GCE

Mathematics (MEI)

Advanced GCE **A2 7895-8**

Advanced Subsidiary GCE **AS 3895-8**

OCR Report to Centres

June 2012

Oxford Cambridge and RSA Examinations

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of candidates of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, OCR Nationals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

It is also responsible for developing new specifications to meet national requirements and the needs of students and teachers. OCR is a not-for-profit organisation; any surplus made is invested back into the establishment to help towards the development of qualifications and support, which keep pace with the changing needs of today's society.

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

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

OCR will not enter into any discussion or correspondence in connection with this report.

CONTENTS

Advanced GCE Mathematics (MEI) (7895)
Advanced GCE Further Mathematics (MEI) (7896)
Advanced GCE Further Mathematics (Additional Award) (MEI) (7897)
Advanced GCE Pure Mathematics (MEI) (7898)

Advanced Subsidiary GCE Mathematics (MEI) (3895)
Advanced Subsidiary GCE Further Mathematics (MEI) (3896)
Advanced Subsidiary GCE Further Mathematics (Additional Award) (MEI) (3897)
Advanced Subsidiary GCE Pure Mathematics (MEI) (3898)

OCR REPORT TO CENTRES

4751 Introduction to Advanced Mathematics (C1)

General Comments

This proved to be an accessible paper with almost all candidates able to tackle almost all questions including all the Section B longer questions. There were few signs of candidates failing to complete the paper, and question 12 was done very well by a good proportion of candidates. Questions 7, 9, and 11(iv) were found most challenging. Question 10(iii) allowed a good proportion of candidates to demonstrate clear thinking.

Many candidates showed a good grasp of coordinate geometry and basic algebra, although occasional omission of brackets remains an issue. Some candidates were let down by errors in simple arithmetic such as evaluating powers and working with negative numbers.

Comments on Individual Questions

Section A

1) Finding the equation of the line was mostly done well, although some candidates did not attempt to find the intersections with the axes.

2) In changing the subject of the formula, realising that ± was needed for a full solution was rarely appreciated. Some failed to cope with the fractions and gave answers with 'triple-decker' fractions or a mixture of fractions and decimals.

3) Many candidates did part (i) well. Those who chose to square before taking the cube root in part (ii) had problems but most were successful. There were a few very weak responses that showed no understanding at all of negative or fractional indices.

4) A significant minority, having obtained the correct answer, tried to 'simplify' further by 'cancelling' x's.

5) In part (i), those who tried to rationalise the denominator were usually unsuccessful. There were quite a few '$\sqrt{24} = 4\sqrt{6}$ ', and even the numerator ending up with '360' or '$360\sqrt{6}$ '. A common error was ending up with $\frac{60\sqrt{6}}{2\sqrt{6}} = 30\sqrt{6}$. Some failed to simplify expressions such as $5(\sqrt{6})^2$. Relatively few used indices.

   Many did the second part very well. Those that did not either could not cope with multiplying out brackets containing roots, or did not recognise the need or know how to find a common denominator.

6) Some did not know how to interpret the notation in part (i). Many candidates did not recognise its relevance to part (ii) and started again to find the coefficient of x^3 in the binomial expansion. Many forgot to cube the –2, whilst some used 2 instead of –2. A small minority did not know how to assemble the various factors which produce the coefficient.

7) Some candidates did not know how to approach this question. Of those who did, using $2k^2$ instead of $4k^2$ in the discriminant was a common error. Of those who successfully reached $k^2 < 20$, many then simply gave $k < \sqrt{5}$ and did not appreciate the need to look for a 'double' inequality in solving a quadratic inequality.

8) As expected, quite a number of candidates found interpreting the remainder difficult, with some using f(3) instead of f(–3). Those who attempted the long division method rarely got beyond the method mark, although some fully correct solutions using this method were seen. Errors in eliminating a variable from their two equations in *b* and *c* were also common.

9) The mark for obtaining $6n + 9$ was usually earned. Some did not give enough detail to show that the result was always odd. The final part was generally not well done, with some candidates confusing factors and multiples. Some candidates ignored the 'Hence' in the question. There was more success with the use of $6n + 9$ than there was with $3(2n + 3)$.

Section B

10) (i) Most candidates showed good, clear working, but some used poor notation, mixing up expressions for AB^2 and AB. Not many used diagrams, but where these were used they were generally good and led to full marks. Some students calculated gradients instead of lengths.

(ii) Showing that the lines are perpendicular was usually done well, but some struggled with arithmetic involving negative numbers. Only a few had their gradients upside down. Most knew the condition for perpendicular lines, and expressed it clearly, although some just calculated gradients and then stated 'so they are perpendicular'.

(iii) This question required some problem-solving skills from candidates, and most candidates made a good attempt. The most common approach, usually successful, was to find the equation of BD, check that the midpoint of AC lies on this line, then find the midpoint of BD and show that this does not lie on AC. Most did not realise that having shown that the midpoint of AC lies on B, showing that the midpoint of BD is not the same as the midpoint of AC is sufficient to show that AC does not bisect BD. Errors in midpoints or equations of lines were fairly common. Some candidates worked with lengths but these approaches were often muddled. Few attempted to use symmetry arguments, and those that did usually did not provide enough explanation.

11) (i) Most candidates obtained the first mark for obtaining the factors from the roots. Many candidates wrote $(x + ½)$ in place of $(2x + 1)$ as one of their factors, and those that did sometimes omitted to find the equation of the curve in the required form and so did not obtain the last mark. A few candidates, instead of writing down the factors as instructed and then multiplying out the factors, attempted to set up simultaneous equations using the factor theorem. One or two marks were obtained this way but it was very rare to see the method taken to a correct conclusion.

(ii) Most knew the correct shape for the graph of a cubic but some were drawn poorly. A common fault, leading to a very distorted graph, was to assume incorrectly that there was a minimum at the intersection with the *y*-axis. A surprising number, having obtained the correct equation in part (i), thought that the *y*-intersection was –5, possibly because they were starting again by thinking about the *x*-intersections. Some confused factors with roots thus reversing the signs.

(iii) Most knew that they needed to subtract 8 from their *y*-intercept, although a few added 8.

(iv) The best approach using the factors was usually only seen from the better candidates. Many correctly found the new roots but wrote down g(x) using (x – 2.5) rather than (2x – 5). Some started by substituting $x - 3$ into the expanded form of f(x) and then attempted to multiply out and simplify – most of these did not even attempt to give g(x) in factorised form as requested. Many picked up a final mark by substituting x = 0 into their g(x). Some candidates incorrectly translated to the left by using (x + 3) and could obtain 1 or 2 marks.

12) (i) A few candidates did not know where to start and a significant number confused the ideas of sketching and plotting. As a consequence the full range of integer values from $x = -1$ to x = 5 was not used. Some thought that three or four points plotted would suffice. Other candidates found where the curve would cross the x-axis and/or determined the minimum point by completing the square, and then relied on a sketch for the rest of the curve. A significant minority did not attempt to find intersections at all. Of the rest, some gave only 2 intersections, and some could not cope with the scale on the y-axis, or omitted the negative sign for the y-coordinates of the first 2 roots.

(ii) Deriving the given equation was usually done well, with most candidates starting off with the correct step of equating $\frac{1}{x-3}$ to $x^2 - 4x - 1$. Very few algebraic errors were seen here. Some candidates just substituted x = 4 into the given answer. Other poor attempts started with the final expression, often equating it to $\frac{1}{x-3}$, so made no progress.

(iii) This part was well attempted. Long division seemed less successful than inspection; however most candidates found the correct quadratic factor. Most knew the quadratic formula and applied it correctly. Some fully correct responses were spoilt by wrong attempts to further simplify their roots. Some solved by completing the square but were usually less successful in reaching the correct roots

4752 Concepts for Advanced Mathematics (C2)

General Comments

The paper was accessible to the majority of candidates and there was a full range of responses. Many candidates set out their work clearly, logically and succinctly. Most worked with calculator figures and rounded their answers at the end of the question. However, some candidates lost easy marks by working with prematurely rounded answers and a surprising number lost accuracy marks by ignoring specific requests such as "give your answers correct to one decimal place". Some lost marks by keeping their calculator in radian mode when degrees were specified or vice versa. A small minority of candidates presented little or no working – just an answer - in responding to some questions. In some cases, particularly where calculus was specifically requested, a penalty was incurred. When faced with a request to "show that", a significant proportion of candidates still opt for a verification approach, which does not score.

Comments on Individual Questions

1) There were many fully correct responses to this question. However, not all were able to resolve both terms into index form correctly. The second term was sometimes written as x^{-3} or occasionally 3^{-x}, 3^{-1} or just plain $3x$ were seen. The first term was sometimes "differentiated" as $x^{3/2}$, and x^{-3} was occasionally "differentiated" to $-3x^{-2}$ and $-3x^{-1}$ to $-3x^{0}$.

2) The majority of candidates obtained full marks. A small minority of candidates interpreted $u_n + 3$ as $n + 3$, thus obtaining 5 and 6 as the second and third terms. Similarly, a few candidates omitted to state the second and third terms. A few made mistakes with the formula for the sum to n terms, such as $\frac{50}{2}(10+24\times3)$, $\frac{50}{2}(10\times49\times3)$ or $\frac{50}{2}(10+49)\times3$ and a small number of candidates used the formula for the sum of the terms of a geometric progression. Some simply found the fiftieth term.

3) (i) This was very well done, with most candidates scoring full marks. A small number lost the last mark because they worked in radians or through premature rounding. Others lost the second mark by evaluating $(6.4^2 + 9.8^2 - 2\times6.4\times9.8)\cos53.4°$, and a small number failed to score because they assumed the triangle to be right angled and used Pythagoras or calculated 9.8sin53.4°. Occasionally candidates used the sine ratio instead of cosine in the correct formula; similarly a few candidates attempted to use the Sine Rule.

(ii) There were many correct answers to this question, but a significant minority used the correct formula with CD instead of BC, thus failing to score. Similarly, some candidates found the area of ABD instead of ABC. As with part (i), some candidates worked in radians, although some worked in degrees in part (i) and radians in part (ii) and vice versa. Similarly, a significant minority assumed a right angle and calculated ½× base × height. Of those who found the area of ABD and subtracted the area of ACD, only a tiny fraction successfully obtained the correct answer. Some candidates lost the second mark through poor rounding.

4) (i) By and large this was done well. The most common errors were (18, 9), (18, 3), (6, 6), $(6, \frac{3}{4})$ and (6, 1). Occasionally candidates hedged their bets and gave the answer (6, 3), which didn't score at all.

(ii) This was generally well done. The most common error was (24, 3), but occasionally (24, 12) and (6, 12) were seen.

5) There were many completely correct answers to this question. The majority were comfortable working in radians, but some of those who converted to degrees did so successfully and managed to convert back without losing accuracy. A few candidates simply stopped when they had found the radius, and some thought they had found the perimeter when all they had done was find the arc length. A few candidates used the wrong formula initially: $\frac{1}{2}r\theta$, $\frac{1}{2}r\theta^2$, $r^2\theta$ and $\pi r^2\theta$ were all seen. Often they were able to go on and earn the final method mark. A small number of candidates thought the angle was 1.6π, and a few converted to degrees and worked with $\frac{1}{2}\times r^2\times 91.7$.

