency or number of years; there was confusion as to how to scale or label the horizontal axis between 70 and 190, the horizontal scale was sometimes shown in intervals as $70 \le x \le 100$, $100 \le x \le 110$ etc instead of a linear scale. A lot of candidates drew histograms or cumulative frequency histograms or frequency polygons. Some even calculated 'fx' and then calculated a 'cumulative fx'. In drawing the graph the point (70, 0) was often omitted and the cumulative frequency curve was left 'hanging' or was taken back to the origin or some other random point between 0 and 100. In finding the 90th percentile there was use of 90% of 50 or 90% of 190 as a method. Some weaker candidates looked at 90 on the horizontal axis and gave a value from the cumulative frequency axis as their answer. The major error was the use of mid-points rather than the upper class boundaries in plotting the points, an error made by a very large proportion of the candidates. Some candidates, even after they had plotted the correct points, made the fatal error of trying to draw a 'curve of best fit' rather than join their points with a smooth curve.

7) Few candidates scored very highly in this question. In part (i), $p(X = 1)$ was usually well answered although a number omitted the $^{12}C_1$ term. In part (B) $p(X \ge k)$ was often answered as $1 – P(X \le k) = 1 - 0.9978 = 0.0022$ instead of $1 – p(X \le k-1) = 0.1184$ or was omitted by the weaker candidates. There were in general good answers to the expected number of faulty bags although many candidates rounded their answer of 0.6 to 1 and a few thought that the question meant finding the most likely number of faulty bags.

The majority of candidates did not seem to understand what was meant by "finding any faulty bags in the sample". Some thought that it meant no faulty bags leading to $0.95^n < 1/3$; others used the probability of one faulty bag leading to a trial and error method using tables. The few who reached $0.95^n < 2/3$ often then obtained the correct answer of $n = 7$. A very small number of attempts failed because 0.6634 was deemed to be greater than 2/3 or similar.

The hypothesis test was poorly answered except by the best candidates. Common errors initially included a failure to define the parameter p, the writing of $H_0 = 0.05$, and the use of $p = 1/60$ or even 0.1. In performing the test candidates often wrote $p(X = 1) = 0.1455$, reject H_1 or similar without ever stating a critical region or indicating that they should be considering $p(X \le 1)$.

4767: Statistics 2

General Comments

The majority of candidates were well-prepared for this examination, continuing the pattern of recent years. It was evident that no question stood out as being either more difficult or more straightforward than the others. In general, candidates' abilities to structure answers to questions involving hypothesis tests, using correct notation and terminology, have shown improvement. As in recent sessions, many candidates struggled to obtain marks for explanation/interpretation, but otherwise scored well. The overall standard was high.

Comments on Individual Questions

Section A

1) (i) The majority correctly identified x as the independent variable, realising that growth depended on the hormone concentration. Few candidates stated that x was controlled.

(ii) Well answered with most candidates gaining full marks. Those leaving the equation of the regression line in unsimplified form were penalised. No extra credit was given to those candidates who calculated the p.m.c.c.

(iii) Most candidates successfully used their equations to obtain estimates of shoot growth, and the comments on the reliability of their estimates were generally as required. A number of candidates commented that the estimates were similar to the values on the graph, gaining no credit. The most successful used the idea of interpolation/extrapolation.

(iv) Most managed to obtain two of the three available marks, losing out on the final mark by providing a positive rather than negative residual.

(v) This part was poorly answered with only a few candidates obtaining full marks. Most candidates commented entirely about the context, completely avoiding discussion about the mathematical model and its suitability in the range given.

2) (i) Well answered. Several candidates used n = 90, leading to problems in the later parts of the question. In such questions it is expected that candidates will provide parameters and not just quote "binomial".

(ii) Well answered. Some candidates missed the point of this question and simply churned out comments relating to the conditions for a Poisson model to be used, generally, and not as an approximation to the binomial distribution.

(iii) *A* Well answered, with many candidates scoring full marks.

(iii) *B* Most candidates realised what was required, but some failed to correctly obtain the value of P($X \geq 4$).

(iv) Well answered.

(v) *A* Some candidates missed out on the marks here by writing down the Normal approximating distribution at this stage, bypassing the binomial distribution.

(v) *B* The Normal distribution was handled well. Many candidates failed to use an appropriate continuity correction and were penalised. Many used a Normal approximation to the Poisson distribution, leading to loss of accuracy.