6) Only the best candidates managed full marks here. The most common approach was to find the gradient (nearly everyone managed this) and then work towards $\log y = 3\log x + 2$. Many went wrong, usually through substituting in log5 and log1 instead of 5 and 1. A significant minority gave the answer as $y = 3x + 2$, and of those who did obtain the correct equation in logarithmic form, most stopped. Some did manage to obtain $y = 10^{3\log x + 2}$, but then stopped or went astray. A small number of candidates realised that a straight line relationship between $\log y$ and $\log x$ implies a relationship of the form $y = kx^n$, with n = gradient and k = $\log y$ intercept. Many of these candidates successfully found the correct equation by substitution.

7) This was very well done, with many candidates obtaining full marks. A few candidates substituted $x = 4$ to obtain gradient = 7, and thus arrived at $y = 7x – 8$, and others went straight to $y = (6x^{\frac{1}{2}} – 5)x + c$. A few made mistakes in resolving the fraction, or with substitution of (20, 4). A small number omitted "+ c" and then floundered.

8) Many candidates divided by 2 before using the inverse sine function, and thus failed to score. A few made an initial step of $\theta = 0.7 \div \sin 2$, and others multiplied by 2 having correctly found arcsin0.7. Many worked in degrees and then lost marks either by failing to convert back to radians, or through premature rounding. Only a few were able to obtain all four angles in the correct form to the specified accuracy. Having found 0.388 correctly, many gave the next answer as 1.18 (or surprisingly often) 2.75 and stopped. A few candidates found one or more correct values and then multiplied them all by π.

9) (i) Given that the formula for the Trapezium Rule is in the data booklet, this question attracted a high proportion of poor responses. Many candidates were unable to reproduce the correct basic shape of the formula, with omission of the outer brackets being the most common error in this regard. The instruction to use six strips was often disregarded; many candidates seemed put off by the fact that both end ordinates were zero. Some candidates substituted the x-values, and $h = 1.2$ was fairly common. A number of candidates substituted all the correct values in the formula, but with one exception: one of the zeros was replaced with 1.2. A few candidates calculated the area of each individual trapezium: about half did so successfully. Most knew that the volume was found by multiplying the area of the cross-section, but often multiplied by (50÷1.2) and missed an easy mark (or two).

(ii)A Most candidates scored at least one mark, but many lost the accuracy mark through premature rounding. A few substituted an incorrect value (such as 0.45, 0.9 or 0.6), and a small number of candidates differentiated or integrated before substitution, and didn't score.

(ii)B Most integrated correctly: the most common error was to give the last term as either 4.2, or $\frac{4.2^2}{2}$. A common mistake was to then evaluate F[50] – F[0]; less common was F[0.2] – F[0]. A significant minority of those who knew the correct limits evaluated F[0] – F[0.9]. Most knew to multiply their result by 50, but a surprising number gave a negative answer or multiplied by (50÷0.9). A number of candidates lost the accuracy mark at the end due to writing the coefficient of x^3 as 2.56 or 2.57.

10) (i) Most successfully differentiated and set the derivative equal to zero. A surprising number then resorted to the quadratic formula and made mistakes or were unable to solve the equation directly. Many missed the negative root, and many neglected to find the *y*-values. Only a minority found both sets of co-ordinates successfully and gave the answers to the specified accuracy. A small number of candidates simply wrote down the correct co-ordinates, more often than not with the explanation that a graphical calculator had been used. It was made clear in the question that calculus was required, so this approach did not score.

(ii) Most candidates realised that the curve passes through the origin, and tried to factorise in order to find the other intercepts. As with part (i), the negative root was often missed, which resulted in candidates trying to fit a cubic of correct orientation to two *x*-intercepts instead of three. Although there were many correct answers, all too often marks were lost due to sloppiness such as failing to mark the intercepts or drawing the graph carelessly so that it didn't pass through the origin. Occasionally a cubic with the correct intercepts but of the wrong orientation was seen, as were parabolas and curves which were clearly not functions.

(iii) Most candidates correctly obtained the given result, although a few made sign errors or slipped up with the substitution in the derivative. Occasionally there were sign errors or exponent errors in the final statement, so an easy mark was lost. The last two marks proved more problematic. A surprising number of candidates made the initial step $x(x^2 – 3) = – 2$ so $x = – 2$ or $x^2 = 3$, which didn't score, or attempted to apply the quadratic formula, which also didn't work. Many opted for long division, but often went astray. Surprisingly few candidates tested the factors of 2 in the Factor theorem.

11 (i) Some candidates ignored the request for two equations in *a* and *r*, and either just wrote down one equation (usually $25 = \frac{a}{1-r}$) and then substituted 10 and 0.6, or went straight to two equations with $a = 10$ already substituted. A trial and improvement approach thereafter sometimes yielded the other correct pair of values. Some candidates gave the denominator as $r – 1$, and occasionally gave the second term as ar^5. Of those who did make the correct initial steps, a minority were unable to eliminate one of the variables successfully and then resorted to trial and improvement. The majority, however, successfully eliminated to obtain an equation (more often than not) in *r*, which was successfully solved. This usually led to full marks, although occasionally candidates lost one mark for failing to show that $a = 10$ – either the value was simply stated or the value was obtained from an initial verification.

(ii) Many candidates made no attempt to answer this question. Of those that did, many opted for a verification approach, which did not score. Some candidates were able to write down the correct n^{th} terms but most made no further progress. However, a variety of elegant approaches was seen from the best candidates.

4753 Methods for Advanced Mathematics (C3 Written Examination)

General Comments

This proved to be an accessible paper, and raw marks were consequently higher than in recent examinations, with quite a few candidates managing to score full marks. Few candidates had difficulty completing the paper in the allotted time. Many scripts were well presented, though the longer part questions, such as 8(iii), sometimes suffered from a lack of systematic presentation. There was evidence in some scripts of attempts to 'fiddle' expressions to achieve given results – the resulting inconsistency often lost marks.

Comments on Individual Questions

1) This was a straightforward starter question, for which many candidates scored full marks. The most popular strategy was to use the substitution $u = 3x - 2$, and candidates were generally adept at replacing dx with 1/3 du, integrating correctly and substituting correct limits. In a few cases ln $u^{½}$ was obtained after integration. The substitution $u = (3x - 2)^{½}$ was less common and caused greater difficulty. Relatively few students attempted to integrate directly without substitution, but those that did often succeeded, and gained the 5 marks with ease.

2) Most candidates scored at least two of the marks. A very common error was failing to change the inequality sign when proceeding from $-2x > 5$ to $x < -5/2$. A few sketched the graph of $y = |2x + 1|$ to solve the problem. Other errors seen occasionally were $|2x + 1| > -4$ and $|2x| > 3$. Even some good candidates do not seem to appreciate that nesting the two inequalities as $-5/2 > x > 3/2$ is incorrect.

3) This implicit differentiation was generally well done. The most common error was $d/dx(e^{-x}) = e^{x}$ instead of e^{-x}. Some candidates re-arranged the original equation correctly to give $y = ½ \ln(5 - e^{-x})$, though log errors were quite common here; however, many went on from here by differentiating this incorrectly.

4) (i) This was usually correct, though leaving the final answer as $x = 1/3$ was quite common, and some candidates left their answer as $\sqrt{(1/9)}$, or gave $a = \pm 1/3$.

(ii) The domain was frequently given instead of the range. Other answers scoring zero included $0 \le x \le 1$, $y \le 1$, 0 to 1 (which does not settle the inclusion of the endpoints), and 1.

(iii) Many gained only the method marks because they omitted to indicate the domain or range on their sketch. Others did not indicate the x-coordinates of the endpoints. Some stretches looked more like enlargements. To get the final 'A' mark, we required the axes to have approximately the same scale.

5) (i) The initial value of $P = 5$ was answered correctly by nearly all candidates, but the long-term value defeated some.

(ii) This part was equally well answered. The most common errors were to re-arrange the initial equation incorrectly or to take logarithms of each side incorrectly, e.g. $\ln 5.5 = \ln 7 - \ln 2 \times k$.

6) (i) This was generally answered successfully, with only a few failing to give the exact value $\pi/3$.

(ii) (ii) Most candidates successfully found the inverse function, but ½ sin *x* was occasionally seen. Once that hurdle was crossed, most differentiated sin ½ *x* correctly, though cos(½*x*) and 2 cos(½*x*) were seen. The substitution of $x = \pi/3$ was usually correct, though a small number used $x = 1$. The gradient at P was usually the reciprocal of that at Q, with $-1/m$ (instead of $1/m$) being the most common error. A few candidates differentiated f(*x*) directly, often with success.

7) As often happens when candidates are attempting to prove this type of result, many work with both sides at once, producing repetitive and confused solutions which did not always receive the benefit of the examiner's doubt. Most seemed to know about odd and even functions, but often failed to express this correctly, for example writing statements such as f(*x*) = −f(*x*).

(i) (i) This two-line proof defeated most candidates, mainly because they failed to start off with s(-x) = f(-x) + g(-x) = … Starting with f(*x*) = −f(−x) also made life harder than necessary. A few candidates used the functions f and g from the previous question rather than treating these as general functions.

(ii) (ii) Quite a few candidates recognised that p(x) was even, but we wanted to see a proper argument to justify this, and, as in part (i), this really required them to start p(-x) = f(-x)g(-x).

8) (i) The vast majority differentiated correctly - though 2xcos2x was seen occasionally - and equated their derivative to zero. Most then succeeded in dividing by cos 2*x* to arrive at the required result. Some candidates, however, divided before equating the derivative to zero, and gave the derivative as 2*x* + tan 2*x*.

(ii) Most candidates solved x sin 2x = 0 to obtain x = π/2 at P. The derivative was then required to obtain the gradient of the tangent and hence its equation, but some used the given tangent equation itself to find the gradient. The last part was successfully completed by nearly all candidates, with the given tangent equation being used to obtain the correct y-coordinate at Q of $\pi^2/2$.

(iii) Most candidates attempted find the area of the triangle and the area under the curve, though a clear statement of method was not always given. Quite a few candidates attempted to find the triangle area by integration, and came unstuck in the process. The area under the curve was generally recognised as integration by parts, but marks were lost through incorrect v', or mistakes with signs. Some tried to combine both integrals (for line and curve), and got into a muddle by stock-piling negative signs, rather than simplifying these on a step-by-step basis. Nevertheless, good candidates had little trouble in supplying a fluent solution.

9) (i) The majority of candidates obtained full marks; part (A) was not as well answered as (B): sometimes marks were lost through stretching horizontally rather than vertically.

(ii) This was all relatively routine work which good candidates had little trouble with; however, several candidates made slips in expanding the bracket in the numerator of the quotient rule. This was a costly error, as were errors in the quotient rule such as uv'−vu' in the numerator.