3) (i) Mostly well answered, but many candidates lost the final accuracy mark through using z-values rounded to 2 d.p..

(ii) This proved difficult for many. Inappropriate attempts at continuity corrections were seen. Nonetheless, many managed to complete the question using the correct probability calculation with their values.

(iii) Well answered on the whole. Most candidates managed to draw a diagram containing two Normal curves and correctly label their means on a horizontal axis. Many managed to draw sketches which highlighted the difference in variance, but did not realise that this meant the curve for adults would have a lower maximum value.

(iv) Well answered. Some candidates lost marks through failing to handle the negative z-value correctly. A small number gave a negative value for σ.

4) (i) Well answered. Most candidates provided correct hypotheses. In calculating the test statistic, most candidates managed to work to an appropriate level of accuracy, helped by the lack of a need to round expected frequencies, and gained full marks for this. Some candidates failed to provide a table (or list) showing individual contributions to the test statistic despite being requested in the question, and hence lost marks. Most candidates correctly identified the correct number of degrees of freedom and critical value, and went on to make an appropriate conclusion.

(ii) Reasonably well answered. Most candidates scored a mark for providing correct hypotheses, but candidates still find the mark for defining μ as the population mean elusive. Indeed, many defined μ as the sample mean. Most candidates managed to obtain the correct test statistic and critical value then make an appropriate conclusion. A small number of inappropriate comparisons were seen, usually involving comparing a z-value with a probability. Several candidates treated the value 68.3 as a single observation rather than a sample mean and were penalised.

4768: Statistics 3

General Comments

Once again the general standard of many of the scripts seen was pleasing. However, the work of equally many candidates showed carelessness and a lack of thought, together with an apparent failure to read the question properly. As in the past, the quality of the comments, interpretations and explanations was patchy, and usually less good than the rest of the work.

Invariably all four questions were attempted. Marks for Questions 2 and 3 were found to be somewhat higher on average than Questions 1 and 4. There was no evidence to suggest that candidates found themselves short of time at the end.

As in the past the examiners found themselves having to cope with sloppy notation from candidates who should know better. One further general point worth making is that when the conclusion to a hypothesis test turns out to be "Accept H_1" then it is not correct to say "there is no evidence for H_0."

Comments on Individual Questions

1) **Continuous random variables; Wilcoxon single sample test; times for a computer to perform various tasks.**

(a)(i) Answers to this opening part were very disappointing. It was felt that candidates rushed into it, apparently believing that the given expression was the p.d.f. This suggested either that they had not read the question properly in the first place or that they had a poor understanding of the relationship between probability and the c.d.f. Consequently many candidates were unable to show $k = 1$ without a fudge of some kind. Difficulties here usually had implications for the next two parts too.

(ii) Many candidates were able to indicate that they expected to differentiate something but often it was not well done. Frequently the outcome was a negative p.d.f. which seemed not to cause them concern. The notation often left the examiner wondering if the candidate knew which was the p.d.f. and which the c.d.f.

(iii) The integration was generally badly set up and badly carried out. The errors seen included using the wrong limits, obtaining a negative mean (and then the minus sign would be crossed out!) and substituting $t = 0$ into an expression of the form $1/t^n$.

(b) In contrast to part (a), this part was done well and successfully by very many candidates. There was just one widespread fault: the omission of the word "population" in the hypotheses. A noticeable minority of candidates appeared not to realise that a non-parametric test was required, and even after writing hypotheses involving the median they went ahead with a test for the mean.

2) **Combinations of Normal distributions; confidence interval for a population mean; weights of leeks.**

This question was very well answered with very many scoring full marks. Candidates seemed well prepared for it and understood what was expected. In many cases their answers were concise and to the point. Those who take the trouble to provide simple sketch graphs of the standard Normal distribution do much to enhance the quality of their responses and to guard against careless errors.

(i) This part was always answered correctly.

(ii) Except for a very occasional problem with the variance, this part, too, was almost always correct.

(iii) Usually the mean total weight was correct, but often the variance was not. Typically the error came about through a lack of proper understanding of the difference between Var(4*Y*) (= 4^2Var(*Y*)) and Var(Y_1 + … + Y_4) (= Var(Y_1) + … + Var(Y_4)). Here the former was used when it should have been the latter. Even good candidates wrote Var(4*Y*) when they subsequently worked out Var(Y_1) + … + Var(Y_4)

(iv) Correct answers were not seen here as often. Candidates seemed to experience difficulty with the formulation of the requirement of this part. In fact an explicit statement of it in symbols was conspicuously missing and this, together with choosing the upper instead of the lower percentage point, seemed to contribute to their lack of success.