(iii) Most candidates were successful, guided by the given answer, though a few found f(*x*) + 1.

(iv) Most integrated the function correctly, though ¼ ln(*x*) was seen occasionally. The question asked candidates to give the answer in terms of *a* and *b*, but some omitted this. The final answer required candidates to realise that *a* = 1 and *b* = 2, rather than 0 and 1 (notwithstanding the appearance of ln 0 in the lower limit), but this was spotted by only the better candidates.

4754 Applications of Advanced Mathematics (C4)

General Comments

This paper proved to be of a similar standard to that of previous years. The questions were accessible to candidates of all abilities, the students seemed well prepared and there were very few low marks.

This Paper B was more accessible than most and most candidates scored well here, although many failed to draw a tangent in question 2.

In Paper A most candidates scored highly on the straightforward, well practised questions. Marks were more frequently lost where candidates had to think for themselves in less familiar questions.

It was pleasing to see that, unlike on previous papers, almost all candidates included a constant of integration-particularly in question 6.

Algebraic errors still caused an unnecessary loss of marks. In question 1, $-3(x+1) = -3x-1$ or $-3x+3$ or $-3x+1$ were all familiar errors. In question 4 some candidates felt that if $\sin^2\theta + \cos^2\theta = 1$ then $1/\sin^2\theta + 1/\cos^2\theta = 1/1 = 1$ and others felt that in question 5, if $\sin x + \cos x = 2\sqrt{2}\cos x$ then $\sin^2 x + \cos^2 x = 8\cos^2 x$.

The less structured form of question 6 caused some candidates to lose many marks as they did not realise that they needed to use partial fractions.

Candidates should be advised to read questions carefully and to show all working when establishing given answers or when asked to 'show' results.

Centres are reminded that Papers A and B are no longer marked together and so additional sheets must be attached to the correct paper.

Comments on Individual Questions

Paper A

1) The majority of candidates understood the method needed to add the fractions and solve the quadratic equation. Most errors were algebraic, the most common being the incorrect expansion of $-3(x+1)$. Those who continued were able to gain marks for solving their quadratic equation provided that 'b^2-4ac' ≥ 0. Those with a negative discriminant should have realised they had made an error and checked their work.

2) This was probably the most successful question on paper A and few errors were seen. A few omitted the set of values for which the expansion was valid.

3) (i) Most candidates scored the first mark for writing down the differential equation. Those who differentiated often scored full marks. Common errors included, incorrectly differentiating the inside of the bracket- instead of $1/2k$, a variety of errors were seen, including functions of t, and, for those who did differentiate correctly, failing to equate this to $k\sqrt{V}$ at the final stage.

Quite a number omitted this differentiation. Some others decided to ignore the instruction given and integrate instead in order to derive the given result instead of verifying it. Very few of these attempts gained any further credit as they failed to deal with the change in constant. Those who integrated to reach $2\sqrt{V}=kt+c$ then, too often, gave $\sqrt{V}=$ [$1/2(kt+c)$ =] $1/2kt+c$ when trying to establish the given result and obtained no marks unless they explained the change of constant.

(ii) The majority scored two marks for writing down two correct equations. Those who then square rooted say, $(1/2k+c)^2 = 10{,}000$ to reach $1/2k+c = 100$, and the other equation to obtain $k+c=200$ usually obtained full marks. Those who did not square root the equations were sometimes successful but more often made errors or abandoned their attempts.
Some felt that $(1/2k+c)^2 = 1/4k^2+c^2$

4) The most common and most successful method seen was from those that changed $\sec^2\theta+\mathrm{cosec}^2\theta$ to $1/\cos^2\theta + 1/\sin^2\theta$ and added these fractions together and then used $\sin^2\theta + \cos^2\theta=1$.
There were other successful methods including changing both sides to $\tan^2\theta+\cot^2\theta+2$ or starting with
$\sec^2\theta\mathrm{cosec}^2\theta=\sec^2\theta(1+\cot^2\theta)=\sec^2\theta+ \sec^2\theta\cot^2\theta=\sec^2\theta+1/\cos^2\theta \times \cos^2\theta/\sin^2\theta$
$=\sec^2\theta+1/\sin^2\theta=\sec^2\theta+\mathrm{cosec}^2\theta$
Some candidates seemed to write down every relevant trig identity they could think of and make multiple starts of attempts without any clear structure to their methods. Some attempts included taking reciprocals term by term. In general, candidates need to be encouraged to produce more structured responses when proving identities.

5) Most candidates correctly expanded the double angle formula, substituted the values for sin 45° and cos 45° and gained the first three marks.
Many candidates then proceeded correctly to obtain full marks. Others squared term by term and lost the last three marks.
There were few instances of additional solutions in the range being given although not all gave their final solutions to the required degree of accuracy.

6) Almost all separated the variables correctly with the intention of integrating.
Partial fractions is always a well answered part of this paper, but on this occasion candidates had to realise for themselves that they needed to use partial fractions.
Those that did usually gained at least the first 5 marks. The others used a wide variety of incorrect methods in order to try to integrate $1/x(x+1)$. These included,
$1/(2x+1)\ \ln(x^2+x)$ and $\ln x \times \ln(x+1)$.
For those who proceeded correctly, $\ln y=\ln x - \ln(x+1) + c$ was almost always obtained.
Those who substituted first were usually successful in gaining the mark for finding the constant.
For some, the laws of logarithms were not applied correctly. Such errors as $y=x/(x+1) + c$ being common.

7 (i) The majority of candidates failed to read the question carefully and, although they obtained the correct coordinates, lost a mark by failing to name the points, particularly P.

(ii) Nearly all candidates understood the principle of finding $dy/d\theta$ and $dx/d\theta$ in order to find dy/dx. There were errors including wrong signs and ½ instead of 2 but there were many fully correct expressions. A pleasing number continued correctly throughout the question, substituting both $\pi/2$ and $-\pi/2$ into dy/dx and explaining that since the gradients multiplied to give -1 they must be perpendicular lines.
Some had either the correct expression for dy/dx but cancelled it incorrectly or made errors in dy/dx and so forfeited the last two marks. Others failed to show their substitution of $-\pi/2$, and merely stated that the other gradient must be -1 since $1 \times -1=-1$.

(iii) Many successfully solved $\sin 2\theta=1$ or $\cos 2\theta=0$ (full marks were available even if the coefficient in (ii) had been incorrect), and proceeded to obtain full marks. Others thought that $\cos 2\theta/\sin\theta=0$ implied that $\cos 2\theta=\sin\theta$ and tried to solve that. Others obtained more than one solution for θ and chose the wrong one.
Almost all gave their answers in exact form as required.

(iv) Those who used $y=\sin 2\theta = 2\sin\theta\cos\theta$ usually squared and gained at least two marks although some failed to square the 2.Those who answered the question and expressed $\sin^2\theta$ in terms of x usually obtained full marks. Some candidates did not explicitly state the identities or seemed to be working backwards from the answer.

(v) Many candidates obtained full marks for this integration. Those who did not either did not use the correct limits (despite having usually found them correctly in (i)) or made various errors when attempting integration by parts instead of multiplying out the brackets. A few lost the π.

8) (i) Most candidates found AA' but did not always show the subtraction and they were asked to 'Show'. They also often failed to make reference to the normal. Some, unnecessarily, calculated scalar products at this stage. Many correctly found the point M and showed that it lay in the plane.

(ii) There were many completely correct solutions in this part. Other candidates made errors in the algebra when finding the coordinates of B and their point was then followed through for the following marks.
The main error in this part was that candidates felt that B= (1,2,4) +(1,-1,2) =(2,1,6). Others found B apparently correctly as (0,3,2) but having used just the x coordinate as $1+\lambda=0$ hence $\lambda= -1$ and thus found B fortuitously.
The follow through marks helped many candidates here.

(iii) Most candidates knew the correct method here but did not always have the correct vectors and so obtained the method marks.

(iv) Many candidates made no response to this part. Full marks was only obtained in a minority of cases. The most common error from those who attempted this being an attempt at solving $x+z=0$ rather than $y=0$.

Paper B

1) This was often correct. In some cases 4 000 000 being given as 4000 thousand. The most common error was to give the answer as 4000 (or 3950). Some only gave the number of males or females.

2) (i) The majority did not draw a tangent. Those who did usually scored full marks although a few gave too many significant figures in their answer.

(ii) This was marked as a follow through whatever their answer in part (i) and most scored marks here. Some, again, over-specified their answer, others failed to multiply by 100 and some were confused by how many 0s there were in a billion.

3) (i) Most candidates integrated correctly and obtained $\ln p=kt+c$. Few then explicitly used the initial condition to find their constant and merely stated the given answer.

ii) Most successfully used ln2/123 to find k.

4) This was less successful than expected. There were many completely correct solutions but also a wide range of incorrect values were seen in the table.

5) Both parts of this question were usually correct.

6) Questions requiring explanations in the comprehension paper usually cause the most problems for candidates. This was less so on this occasion. Most candidates scored the first mark for saying that as the birth rate declined over time the life expectancy increased.
A few only gave the values at the end points, or did not link it to change over time.
Fewer candidates linked this change with the developing economy in the UK in order to obtain the second mark.

4755 Further Concepts for Advanced Mathematics (FP1)

General Comments

This paper was well answered by the majority of candidates. Nearly all candidates were able to attempt all the questions in the time. There were many extremely good scripts, with well-expressed work. Some candidates would benefit from taking more care with the quality of their written communication. It is unfortunately a common practice to misuse the implication sign '$\Rightarrow$', which frequently is seen to replace ' =' or words, to the detriment of sense. Graph paper is not needed and can be extremely difficult to read on screen. There appeared to be rather more candidates writing answers in the wrong places in the answer booklets than on previous occasions.

Comments on Individual Questions

1) This straightforward question produced a varied response.
In (i), one mark was frequently lost through incomplete description of the rotation. Not many candidates felt the need to show any working or diagrams; not essential, but might have helped some.

In (ii), the product was mostly found correctly, the common error being to multiply in the wrong sequence, which usually led to the wrong transformation in (iii). A visual check on the sequence of transformations could either reinforce or, in some cases, provide a correction following a wrong result. A point of language: reflections are usually *in* a line not *along* it.

2) (i) This was well done by many, but the following comments apply.
The arithmetic was not always correct. Several candidates made the mistake of using $3\sqrt{3}j$ in calculating the modulus of z_1. An argument expressed in degrees was not acceptable.

(ii) Those that sketched the position of z_2 were usually correct. A number of candidates responded to $|z_2| = 5$ by deducing that $a = 3$ and $b = 4$, or vice versa. An attempt to solve the simultaneous equations $\tan\frac{\pi}{3} = \frac{b}{a}$ and $a^2 + b^2 = 25$ was rarely successful. Not all answers gave the exact form of b and it is preferable to give the values as ratios, not decimal fractions. It was quite common to finish with a statement about a and b, rather than to write the full expression for z_2 which was requested.