(v) There were many good answers to this part; the problems that did occur were the result of errors in the variance again.

(vi) The confidence interval was often obtained correctly, although quite a few candidates selected the wrong percentage point (usually from t_{100} instead of the Normal distribution).

3) **The *t* distribution: hypothesis test for the population mean; confidence interval for a population mean; temperatures in a reaction chamber.**

(i) Although most candidates scored some marks in this part it was relatively rare to find three correct, carefully expressed reasons for carrying out a *t* test. Furthermore it was important to specify clearly whether one was referring to the population or the sample.

(ii) The hypotheses were well expressed and were usually accompanied by a carefully worded definition of the symbol "μ".
In general candidates obtained correct values for the mean and sample variance, but there were a number who were a little less than careful about the accuracy and so the test statistic suffered slightly from premature approximation. Similarly the test was carried out and concluded correctly, the most common problem being the use of the wrong critical value (-2.201 instead of -1.796). Furthermore when the test is one-tailed, requiring the lower tail critical value and involving a negative test statistic, candidates are often less than clear and careful about the negative signs.

(iii) Most candidates showed that they were familiar with how to construct a confidence interval, and did so successfully. Unsurprisingly, there were a number who seemed to forget that they should still be using the t distribution.

(iv) Answers to this part were interesting to say the least. Many candidates responded much along the lines intended, but there were quite a few whose answers were, in effect, the opposite, suggesting that they had little or no understanding of the issue. Of particular interest, though not expected or intended, were the relatively few candidates who wrote in terms equivalent to a discussion of Type I and Type II errors.

4) **Chi-squared test of goodness of fit of a binomial model; Sampling; numbers of girls in families with 5 children.**

(a)(i) This part was almost always answered correctly, the given estimate of p being obtained convincingly.

(ii) By and large the expected frequencies and the value of the test statistic were calculated correctly, although some inconsistencies in rounding results were noticed. Quite a few used the wrong number of degrees of freedom, usually because they forgot to allow for the estimated parameter or thought that there was more than one, and hence their critical value was inappropriate. Following the conclusion of the test, most simply omitted to comment on their findings. Candidates were expected to undertake a brief discussion of what can be deduced by looking at the data in order to explain the outcome of the test. Furthermore most candidates did not even attempt to address the conditions of independence of trials and constant probability of outcome that are needed for a binomial model, and those who did attempt it failed to show any real understanding.

(b) Stratified sampling was by far the most popular choice among the candidates, but whatever the choice the description of how it should be done was often left wanting. A common shortcoming was a failure to appreciate that the sample was to be taken from the original 500 families of part (a).

4771: Decision Mathematics 1

General Comments

Candidates generally performed well on this paper, with the exception of Question 3. In that question few were able to work through the algorithm.

The prepared answer books are now well-understood and seem to be helpful to candidates.

Comments on Individual Questions

1) **Graphs**

Most candidates scored well on this question. Not all were able to count the six possibilities in each of parts (i) and (ii).
It was pleasing to see most candidates dealing with the semi-Eulerian issue in part (iv).

2) **LP**

Most candidates were able to draw the graph and identify the feasible region, and many were able to identify the point (3.6, 0.6). However, very many failed to complete their answers to part (i) − they did not solve the problem.
It seemed that candidates were distracted from finishing part (i) by the requirements of part (ii).

3) **Algorithms**

It was rare to see a correct answer to this question. Candidates either were unable to master integer division, or to take due note of brackets, or both. This inability correctly to perform calculations was worrying, and it led to many candidates battling on with obviously silly values.

4) **Simulation**

(i) (ii) The specification of simulation rules was done well in both parts.

(iii) In the brown/blue cases and the blue/green case candidates needed both to describe their rule and indicate which random number they were using. In the blue/blue case they needed to use their rule from part (ii) and to identify the random number, or numbers, which they used. Whilst many candidates produced complete explanations of their simulations, many others failed to indicate which random numbers were being used.

5) **CPA**

(i) (ii) Most candidates scored well in parts (i) and (ii). A common difficulty was the failure to use a dummy when two activities would otherwise have the same *i* node as each other and the same *j* node as each other.

(iii) (iv) (v) It is very much regretted that there was a typographical error in the question, with G being printed instead of H in the stem to these parts. Only a few candidates seemed to notice this, and whether H was speeded up, or G, made no difference to the difficulty. Both were allowed in the marking scheme.

6) **Networks**

(i) Most candidates found, if not the minimum connector, then at least a connecting tree, but a significant minority ended up either with a cycle or with two disconnected sets of arcs. Many made mistakes with the arithmetic.

(ii) A surprisingly small number of candidates collected both marks in part (ii). There were those who failed to match description to name, and many who "hedged their bets" − e.g. by giving a description of Prim and then adding in for supposed good measure a requirement to avoid cycles. These answers did not gain the second mark.

(iii) As always, there were many candidates who failed to convince examiners that they were applying Dijkstra − the onus is on the candidate to be convincing. However, the final part was done well more often than we had anticipated.

4776: Numerical Methods (Written Examination)

General Comments

It is pleasing to be able to report that many candidates performed well on this paper, showing a good grasp of theory and technical facility. However, a weakness that has been commented on before was still evident: some candidates present their work as a jumble of figures rather than in tabular form. Numerical algorithms lend themselves to a systematic style of presentation that aids understanding, checking and, indeed, marking. Those adopting a more casual approach are likely to make more errors and to score fewer method marks.

Comments on individual questions

1) **Secant method**

The single step of the secant method was generally carried out accurately, though some candidates gave the answer to only one decimal place. The sketch to show that the method could be very inaccurate was not well done. Indeed, many sketches showed cases where the method would be accurate. The sketch could have shown a turning point on the curve close to $x = 3$, with the root some considerable distance away.

2) **Integration**

This question was very well done with many scoring full marks. The vast majority understood clearly what was meant by trapezium and mid-point estimates with $h = 1$. Then almost as many were able to generate the required further estimates by using these values.

3) **Lagrange's interpolation method**

Most candidates gained high marks on this question with relatively few committing the error of confusing the x and the f(x) values. The question asked for the value of f(2). There was no need, therefore, for candidates to find and simplify the quadratic in its algebraic form.

4) **Bisection method**

Candidates were all familiar with the idea of bisection, though many chose not to lay out their work in a table. In some cases this made it impossible for the examiner to decide which value the candidate was offering as the answer. The final section, identifying the number of further iterations required, was very well done.

5) **Differentiation**

The sketch to show that the forward difference can be very inaccurate when h is large was often poorly done. Most candidates failed to show clearly that the chord from x to $x + h$ could have a very different gradient to the tangent at x. Sometimes the point illustrated was that f(x) and f($x + h$) could be very different. This is true, but not relevant. A large difference between f(x) and f($x + h$) might arise when the gradient of the chord is, in fact, very close to the gradient of the tangent.

The numerical part of the question, however, was done well with the majority of candidates appreciating that as h decreases precision is lost.

6) **Newton's interpolation method**

A significant minority made errors in drawing up the difference table. Some simply made numerical slips, while others consistently had their differences the wrong way round. (The latter, though unconventional, is acceptable if the signs are handled correctly in subsequent work.) The quadratic, required in algebraic form, was usually correct, though some made errors in the simplification. Finding the maximum was just a simple matter of differentiation and finding the root just required the use of the quadratic formula. Some candidates invented very elaborate methods here. In the final part, the cubic estimate of f(4.5) does not require the cubic to be found algebraically. The integral comes out as a negative number. Only a very small number of candidates supposed that they were finding an area and that the answer should be positive.

7) **Errors and representation of numbers**

Though many candidates made a good attempt at this question, it was clear that some had a poor understanding of how computers store and process numbers. Rounding was understood better than chopping. A common error was to assume that the maximum possible error in chopping to 6 decimal places is 0.000 000 9 rather than 0.000 001. Most understood that the two sums in part (iv) will produce different answers, but a significant minority missed the point altogether, Curiously, what is essentially the same phenomenon in part (v) was better understood. In the final section the two required features of a spreadsheet were that it works to greater accuracy – i.e. a greater number of significant figures – than the simple computer program, and that it does not display all the significant figures that it uses. The second point was appreciated by only a few. The existence of "guard digits" in computer software and in calculators is an important point – and it is quite distinct from working to a large number of significant figures.