(iii) It was sufficient here to state that the two complex numbers had the same argument. Explaining this in terms of an angle was rarely coherent, and sometimes misleading. Angles cannot be made 'with the origin'. 'At the origin' requires a little more explanation. Some realised that one complex number was a real multiple of the other, but did not specify the scale factor, nor mention that the multiplier was real.

3) Most often answers to this question were completely correct and well set out. The relationships between roots and coefficients was the most popular route to the solutions, and probably the easiest. The common mistake was to forget the coefficient of x^3 , either altogether or at some point during the solution. Another was to omit the minus sign in finding q , and sometimes in finding α .

Candidates who began by trying to expand factors using α , $\frac{\alpha}{6}$ and $\alpha - 7$ were often defeated by the algebra, but those who used the factors after finding α managed perfectly well.

4) This probably produced the least satisfactory answers. There were many partial solutions with inadequate working where the sign of $x-4$ was ignored. Most successful were those who multiplied both sides by $(x-4)^2$, and then solved the resulting quadratic inequality. Candidates who chose a graphical approach were also usually successful, although many made algebraic errors, and the sketches produced were often extremely scruffy. The best solution, very rarely seen, considered the two inequalities $0 < x-4 < 3$ which immediately supply the solution.

5) (i) This result was nearly always correctly shown, unless there was loss of a necessary bracket. It is expected that correct notation is used at this level.

(ii) This question was also successfully answered by the great majority of candidates. There were those that forgot the factor $\frac{1}{2}$ in the final stages and some who showed a careless disregard of signs.

6) (i) Very few errors were seen here, as would be expected.

(ii) There were numerous satisfactory and well expressed answers, where all the details were included. Many candidates coped well with the algebra but failed to produce the desired argument at the final stages, one place where '$\Rightarrow$' could usefully and correctly be employed. In words, 'if….then…' are those needed, and few others are adequate. There were candidates who made the mistake of trying to add a term, as in a series, and others who were less then attentive to every line of their working in finding the expression for a_{k+1} .

7) (i) Mostly correct. Any errors were usually in notation. It would be good to see co-ordinates presented in the conventional manner. Equations of lines were permitted if each point had two.

(ii) Vertical asymptotes were correctly identified in the majority of scripts. There was some confusion over the equation of the horizontal asymptote; $y = \frac{1}{3x}$ was fairly frequently seen, and also, less appropriately, $y = \frac{1}{3}$.

(iii) When $y = 0$ had been found in (ii) this was usually correctly answered. Otherwise the marks were only available to those who specified that y approached zero, as their calculations should have demonstrated.

(iv) There were many clear and carefully drawn graphs. Some diagrams failed to show some of the features. In particular the approach to the horizontal asymptote, following obvious turning points, was wanted, also labelling of all three intercepts on the axes, with no extras. Some graphs failed to show all four branches; a quick numerical check should have revealed that they existed.

8) (i) This was in general well answered. Most candidates substituted $z = 1 + 3j$ and reduced the polynomial to zero without mishap. Not many bothered to state that this demonstrated that $1 + 3j$ was indeed a root of the equation. Some evidence of manipulating the required result occurred. Necessary alterations should be traced back to their source if marks for accuracy are to be earned. Some answers took the long route of showing the factorisation of the polynomial, assuming that $1 + 3j$ was a root, which earned the marks provided there was adequate explanation, and of course made short work of part (iv).

(ii) It was needful to refer to the complex conjugate as another root and to explain that there were only three roots to a cubic equation. This was not always achieved.

(iii) The root $1 - 3j$ was usually recognised, but not always stated to be a root. The neatest solutions used the root relationships, but some candidates made errors with signs or, in using the coefficients, $a = 3$ was sometimes forgotten. Those candidates who used the complex roots to find a quadratic factor were usually successful in proceeding to the real root, but it was evident that some did not know the difference between a factor and a root.

9) (i) This was well done, but the answers were given and as a result there was a penalty for carelessly written expressions.

(ii) Nearly all realised that the inverse of **A** involved **B**, and only a few forgot the factor $\frac{1}{79}$.

(iii) Again, well answered by nearly all candidates. Some were unable to show that a matrix method was used to solve the equations.

4756 Further Methods for Advanced Mathematics (FP2)

General Comments

Most candidates found this paper accessible and were able to provide evidence of what they knew, understood and could do across the whole specification. More than one-third of candidates scored at least 60 marks and only about 5% scored 20 marks or fewer. Question 1, on calculus and polar co-ordinates, produced the highest scores, while Question 4 on hyperbolic functions yielded the lowest mean. Fewer than 1% of candidates attempted Question 5 on investigations of curves: this option is to be examined for the last time in this paper in January 2013.

Candidates appeared well-versed in the standard results and processes which appear at this level, for example Q1(a)(ii) on arcsin integrals, Q2(b)(i) on square roots of a complex number, Q3(i) on the inverse of a 3 × 3 matrix and Q4(i) on a hyperbolic identity. Most proofs and methods offered in these questions were clear and concise. As might be expected, the part-questions yielding the lowest average scores were those which covered slightly less familiar ground, such as Q1(b), Q2(b)(ii), Q3(iii) and Q4(iii) and (iv). Although much fluency was seen, even very competent candidates could be seen struggling to keep control of their signs, for example in Q3(iii).

The structure of questions is intended to assist candidates. Thus it was surprising to find some candidates using inverse hyperbolic functions in the integrals in Q1(a), in which they have already been asked to differentiate arcsin; ignoring the instruction to "use the identity in part (ii)" in Q2(a)(iii); not using "hence" in Q3(ii); and not spotting the connection between the indefinite and the definite integrals in Q4(iii) and (iv).

Comments on Individual Questions

1) **Calculus with inverse trigonometric functions; polar co-ordinates**

(a) (i) The first three marks were obtained quickly and easily by most candidates. Very few scored the final mark by giving an explanation as to why the positive square root is chosen. Most did not seem to realise that there was a choice. A very few just asserted the result "from the formula book".

(ii) Almost all candidates realised that these were inverse sine integrals. (A) was very well done with about 90% of candidates scoring full marks. In (B), a few more errors with the constants crept in. Most used the "standard result" rather than attempting a substitution from first principles. A very few tried to use inverse hyperbolic functions, and another small group insisted on using degrees.

(b) The best answers were concise and clearly established each answer, leaving no details to be filled in by the examiner. Proving that $x = \sin\theta$ was probably the trickiest part. The other two expressions were derived more consistently and the equation of the asymptote was frequently correct.

2) **Complex numbers**

(a) (i) Most candidates achieved full marks here. The most common slips involved missing out the *j*s or the *n*s.

(ii) Most candidates knew what they had to do and the binomial expansion was usually carried out correctly. The main error was to omit the factors of 2 when introducing trigonometric functions on both sides of the expansion. A small number tried to use a succession of trigonometric identities to solve the problem, despite the instruction in the question to begin with $(z + 1/z)^4$.

(iii) Most realised that they had to substitute for cos 2θ but could not do so accurately, with a large number thinking that $\cos 2\theta = \cos^2\theta - 1$. Poor algebraic manipulation prevented many from achieving the correct answer.

(b) (i) This part was done very well, with the best answers achieving full marks with just a few lines of working and a clear diagram. Some ignored the instruction to give $r > 0$. A few squared z rather than finding its square roots, and a few had more than two square roots.

(ii) The first mark, for $n = 3$, was frequently scored, although many thought 0 was a positive integer (some scripts contained debate about whether 0 was an integer at all). Showing that z^n was never imaginary was found quite difficult. A whole variety of different explanations was seen: the best answers displayed clear thinking, were easy to follow, and covered both the positive and negative imaginary axes. Many candidates thought it was enough to assert that $n\pi/3 = \pi/2 \Rightarrow n = 3/2$ which was not an integer, while others thought that, if z^n were imaginary, $\sin n\pi/3 = 1$. Some candidates produced extended essays. The final two marks were easier to obtain and even if candidates had incorrect values of w they usually scored the method mark for cubing them. A very few obtained w in the form $a + jb$ and tried to cube that.

3) **Matrices**

(i) The majority of candidates achieved full marks in this part. Most were able to find the determinant accurately, most often by expanding by the first row although Sarrus' method was also quite popular. As always, there were a few sign errors. A minority of candidates, having obtained $42 - 7a$, used $6 - a$ as the determinant, which also affected part (ii): this was dealt with by a special case in the mark scheme. As is usual, the inverse matrix was found efficiently and accurately. Errors, when they appeared, included: failing to change the signs of the minors to obtain the cofactors; sign errors in the cofactors; forgetting to transpose; and multiplying the cofactors by the corresponding elements.

(ii) Again, this was well done. A minority of candidates ignored the "hence" in the question and used an algebraic method to solve the equations: this scored a maximum of 2/4. A very few quoted the answer without working, presumably from a calculator: this did not receive any credit.

(iii) The best solutions, once again, were concise and easy to follow, often producing the required answer in a few lines. The "standard" approach was to eliminate the same unknown between two different pairs of equations, and poor manipulative algebra often prevented competent candidates from obtaining the correct value of b: they would be well advised not to try to do so much in their heads! "Line" or "sheaf" (or even "sheath") appeared fairly often, while finding an accurate general solution proved challenging and, here again, poor manipulation was the main barrier to full marks. Some found a point and then stated the solution was a line.

4) **Hyperbolic functions**

(i) This was done well with over three-quarters of candidates obtaining full marks. Again, the best proofs were concise and clear, leaving no details for the examiner to fill in. Other candidates lost all three marks by ignoring the instruction in the question to “prove from definitions involving exponential functions”.

(ii) This was also done well and it was pleasing that so many candidates considered the $\pm$ and gave valid reasons why the $-$ sign should be dropped. Others gave spurious reasons such as “you cannot take the natural logarithm of a negative number”.

(iii) Most candidates used the suggested substitution accurately although some candidates found it hard to find *dx* in terms of *du* and did not score. Then most used a hyperbolic identity to obtain an integrable form, while a small minority converted everything to exponentials. Obtaining the last two marks, by putting the result of the integration into the required form, was found challenging, and the methods used were not always transparent. Some attempted to express sinh $2u$ in terms of exponentials, but very few were fully successful by this method.

(iv) Many did not attempt this part or, even after having attempted (iii), started again, not realising that all that was expected was substitution of the limits. Those who made progress usually tried to give the answer in the required “exact form” and used part (ii) accurately.

5) **Investigations of curves**

Very few candidates attempted this question and, although there were a few good attempts, the evidence suggests that candidates tried this question mainly after an unsuccessful attempt at Q4.

4757 Further Applications of Advanced Mathematics (FP3)

General Comments

Each question on this paper contained parts which were accessible to most of the candidates, and other parts which presented a significant challenge. This resulted in a wide range of marks providing good discrimination between the candidates. The most popular options were Q1 (vectors) and Q2 (multi-variable calculus) which were both attempted by the majority of candidates, and the least popular was Q3 (differential geometry) which was attempted by about a quarter of the candidates.