Coursework

Administration

A significant minority of centres are still failing to send the authentication form CCS160 which contributed to an unnecessary extra burden of time. It also helps the process considerably to have the paperwork for the Moderator complete. This includes the filling in of the cover sheets - a few centres fail to fill in candidate numbers.
Most centres adhered to the deadline set by OCR very well and if the first despatch was only the MS1 then they responded rapidly to the sample request. A small minority, however, cause problems with the process by being late with the coursework despatch. This was worse this session than before, with a considerable number of centres submitting their marks either so close to Christmas that a sample request could not be dealt with before the break or even after Christmas. We would ask that all centres heed the deadlines published by the Board and organise their own processes of assessment, internal moderation and administration to enable these deadlines to be met.

The requirement is to provide marks to the External Moderator on the second copy of the MS1. For reasons outside our control this is the worst sheet of the three and some marks are indecipherable. This is made considerably worse when centres fill in the lozenges but do not put the mark in the appropriate box. Additionally, centres are asked to provide teaching groups and this does not always happen.

The marks of most centres were appropriate and acknowledgement is made of the amount of work that this involves to mark and internally moderate. The unit specific comments are offered for the sake of centres that have had their marks adjusted for some reason.

Moderators have noticed an increasing use of notation in the marking that can result in a problem. Teachers might note that the candidate has failed to address a particular criterion properly but does not feel that the work is so bad as to merit the loss of half a mark. They will then write 1^{-} on the cover sheet. The use of such a notation is perfectly acceptable if it helps assessors come to a decision as to whether the final mark of half should be rounded up or down. In many instances, however, assessors have looked at the marks and decided that because they see two or more of these symbols that they will give a final mark less than the sum of criteria marks. This means that, for external moderators who can only add the marks they see, there is a transcription error as the final mark does not agree with the criteria marks. Assessors are asked to ensure that they adjust the criteria marks in such a way that the final mark on the cover sheet agrees with the submitted mark on the MS1 and is the sum of criteria marks.

Additionally, some assessors only give domain marks. This might be fine if the candidate deserves full marks (or zero!) for a domain, but it makes it very difficult for external moderators to understand the marking if a mark has been withheld – in this case we do not know which of the criteria have in the opinion of the assessor not been met adequately.

Teachers should note that all the comments offered have been made before. These reports should provide a valuable aid to the marking process and we would urge all Heads of Departments to ensure that these reports are read by all those involved in the assessment of coursework.

C3 – 4753/02

The marking scheme for this component is very prescriptive. However, there are a significant number of centres where so many of the points outlined below are not being penalised appropriately that the mark submitted is too generous.

The following points should typically be penalised by half a mark – failure to penalise four or more results in a mark outside tolerance.

<u>Change of Sign</u>

- Lack of a proper graphical illustration – graphs of the function being used do not constitute an illustration of the method.
- Use of trivial equations to demonstrate failure.
- Tables of values which actually find the root.
- Graphs which candidate claims crosses the axis or just touch but don't.
- No statement of the root - answer given as an interval.

<u>Newton Raphson</u>

- Equations with only one root; assessors are then giving the 2nd mark in the domain.
- No iterates given, simply a statement of the root.
- No work done by the candidate – just a print out from "Autograph".
- Poor illustrations (for example, an "Autograph" generated tangent with no annotation or just a single tangent.)
- Graphs not matching iterates.
- Error bounds not established by a change of sign.
- Failures lacking iterates.
- Starting values too far away from the root or too artificial.

<u>Rearrangement</u>

- Incorrect rearrangements not spotted and sometimes marked as correct.
- Graphs not matching iterates.
- Graphs not explained.
- Weak discussions of g′(x). Candidates should not just quote the criterion without linking it to their function.

<u>Comparison</u>

- Different starting values.
- Sometimes different roots are found.
- Different degrees of accuracy.
- Not quoting number of steps to reach given accuracy.
- Thin discussions.

<u>Notation</u>

- Equations, functions, expressions still cause confusion to candidates and teachers! Candidates who assert that they are going solve $y = x^3 + x + 7$ or that they are going to solve $x^3 + x + 7$ should be penalised.

<u>Oral</u>

The specification asks for a written report.

More than one centre used the out of date cover sheet which is in the original specification booklet. Some used both and we detected more than one assessor using both. This tended to make marking more erratic.

Differential Equations - 4758/02

As is the usual pattern of entry, only a small number of centres submitted work this session. Therefore any generalisations may be a little misleading.

The essential function of the coursework element of this module is to test the candidate's ability to follow the modelling cycle. That is, setting up a model, testing it and then modifying the assumptions to improve the original model. If two or three models are suggested at the outset and tested, more or less simultaneously, and the best chosen, then the modelling cycle has not been followed.