Comments on Individual Questions

1) In part (i) the vector product was usually evaluated correctly. A fairly common error was to divide by a common factor (usually 10) to make the numbers more manageable, obtaining an answer which was a multiple of the correct one. Almost all candidates knew how to use the vector product to find the equation of the hillside.

   In part (ii) most candidates applied a valid method for finding the shortest distance from a point to a line, usually the standard formula based on the magnitude of a vector product. There was some confusion with the formulae for the distance from a point to a plane and for the distance between two lines.

   In part (iii) the method for finding the shortest distance between two skew lines was very well understood, and most candidates carried it out accurately.

   In part (iv) the most efficient method was to set up three equations from the coordinates of the two intersecting lines, from which the point of intersection and the value of p could both be found. Some candidates used a separate method for finding p based on the shortest distance between the lines being zero. About half the candidates obtained both the point and the value of p correctly, with careless errors, often leading to very awkward numerical values, spoiling many answers.

2) In parts (i) and (ii) the partial derivatives and the equation of the normal line were usually given correctly. A few candidates gave the equation of the tangent plane instead of the normal line.

   In part (iii) candidates needed to relate both the change h in g and the length of PQ to the parameter in the equation of the normal line. Most candidates considered just one of these (usually the first), with about 10% of candidates earning full marks in this part.

   In part (iv) almost all candidates realised that $\partial g/\partial x = \partial g/\partial y = 0$. To proceed beyond this it was necessary to use the equation of the surface, and very many candidates did not do this; a common error was to assume that $\partial g/\partial z = 1$.

   In part (v) most candidates knew that the three partial derivatives were equal. It was then necessary to substitute into the equation of the surface to find the coordinates of the appropriate points on the surface and hence the values of k. Many candidates made algebraic and numerical slips in this process, and many did not use the equation of the surface at all, usually taking the common value of the partial derivatives to be 1.

3) In part (i) the relevant techniques were well understood, and most candidates made substantial progress. About a half of the attempts completed the derivation of the intrinsic equation successfully. A minor error made by many candidates was not considering the constant of integration when obtaining the expression for *s*.

In part (ii) the radius of curvature was usually given correctly; those who differentiated the intrinsic equation were much more likely to obtain the right answer than those who used the formula involving second derivatives. The method for finding the centre of curvature was well understood, and about one third of the attempts obtained both coordinates correctly. Many candidates made minor slips in this process, particularly when finding a unit normal vector.

In part (iii) many candidates produced a correct integral expression for the surface area, and about a quarter of the attempts completed the integration to obtain the correct value.

4) In part (i) most candidates produced a satisfactory proof that *P* is a group.
The group algebra in parts (ii), (iii) and (iv) was quite well done; the main error was to state that the group is commutative without justifying this assertion.

In part (v) almost all candidates completed the composition table correctly. Very many candidates did not state that *R* is closed, which is necessary to show that *R* is a subgroup of *Q*. Most candidates gave a satisfactory reason why *R* is isomorphic to *P*.
Almost all candidates gave the orders of the elements in part (vi) correctly; the most common error was to give the order of the identity *E* as 2 instead of 1.

In part (vii) most candidates listed the five subgroups of order 2 and the cyclic subgroup of order 4. Part (v) of this question shows how subgroups containing four self-inverse elements can be identified; very many candidates did not include the two subgroups of this type.

5) Almost all candidates identified the reflecting barriers in part (i) and wrote down the transition matrix in part (ii) correctly.

In part (iii) most candidates understood how to find the probabilities. A significant number gave what were in fact the positions and probabilities after 9 steps instead of 10.
About half of the candidates knew how to answer part (iv). Parts (v) and (vi) were generally well answered.

Part (vii) was also quite well understood. Some candidates multiplied the equilibrium probabilities by 100 instead of 50, and many confused this with the problem of finding run lengths.

In part (viii) many candidates found the expected number of movements correctly. Finding the expected time was more challenging.

4758 Differential Equations (Written Examination)

General Comments

The standard of the work presented by most candidates was very high. Solutions were presented neatly and concisely, displaying a sound understanding of, and an ability to apply, the various methods and techniques required. As usual, almost all candidates opted for the questions involving second order linear differential equations and then one of the two questions on first order differential equations. In this series, few candidates made serious attempts at all four questions.

For many candidates, the only loss of marks was in the parts of questions where the request was unfamiliar, requiring some interpretation of results obtained by well-understood methods.

Comments on Individual Questions

1) Second order linear differential equation

(i) Almost all candidates found the general solution in a methodical manner. Some arithmetical slips occurred when solving the simultaneous equations to find the values of the constants for the particular integral.

(ii) Candidates had no problems in applying the boundary conditions to obtain a particular solution of the differential equation.

(iii) Many candidates offered lengthy explanations in which the required answer was identifiable. A simple statement, along the lines of stating that the two given functions each appeared already in the complementary function, was sufficient.

(iv) Again, the method for finding the particular integral for this new differential equation was well executed by the vast majority of candidates. Some made their work more complicated by unnecessarily including terms mentioned in part (iii).

(v) This part of the question required some analysis of the quadratic function appearing in the particular solution obtained in part (iv) and proved difficult even for candidates who had earned full marks up to this point. Most focussed solely on the behaviour of the particular solution for large values of *x* or for particular values of *x*. The key feature that candidates needed to identify was that the coefficient of the quadratic was positive, leading to a consideration of the positioning of the graph of the quadratic relative to the *x* -axis.

2) First order differential equations

This was the least popular choice of question, although a significant number of candidates made an attempt at the first two or three parts and then abandoned the rest in favour of attempting a different question.

(i) The application of Newton's second law to a mechanics problem was well done, followed by the successful use of the method of separation of variables with good use of integration techniques.

(ii) This was almost always correct.

(iii) Most candidates who attempted this part of the question produced excellent solutions using the method of separation of variables. A few opted to find a complementary function and a particular solution and again were usually successful. A minority tried to use the integrating factor method and almost invariably gave up and started on a different question.

(iv) Follow-through was applied to any solution to part (iii) obtained by a legitimate method and this mark was gained by most who attempted it.

(v) This caused problems for some candidates, with a significant minority reverting to the previous model with solution given in part (i). Others, who realised that integration of their solution to part (iv) was required were unsure about limits.

3) First order differential equations

(i) Almost all candidates displayed a good working knowledge of the integrating factor method, with the majority scoring full marks

(ii) There were some excellent sketches of the graph of the particular solution, identifying the key features of oscillations with growing amplitude and two maxima on the *x* -axis. Many of the other sketches were simply variations on the basic sine or cosine curve, centred on the *x* -axis and with constant amplitude.

(iii) The need to use the method of separation of variables was identified by most candidates and applied successfully by many. Common errors were $\left(2y^2\right)^{-1} = 2y^{-2}$ and $\frac{1}{2\ln x + c} = \frac{1}{2\ln x} + \frac{1}{c}$

(iv) and less often, $\int y^{-2}\mathrm{d}x = -\frac{1}{3}y^{-3}$.

Although almost all candidates were aware of how to apply Euler's method, this particular example caused more problems than usual. One common cause of error was in manipulating the very small numbers involved and putting the wrong number of zeros after the decimal point.

(v) This routine request was answered correctly by most of the candidates.

4) Simultaneous first order linear differential equations

Candidates are extremely competent at finding the general and particular solutions for *x* and *y* from a pair of simultaneous differential equations of this type. As always, it was the last part of the question, which called for some interpretation of the solutions that often led to the loss of a few marks.

(i) The accuracy with which most candidates work in this type of solution is very pleasing. The vast majority obtained the correct second order linear differential equation satisfied by *x* and solved it successfully. Some made sign errors on the way but were still able to earn most of the available marks.

(ii) This was answered well.

(iii) Again the method was universally known, the only loss of marks being due to slight algebraic slips carried through from earlier parts of the question.

(iv) The first two marks proved very accessible to almost all candidates and follow-through was applied to their solutions in part (iii). The last three marks, however, were gained only by a minority of candidates. Most seemed to have no idea of what was required and did not think to pursue the obvious route of substituting their solutions for x and y into the given expression $y = kx$. Of those who did embark on this route, most did not realise that they could cancel out the exponential term as a non-zero common factor.

4761 Mechanics 1

General Comments

Most candidates were successful on much of this paper. There were very few really low scores and many in the 50s and 60s (out of 72); few, however, scored full marks.

The questions in section A tended to be higher scoring than those in section B, which proved somewhat more demanding.

Comments on Individual Questions

1) This question involved interpretation of a speed-time graph. Virtually all candidates scored highly on it. Many, however, lost a mark in part *A*; typically they knew that the statement that the graph showed the runner had returned to his starting point was false but were unable to explain why, not distinguishing between distance and displacement.

2) This question involved motion with non-constant acceleration and so required the use of calculus. Most candidates recognised this and scored highly but some lost marks by omitting the arbitrary constants from the integrations or by failing to evaluate them correctly. A more common mistake, however, was to attempt to use constant acceleration formulae; no credit was given for this.

3) This question involved adding three vectors together to obtain a zero sum. This result then had to be interpreted in two different possible contexts. It was well answered with most candidates scoring all three marks. In part (ii)(*A*), some candidates, however, stated that when the three vectors were forces acting on a particle, the zero sum indicated that it was stationary (instead of being in equilibrium or moving with constant velocity).

4) This question involved the use of constant acceleration formulae and it was well answered by a large majority of candidates. The commonest mistake was to misread the given information and conclude that the distance AC is 800m and not 500m (candidates who worked correctly following this error lost only 1 mark).

5) This question was about the forces acting on a block which was in equilibrium on a rough horizontal plane.

   In part (i) candidates were asked to mark in the forces on a diagram; only a small minority got this right. Common reasons for losing marks were: missing out forces; including extra forces; not labelling forces; omitting the arrows. Some candidates gave both the tension, T, and its resolved components $T\cos30^\circ$ and $T\sin30^\circ$. The convention used for marking this duplication is that it counts as an extra force unless the components are shown in a different style (eg with broken lines) from the other forces; candidates should be warned that similar colours (eg blue and black) will be indistinguishable when their scripts have been scanned for marking.

   Many candidates who had made mistakes on the force diagram nonetheless continued with the question correctly; almost all got part (ii) right.

   A common mistake in part (iii) was to forget the vertical component of the string's tension and so say that the normal reaction was equal to the weight of the block.

   In part (iv) many candidates simply added the horizontal and vertical components of the force instead of using a Pythagoras-type calculation to find their resultant.

6) This projectiles question was set in a slightly unconventional style with the modelling assumptions not stated in the initial stem, but made the subject of part (ii) instead.

Part (i) was well answered and many candidates obtained full marks for it. There were a variety of possible approaches. However, some candidates wasted time finding the coordinates of the highest point of the trajectory, and the time at which it was attained, all of which was irrelevant to the question; many such candidates then recovered, either by effectively starting again, or by using the maximum point as a staging post and considering what happened next.

Part (ii) asked for one modelling assumption. Most candidates correctly said that air resistance had been neglected; other possible correct answers included the ground being horizontal, the ball starting on the ground, there being no wind, etc. This part, too, was well answered.

7) Many candidates found parts of this question difficult. It was about a train and in parts (i), (iii) and (iv) it was easiest to consider the whole train but in (ii)(*A*) and (*B*) the tensions in couplings were required and so it was necessary to consider the relevant sections of the train. Those candidates who understood this mostly found the question straightforward and many of them obtained full marks. By contrast, many others produced jumbled answers with attempts at equations of motion that were internally inconsistent as to what section of the train they applied to.

Most candidates were successful in obtaining the given answer to part (i). To do so they needed find the mass of the whole train and to express it in kilograms rather than tonnes. A few, however, reverted to tonnes for later parts of the question.

In part (ii)(*A*), candidates needed the equation of motion of the last truck but many incorrectly included the driving force from the locomotive. In part (*B*), they were asked for the tension in the coupling between the locomotive and the rest of the train and this was better answered, most considering the equation of motion of the locomotive (which requires its driving force).

Parts (iii) and (iv) involved the motion of the train on a slope and they were well answered by those who realised that the whole train needed to be considered.

8) Question 8 was about the motion of two boats, described by their position vectors. Most candidates obtained all or most of the marks on parts (i) to (iv) but many did not go on to score well on the last two parts, (v) and (vi).

Part (v) required them to find the velocity of one of the boats and then its speed and direction of motion at a given time. However, many did not take the first step of differentiating the position vector and among those who did, a common mistake was to think that the direction of motion is found from the position vector rather than the velocity vector.

The last part, (vi), involved finding the maximum displacement of one boat from the other. Only the higher achieving candidates answered well.

4762 Mechanics 2

General Comments

The general standard of the work was pleasing. Many candidates showed a sound understanding of the methods and techniques involved and most presented their solutions with clarity. It is worth emphasising, however, that a good clear diagram is often the key to a successful solution. It is also important that candidates read the question carefully. When there is a supporting diagram, information may be given in the text or on the diagram, or both. Particularly careful reading is required when a scenario changes in the later parts of questions to ensure that only relevant information is carried forward.

Comments on Individual Questions

1) (a) Work, energy and power

(i) The vast majority of candidates were able to state and use the formulae for kinetic and potential energy and scored full marks. A minority found only the kinetic energy change.

(ii) Most candidates who found the energy changes in part (i) were able to combine them appropriately to find the work done against resistance. A few made sign errors. Those candidates who did not find the potential energy change in part (i) usually gave it as the answer to this part of the question.

(iii) The most concise solutions to this request involved the use of the two formulae, 'work done = force x distance' and 'power = force x velocity.' Many candidates, however, pursued an incorrect method, using *suvat* to calculate a time and then dividing their answer for the work done from part (ii) by this calculated time. This resulted in an 'average' power, which was indicative of a lack of understanding of the fact that power changes with velocity. Other candidates calculated a force, often the weight of the stone, and multiplied this by 5.5.

(b) Frictional force

(i) This was answered well by almost all candidates. A few solutions were rather too brief and candidates should be aware that they need to give adequate working to support a given answer. A small minority of candidates either omitted *g* in their calculations or lost accuracy when using numerical values for the trigonometric functions.

(ii) Only a minority of candidates scored full marks on this question. Many offered incomplete solutions, including only one of the two required terms, usually the potential energy term. A significant number of candidates changed the value of the coefficient of friction because the angle of inclination of the plane was changed.

2) Rigid body in equilibrium

(i) Most candidates scored full marks. A small percentage of candidates misread the question and attached the strings to *A* and *C* instead of *B* and *C*.

(ii) Most candidates were able to calculate *T* correctly, by taking moments about *A*. The vast majority of candidates then went on to calculate just *one* component of the force exerted on the object by the axis at *A* usually the horizontal component. Of those candidates who calculated both components, a significant number did not proceed to find the magnitude of the resultant force.

(iii) There were some very concise fully correct solutions to this part of the question, displaying a sound understanding of the principles involved. Candidates who did not score full marks seemed confident in considering the slipping situation, but were unsure about how to get a condition for tipping. They attempted to take moments, but often not about the point *D*. A significant minority of candidates did not read the question carefully and retained the force *T*, from part (ii).

3) (a) Centre of mass

(i) Both the presentation and the accuracy of the solutions to this part of the question were very good. Some candidates lost marks because they used the distance from *OJ* of the centre of mass of the triangular part of the metal sheet as the *x*-coordinate in their calculations.

(ii) The majority of candidates realised which angle they needed to calculate and did so accurately from their answer in part (i). Other candidates assumed that triangle *BDG*, where *G* is the centre of mass of the whole sheet, was right-angled at *G*. The minority of candidates who did not attempt to draw a diagram were rarely successful.

(b) Light framework

(i) Almost all candidates marked the forces internal to the rods *AB*, *BC* and *CA*, but many candidates omitted showing any forces on the rods *CT, CS,* and *BR*. Others put arrows in the wrong direction for each of the given forces in *AP* and *AQ*.

(ii) The majority of candidates were able to resolve horizontally at *A* to find the force in the rod *AB* and then vertically to find the force in the rod *AC.* A significant number of candidates made a sign error in the vertical resolution. Finding the tension in the rod *BC* proved difficult for many candidates and it was common to see attempts at resolutions at *B* and *C* with forces missing and incorrect signs. A minority of candidates attempted to find the forces in all of the rods shown in the framework.

4) Momentum and impulse

(i) The vast majority of candidates scored full marks.

(ii) Most candidates were able to apply the Principle of conservation of linear momentum and Newton's experimental law effectively and then solve the resulting simultaneous equations to find the two required velocities. A small number of candidates made algebraic or arithmetic slips.

(iii) Again, most candidates scored full marks.

(iv) Only a minority of candidates scored more than a single mark on this part of the question. The common error was in not realising that the direction of *P* must have been reversed in the collision. This resulted in the inequality $e < 0$, contradicting the fact that e is a positive quantity, but this rarely alerted candidates to think again about their solution.

(v) The majority of candidates realised that the velocities of *P* and *Q* needed to be reversed in direction when applying the Principle of conservation of linear momentum.

(vi) Although candidates knew that the impulse was equal to the change in momentum, only a minority dealt successfully with the signs involved.

4763 Mechanics 3

General Comments

Most candidates answered this paper very well, demonstrating a sound understanding of the mechanical and mathematical principles involved, and presenting their working clearly. They were particularly competent at applying the techniques accurately in questions involving dimensional analysis and centres of mass; and slightly less competent in questions involving simple harmonic motion and motion in a circle.

Comments on Individual Questions

1) In part (i) candidates needed to use Hooke's law to obtain the tension in the string, and then resolve the tension in the horizontal direction. As the answer is given on the question paper it was important to show the two separate steps clearly, and most candidates did so convincingly.

   Again in part (ii) there is a given answer so the working had to be clearly shown, and most candidates obtained the changes in kinetic and elastic energy correctly. Common errors included omitting the elastic energy stored in the string when the block was at C, and using constant acceleration formulae.

   In part (iii) most candidates demonstrated the dimensional consistency by clearly identifying the dimensions of each term in the equation.

   In part (iv) the dimensional method for finding unknown indices in an equation was very well understood, and was applied accurately by most candidates. The numerical application in part (v) was also done very well.

2) In part (a)(i), the horizontal equation of motion was almost always formed correctly. Most candidates realised that the vertical direction is the only one where the forces balance, and used this to find the normal reaction correctly. A very common error here was to resolve perpendicular to the slope, obtaining $R=W\cos 18$ instead of the correct $R\cos 18=W$.

   In part (a)(ii) most candidates obtained two equations by considering horizontal and vertical forces, then solved these simultaneously to find F and R. Common errors included resolving perpendicular (and sometimes parallel) to the slope without taking account of the acceleration in that direction. Some candidates solved the problem very efficiently by resolving the acceleration parallel and perpendicular to the slope, then finding F and R directly without needing to solve simultaneous equations.

   In part (b) candidates needed to use conservation of energy and radial acceleration to obtain two equations involving the length of the string and the angle between the string and the vertical. About half the candidates found these equations correctly. There was quite often confusion about whether the angle used in the equations was measured from the upward vertical, the downward vertical or the horizontal, especially when no clear diagram was drawn. Another fairly common error was to resolve vertically as if the system were in equilibrium.

3) Most candidates derived the given result in part (i) convincingly.
Part (ii) required the candidates to identify parameters in the SHM equation to fit the given graph, and most gave all the values correctly. The most common error was to give ϕ as 3 instead of 3ω.

Most candidates then used their equation successfully to find the maximum speed in part (iii) and the height and velocity in part (iv). For the velocity, those who differentiated the height equation were much more likely to obtain the correct answer than those who used the standard SHM equation relating velocity to displacement from the centre (which was very often confused with the height x).

In part (v) most candidates made a good attempt to find the distance travelled, and about half obtained the correct answer.

4) In part (a) almost all candidates knew how to find the centre of mass of a lamina, and most carried out the calculations accurately. The only common error was the loss of a factor ½ in the y-coordinate at some stage in the process.

In part (b)(i) the centre of mass of the solid of revolution was almost always found correctly.

In part (b)(ii) about half the candidates earned the first mark for indicating clearly that the centre of mass was vertically above the point of contact. The next step, drawing the normal at the point of contact to pass through O (the centre of the 'sphere') was found to be very challenging.

4764 Mechanics 4

General Comments

The performance of the candidates was generally very good, as is usual on this paper. Most candidates showed good knowledge of the techniques and concepts examined. The standard of presentation was very high, though many candidates did not give sufficient intermediate steps when working towards a given answer.

Comments on Individual Questions

1) (*Variable mass – Rocket in deep space*)

(i) Almost all candidates knew to consider momentum-impulse and knew the basic technique. However, the detail was not often well-understood; many candidates took $\delta m > 0$ and worked with the rocket's mass changing from m to $m - \delta m$ rather than either using $\delta m < 0$ and the mass changing to $m + \delta m$ or using $|\delta m|$.

(ii) This was very well answered in general, with only a few candidates making errors in their integration or subsequent manipulation.

2) (*Variable force*)

(i) This was not well answered by the majority of candidates; many ignored the presence of gravity and/or neglected to take into account the tension in the string at the equilibrium point.

(ii) The solution required a relatively simple separation of variables and was well answered by the majority of candidates, including reasonable descriptions of why the negative root is chosen.
Some candidates approached this from SHM or by energy considerations, which was acceptable in this part.

(iii) Most candidates understood which form of Newton's second law was required here. Those that recognised, or looked up, the relevant integral to get arcsine tended to get full marks.
Since the question asked specifically for candidates to integrate, marks were not give for solutions based on energy or SHM considerations.

3) (*Equilibrium*)

(i) This type of question was obviously familiar to most candidates and they performed the necessary trigonometry and calculus with accuracy.