Similarly, choosing 'too good' a model in the first place, e.g. flow $\alpha \sqrt{h}$ initially for 'Cascades', does not leave much room for improvement of the model. Consequently the marks in Domains 5 and 6 are compromised.

For 'Aeroplane Landing', (still the most popular task) marks often seem to be automatically allocated for Domain 3 (Collection of data) when there is little discussion of the source or potential accuracy of the data.

Numerical Methods – 4776/02

There were several cases where incorrect work had been ticked. Assessors are requested not to tick work unless it has been checked thoroughly. One assessor penalised his candidate for not using the ratio $^1/_{16}$ for extrapolation to a "best solution" using Simpson's Rule, while scrutiny of the work would have revealed that the function being used was not well-behaved and that the ratio of differences was on this occasion not converging to the expected value.

The most popular task is to find the value of an integral numerically. The following comments are offered – it is to be hoped that those teaching and assessing will take note so that the problems do not continue to occur with such regularity!

<u>Domain 1.</u>
Not all candidates fulfil the basic requirement of a formal statement of the problem.

<u>Domain 2</u>
Most candidates describe what method they are to use but fail to say why – this is part of the criteria for this domain.

<u>Domain 3</u>
Finding numerical values for the mid-point rule up to M_{16} is not deemed to be substantial.

<u>Domain 4</u>
It is not enough to state what software is being used. A clear description of how the algorithm has been implemented is required, usually by presenting an annotated spreadsheet printout.

<u>Domain 5</u>
It is not appropriate to compare values obtained with "the real value". This might be π.
Additionally, it is accepted that candidates will use a function that they are unable to integrate (because of where they are in the course) but which is integrable. However, it is not then appropriate to state a value found by direct integration.
Many candidates, as a result of their insubstantial application, will state the value to which the ratio of differences is converging without justification from their values. This can of course lead to inaccuracy, and the failure to provide an "improved solution". Indeed, some candidates use the "theoretical" value regardless of the values they are getting (or not if they do not work the ratio of

differences) far too early giving inaccurate solutions. These are often credited, leading to some very generous marking.

Domain 6

Some candidates were given full marks for quoting a value to 3 significant figures! Most of the marks in this domain are dependent on satisfactory work in the error analysis domain and so often a rather generous assessment of that domain led also to a rather generous assessment here as well. Teachers should note that comments justifying the accuracy of the solution are appropriate here, but comments on the limitations of Excel are not usually creditworthy.

Grade Thresholds

Advanced GCE (Subject) (Aggregation Code(s))
January 2008 Examination Series

Unit Threshold Marks

Unit		Maximum Mark	A	B	C	D	E	U
All units	UMS	100	80	70	60	50	40	0
4751	Raw	72	54	46	38	31	24	0
4752	Raw	72	55	48	41	34	28	0
4753	Raw	72	57	50	43	36	28	0
4753/02	Raw	18	15	13	11	9	8	0
4754	Raw	90	77	68	59	50	41	0
4755	Raw	72	55	47	39	32	25	0
4756	Raw	72	59	51	44	37	30	0
4758	Raw	72	62	54	46	38	30	0
4758/02	Raw	18	15	13	11	9	8	0
4761	Raw	72	60	52	44	37	30	0
4762	Raw	72	61	53	45	37	30	0
4763	Raw	72	58	51	44	37	30	0
4766/ G241	Raw	72	56	49	42	35	28	0
4767	Raw	72	62	54	46	38	31	0
4768	Raw	72	54	47	40	33	27	0
4771	Raw	72	60	53	46	39	33	0
4776	Raw	72	58	50	42	35	27	0
4776/02	Raw	18	14	12	10	8	7	0

Specification Aggregation Results

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

	Maximum Mark	A	B	C	D	E	U
7895-7898	600	480	420	360	300	240	0
3895-3898	300	240	210	180	150	120	0

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

	A	B	C	D	E	U	Total Number of Candidates
7895	25.5	50.0	75.5	85.9	95.3	100	106
7896	42.9	85.7	85.7	85.7	85.7	100	7
7897							0
7898							0
3895	22.7	40.7	59.3	77.8	94.8	100	383
3896	80	80	95	95	100	100	20
3897	0	100	100	100	100	100	1
3898	56.4	76.9	87.2	97.4	97.4	100	39

556 candidates aggregated this series

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

Statistics are correct at the time of publication.

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