(ii) The idea that $dV/d\theta = 0$ at a point of equilibrium was well understood, as was the process of deciding on stablilty by using the second derivative of V. Most candidates found it difficult to explain why there were no other points of equilibrium and most failed to cover all the possibilities.

(iii) Most candidates stated that $\theta = \pi/2$ was still a point of equilibrium, but many candidates did not realise that they needed to reconsider whether or not it was still stable.
Dealing with the other two points was found to be difficult by most, in particular very few candidates checked that the value of $\sin\theta$ was valid, and most did not find the second solution in the domain. The manipulation to show the stability of these two solutions was quite tricky, but some candidates were able to do so with great skill.

4) (*Rotation*)

(i) The proof of this standard result about discs was well done by the majority of candidates. Some chose to take the mass per unit area to be 1, but only those that did so explicitly were awarded full marks.

(ii) Many candidates found this question very difficult. In general, the expressions for the mass or moment of inertia of the ends and the curved surface were found, but the necessary manipulation to eliminate the mass per unit area, or to deal with the masses as proportions of the whole mass, was not well done.

(iii) This was well answered by the majority of candidates. Some neglected the factor of 0.5 for the impulse, but all incorrect values were followed through into the next part.

(iv) Many candidates had the sign of the couple as positive rather than negative here, which meant that they had the wrong differential equation to start with. However, those that could get started on the integrals could generally make their way through to a correct answer.

(v) Those candidates that attempted this part generally answered it very well, but many did not get this far through Q4.

4766 Statistics 1

General Comments

The level of difficulty of the paper appeared to be appropriate for the candidates and there was no evidence of candidates being unable to complete the paper in the allocated time. The majority of candidates handled the standard parts of questions very well. Most candidates supported their numerical answers with appropriate explanations and working. Fortunately only a small minority of candidates attempted parts of questions in answer sections intended for a different question/part and most candidates had adequate space in the answer booklet without having to use additional sheets.

It is pleasing to report that the hypothesis test question was generally answered better than in previous series, with most candidates not only giving their hypotheses in terms of *p* but also defining *p* as the probability of a bike frame being faulty. Most candidates also included an element of doubt in their conclusion saying eg. 'There is sufficient evidence to suggest that the proportion of faulty frames has increased'. Unfortunately most candidates lost marks due to over specification of some of their answers, despite recent examiners' reports warning against this. Particular examples are given in the comments on 6(iii) and 6(v) below.

Comments on Individual Questions

1) (i) The majority of candidates gained full marks in this part.

(ii) Once again the majority of candidates gained at least 2 marks out of 3. Those who answered by finding the P(2 blue and one red) and adding it to P(2 red and one blue) were in the majority, but were less successful than those who found 1 – (P(3 red) + P(3 blue)). This was due to the omission of the 3 possible arrangements of each probability.

2) (i) Again the majority of candidates gained full marks. A fairly common error was to add rather than multiply ${}^{9}C_{3}$ and ${}^{5}C_{3}$. A small number of candidates tried to use permutations rather than combinations.

(ii) Many candidates gained full credit for dividing their answer to part (i), correct or not, by 3003. Those who did not see the connection with part (i) did not fare so well, and even if they found the correct product of fractions they rarely multiplied this by ${}^{6}C_{3}$.

3) (i) This question was very well answered, with most candidates scoring all 3 marks.

(ii) Many fully correct responses were seen, although a number of candidates calculated $P(X<29)$ or $P(X\leq 29)$ rather than $P(X\geq 29)$.

(iii) Many candidates gained full credit here, even if as a follow through from their answer to part (ii). A common error was to multiply their answer to part (ii) by 30 or 300 instead of by 10. A number of candidates also rounded their answer to a whole number, thereby losing the second mark.

4) (i)(*A*) Most candidates scored full marks, but a significant number scored zero. Candidates needed to multiply 0.92^2 by 0.08, but a significant number simply worked out 0.08^3, which gained no credit.

(i)(*B*) In this part candidates needed to multiply 0.92 by 0.08 then add this product to their answer to part (i). This was often achieved successfully, but a number of candidates gave their answer to 6 significant figures, thus losing the second mark.

(ii) Many fully correct responses were seen.

5) Many candidates were awarded at least 7 out of the 8 marks available. The hypotheses were generally correct and well defined but a minority of candidates still omitted a definition of *p*. Only a small number of candidates incorrectly used point probabilities. Many candidates used the first method in the scheme, usually successfully. A smaller number used the critical region method, again fairly successfully, but a number thought that the critical region started at 3. Some candidates who used the critical region method, failed to justify their critical region. In this case they were only eligible for the first 3 marks for the hypotheses.

6) (i) On the whole, this question was answered well, with a very high proportion of candidates calculating the frequency densities correctly. Of those candidates who did not calculate the FD correctly, most achieved a mark for the correct widths. There were very few inequality labels on the x axis. However, candidates should be reminded that they need to label the vertical axis. Drawing of the bars was done well although a few candidates struggled to draw a bar of height 0.0035.

(ii) Many candidates thought that the calculation involved subtraction rather than addition and even when the calculation was correct, there was often no element of doubt to their conclusion.

(iii) On the whole this question was very well answered. It was extremely common to award 4 marks in total, due to the over specification of answers. Many candidates gave the exact answer 1890.625, but an element of sensible rounding, to say 1891 or even 1890, was looked for. A significant number did not find the standard deviation correctly, sometimes giving the root mean square deviation or calculating $(fx)^2$ rather than fx^2. The explanation mark was very well answered.

(iv) Again this was also very well answered. Even candidates who had made errors in the previous part usually gained follow through marks. Most candidates knew that the limits for outliers were mean ± 2 standard deviations. A number of candidates did not include an element of doubt in their conclusion about the number of outliers and thus were not awarded the final mark.

(v) Candidates tended to over specify their answer, giving it as 781250000 rather than for example 780000000. Candidates who were unsure how to do this part nevertheless usually gained a method mark for multiplying by 1000.

(vi) Where candidates achieved this mark, they often realised that the duty would reduce the sales of larger cars. They also achieved this mark where they stated that the sample may not be representative, although this needed to be very clearly stated for the mark to be awarded. A number of candidates erroneously stated that people would refuse to pay the duty.

7) (i) This part was very well answered.

(ii) Again many fully correct responses were seen. Many other candidates scored 1 mark out of 4 for finding $0.6 \times 0.5^4 = 0.0375$. Some candidates multiplied 0.6×0.5^4 or 0.4×0.5^4 or indeed both by ${}^5C_1$ rather than by ${}^4C_1$.

(iii) Approximately half of candidates scored full marks in this part. However many lost one or both marks for a number of errors – a non linear vertical scale, one or both labels missing, heights incorrect (particularly the final height), or less often a frequency polygon or a point plot. Candidates should be advised to use a ruler in questions such as this.

(iv) Again approximately half of candidates scored the mark here. The most popular answer was ‘slightly negative’, but some said positive skew or symmetrical and/or unimodal.

(v) Arithmetic errors were common often because of writing the probabilities incorrectly as eg 0.375 rather than 0.0375. Only a few candidates left the variance as 8 or did not square E(X). Very few incorrectly divided by 5, unlike in previous sessions.

(vi) Candidates needed to have a very good understanding of probability to gain marks in this part. However, some got 1, 2 or 3 products of probabilities correct but very few had the coefficients correct.

4767 Statistics 2

General Comments

Most candidates demonstrated good knowledge in all questions on this paper. The parts which proved to be most accessible were those involving hypothesis tests and also basic calculations such as evaluating the product moment correlation coefficient. Not so convincingly well answered were parts requiring knowledge of statistical distributions. Knowledge of modelling assumptions and application of approximating distributions was not as secure as that shown in hypothesis tests. The manipulation of expressions associated with Normal distribution calculations could have been handled better by many candidates; the provision of a diagram to indicate intention would have helped many candidates identify the correct tail. It was pleasing to see sensible answers provided to the parts requiring interpretation, with most candidates providing statistical justification as well as referring to the context of the question. The issue of over-specification in final answers was noticed, but the vast majority of candidates provided answers rounded to a suitable degree of accuracy for the context provided.

Comments on Individual Questions

1) (i) Most candidates found the PMCC value correctly and to a suitable level of accuracy. A few candidates gave their answer to 5dp, and a few rounded their answers for S_{xy} etc. and hence gave an inaccurate final answer. Very few candidates quoted the formula for r incorrectly.

(ii) Most candidates performed well on this question. To gain full marks, candidates needed to show awareness that their hypotheses concerned the population value of the pmcc, either by using correct notation or by including the word 'population' in their worded hypotheses. Most candidates reached the correct conclusion, based on their value of r. Fully correct, non-assertive conclusions were provided by many candidates.

(iii) Many candidates provided the correct distributional assumption. Others replaced 'population' with 'sample'. Most candidates provided a correct explanation of how the distributional assumption could be checked using a scatter diagram. Others thought that visual evidence of 'linear correlation' was sufficient.

(iv) This question was well answered. Responses attracting the least credit referred mainly to technical discussions about bobsleighing. Comments relating to the result of the hypothesis test or the value of *r* were usually well rewarded.

(v)(A) This question was well answered. Some candidates did not provide the critical value for the test at the 1% level

(v)(B) Some excellent responses were seen from some candidates. Many interpreted the smaller significance level as meaning the test was 'more accurate', rather than considering the implications that altering the level of the test can change the conclusion – as seen if parts (ii) and (vA) had been completed correctly.

2) (i) Most candidates gave the correct answer. Some gave the value of *p* as 0.003. Others provided the Poisson distribution as the 'exact' distribution at this stage.

(ii) This was well answered by most candidates. Some simply described the modelling assumptions for a Poisson distribution rather than answering the given question.

(iii)(A) This was correctly answered by most candidates.

(iii)(B) Correctly answered by most candidates. Many thought that $P(X > 4) = 1 - P(X \le 3)$

(iv) Most candidates gained both available marks. Some candidates provided a correct value for the mean but an incorrect value for the variance.

(v)(A) Many candidates realised the need to apply a continuity correction and successfully reached a correct answer. Many did not realise the need for a continuity correction, though once a standardised value had been found, most knew how to use the Normal distribution table to produce an answer.

(v)(B) Most candidates identified the correct z-value for a 5%/95% tail and were able to de-standardise this correctly. Many candidates opted to use +1.645 (incorrectly) rather than -1.645 in their calculations. Few candidates showed appreciation that k needed to be an integer. Use of continuity corrections was rare and poorly handled in the few cases where seen.

3) (i) This question was answered very well by many candidates, with almost all realising that this continuous measure of volume did not require any continuity correction. Of the others who did apply erroneous continuity corrections, several opted for $\pm$ 1 unit instead of the usual $\pm$ 0.5.

(ii) Most candidates attained both of the available marks here. Some candidates mixed up their ‘p and q’ from part (i). Many who lost marks in part (i) earned both marks in part (ii)

(iii) Many candidates found this to be a challenging question and did not recognise the ‘binomial’ situation. Those candidates using the correct distribution usually applied $1 – [P(X=0) + P(X=1)]$ correctly.

(iv) Most candidates obtained the correct z-value of -2.054. Many used +2.054 appropriately and earned full marks. Others provided incorrect equations but managed to correctly rearrange them, though not recognise the absurdity of the subsequent answer.

(v) Many provided fully correct solutions to this question. Others did not correct their working despite it leading to a negative value for σ.

(vi) Most candidates understood the reasoning behind this question and correctly identified which method would be ‘easier to implement’ and which would be ‘preferable’. To earn full marks, candidates needed to show that they understood that reduced variability was preferable.

4) (a)(i) Nearly all candidates scored 3/3 here.

(a)(ii) This question was well answered. Commonly, marks were lost through over-assertive final conclusions and poorly worded hypotheses, though the numerical aspect of the hypothesis test was well done.

(b) Many excellent answers were seen in this question. Often, lost marks were due to inappropriate hypotheses; those not using μ could still achieve full credit if they defined their replacement symbol as the population mean. Others provided over-assertive conclusions and some seemed unsure how to proceed once they had obtained the correct test statistic – inappropriate comparisons were seen quite frequently.

4768 Statistics 3

General Comments

There were 544 candidates (compared with 462 in June 2011) for this sitting of the paper. There were many very competent scripts and yet candidates (including high-scoring ones) often lost marks through carelessness. The topic "Sampling methods" continues to be one on which candidates do less well. In several places where it mattered, candidates did not make explicit the distinction between a sample and a population, many referring to "data" which, at best, seems ambiguous. The numerical work was accurate on the whole.

Comments on Individual Questions

1) (i) For this part candidates needed to identify the variable that would be eliminated by pairing; in this case the variations caused by differences between the surfaces. The majority of candidates did not seem to understand this.

(ii) This part was answered well, but full marks were relatively uncommon largely due to the imprecise nature of the responses. It was necessary to be clear that the population variance is unknown and the assumption of Normality relates to the population of differences. The unqualified use of "data" can be unhelpful since one cannot tell whether the writer is referring to the population or the sample.

(iii) The *t* test was conducted well, by and large. Some candidates need to take more care in specifying the hypotheses and the final contextual conclusion. There was a small number (more than in previous years) of candidates who chose not to attempt a paired test despite the heavy hints of the two preceding parts.

(iv) On the whole this was well answered. Some chose, incorrectly, to use 1.96 as the percentage point, forgetting that they should still be using the same *t* distribution as in part (iii). Occasionally the interval was expressed in a way that implied a negative reduction.

2) (a) There was much repetition of the same points in the answers to the 3 parts about sampling. Candidates did not seem to have read the questions carefully enough.

(i) Many candidates stated reasons for sampling that related to the size of the population. Some knew that accessibility was relevant but could not always state this clearly. Many missed the point of the question: why might one need to take a sample as opposed to a complete census of the population.

(ii) This question was about ensuring that sample data should somehow be "fit for purpose". Two possible answers were that the sample should be "representative" and "unbiased". Many candidates managed at least one of those two points.

(iii) In order to answer this part, candidates were expected to make the connection between the various statistical tests that they have studied and the assumption or requirement each time that the sample used should be a random one. Despite what many thought, a definition of random sampling and/or a description of how to select a random sample were not required here. Candidates did not display a full understand the characteristics of a random sample, nor did they seem to appreciate why a random sample might be preferred (over any other sort of sample), even though there is a risk of it being <u>un</u>representative.

(b)(i) Answers to this part were often muddled and many confused the circumstances and assumption for a Wilcoxon test with those for a *t* test. As in earlier parts, it was necessary to make it clear that the discussion referred to the population and not the sample.

(ii) This part was well answered by many candidates. Again more care was needed with the hypotheses and the final contextual conclusion.

3) Much of this question was answered well by most candidates.

(i) The vast majority were able to answer this part easily and correctly.

(ii) Most responses to this part of the question were competent and correct.

(iii) Again most responses to this part were competent and correct. A few candidates experienced difficulty either in formulating the problem from the information given or in obtaining the correct variance.

(iv) Most candidates were able to demonstrate that they could set up the basic structure of a confidence interval. However, in order to answer this part correctly candidates needed to refer to the *t* distribution and not the Normal distribution. There was then a tendency to over specify the accuracy of the final answer.

(v) Most candidates could give a plausible reason why, for a particular competitor, the times for the different stages were unlikely to be independent of each other. However the same could not be said for the assumption of Normality. Most claimed that Normality was reasonable for reasons that were either much too loose or wrong. One common wrong reason was that if a population is large then, by the Central Limit Theorem, it must be Normal. On the whole very few candidates seemed to take the trouble to think critically about this assumption.

4) (i) As with the other hypothesis tests this part was well answered by many candidates. However, there were the usual errors: hypotheses were not always expressed with due care; candidates forgot to combine the last 3 classes; they chose the wrong number of degrees of freedom. There are still some candidates (but fewer than before) who are fitting data to models rather than the other way round.

(ii) This part was answered with considerable ease.

(iii) There were many good answers to this part of the question, but there were also many unsuccessful attempts. The latter were usually due to having the wrong or no limits for the integral, or to an inability to integrate correctly or, if they used an indefinite integral, to being unable to deal with "+ *c*" correctly. On a number of occasions candidates left the final answer in terms of λ and this was penalised.

(iv) On the whole most candidates answered well. Those who had been completely successful in part (iii) were likely to experience little if any difficulty. A number of candidates, including some who had been unsuccessful in part (iii), did this part by integration and were able to get the right answer. Errors included neglecting inconvenient negative signs.

(v) The quality of response to this part was very similar to part (iv). The majority of candidates, who had found the correct cdf earlier, were successful. Among other candidates the neglectful treatment of negative signs was more extensive.

4769 Statistics 4

General Comments

There were nearly twice as many entries this year compared with last. The standard was on the whole very good, with a small number of outstanding scripts. Very few candidates showed signs of being out of their depth.

No candidates answered more than the required three questions from the four options. Question 2 was most popular despite being somewhat unfamiliar, but with the guidance given there were many strong answers. Question 4 was least often chosen, but often well done.

Comments on Individual Questions

1) This question on estimation was not as popular as either Q2 or Q3.

The information given allowed nearly all candidates to gain full marks in (i). In (ii) the best solutions showed explicitly the use of the density function, likewise in (iii) when $\mathrm{E}(X^2)$ was needed. Credit was given to those who argued from the conditional expectations. Here most candidates realised that $\sigma^2 + \mu^2$ for each sex was needed but not all could find the correct expression to use. There was some evidence of forcing the required result, where accuracy marks were forfeit. In (iv) most candidates were able to deduce the correct distribution, errors in the denominator of the variance being most common. Explicit derivation of $\bar{X}_{st}$ was not always seen in (iv); those candidates who defined the expression through the observed random variables were the most successful in finding the expectation and the variance. In (vi) candidates with the correct variances for $\bar{X}$ and $\bar{X}_{st}$ were easily able to discern the more efficient estimator, but where there were mistakes in one or other expression this was not always possible.

2) Every candidate except one attempted this question on generating functions.

It is important that full working is shown where the required result is given, as in parts (i) to (iv). In the remaining sections nearly all candidates successfully used the information presented to obtain $\mathrm{K}(t)$. In (vii) most candidates successfully negotiated the differentiation required for $\mathrm{K}'(t)$ and found the expectation of Q. With more difficulty, many obtained $\mathrm{K}''(t)$, and the required variance. The final part (viii) was again requiring candidates to show full working in order to earn all the marks, including a common denominator and the exact form of σ_Q^2 .

3) This ‘Inference’ option question revealed a variable set of responses. The statements of appropriate hypotheses in both parts (i) and (ii) were mostly carefully given with explicit mention of ‘population’ values. The alternative hypothesis did not always take account of the suspected inferiority of fertiliser A, leading to a two-tailed test which was inappropriate and lost marks. In a few cases in (i) the wrong conclusion was reached when the size of the Wilcoxon test statistic was compared with the critical value. In (ii) most candidates successfully found the pooled estimate of variance and calculated the correct test statistic. Any error in the degrees of freedom inevitably lost the following marks. In both parts (i) and (ii) most candidates were careful to give a non-assertive interpretation of the test results, in context.

   Part (iii) was on the whole found difficult to answer. Candidates were not always able to say why the t-test was better than the Wilcoxon test if the underlying population distribution was Normal, and not always willing to assert that the Normality was in any way questionable.

4) Design and Analysis of Experiments. This question was answered by half the candidates. The need for a Latin Square design was nearly always recognised, and the accompanying layout was usually correct. Some answers did not recognise the manufacturers as the ‘treatments’ under investigation and did not place them inside the square. In (ii) candidates were able to find the appropriate sums of squares, mean squares and degrees of freedom, but these were sometimes not laid out in the conventional Analysis of Variance table. Most candidates found the correct mean square ratio. The interpretation of the test result was disappointing. Candidates were not prepared to abandon the usual 5% significance level and point out how extreme the result was, even by comparison with the 0.1% point. The question was hoping for insight which was not forthcoming.

4771 Decision Mathematics 1

General Comments

Many candidates found difficulty with this paper.

Comments on Individual Questions

1) This was a context-free application of one of the bedrock algorithms of D1, Dijkstra. It was intended to check the ability of candidates accurately to apply the algorithm. Many candidates either did not know the algorithm, or could not apply it correctly.

2) In the real world optimising is rarely a case of differentiating and setting to zero. Usually the function to be optimised is not known, and all that can be found are function values, often each at great expense in terms of money or time. In the real world functions are usually multivariate, but in the case of a univariate function Golden Section Search is very efficient. The question was about this.

   Six of the eight marks were for applying the algorithm. In this case, instead of experimentation to find function values, candidates had to evaluate a quadratic. Candidates were comfortable with this part of the question although some candidates lost a mark by not giving the required degree of accuracy, and some lost the same mark by giving values in surd form.

   A few candidates gained the difficult penultimate mark. Candidates did not need two evaluations on the second iteration, since they already had one of them from the first iteration. The use of an interval reduction factor of $1/\phi$ saves a function evaluation at each iteration of the algorithm. The algebra involved in deducing this is accessible, the modelling to produce that algebra is less so.

   It was thought that fewer candidates would succeed with the last mark, but in the event several suggested appropriate physical situations.

3) This graph theory question was well answered. It speaks well of candidates' abilities to deal with the abstract, which is an area which one hopes would be developed by GCE mathematics.

4) Part (i) of the LP question was concerned with formulation. Far too many candidates, if they remembered to define their variables, neglected that essential phrase "the **number** of ...".

   The graph was generally drawn well in part (ii).

   In part (iii) too many candidates failed to do the obvious in the optimisation, i.e. to evaluate at the three possible optimal points.

   In the revised optimisation (part (iv)) the issue of integer values needed to be addressed. This was not done well, but then it was not easy. The points that needed to be examined were (9,7), (10,6) and (11,5).

5) Candidates' attempts at parts (i) and (ii) were very disappointing. The need to reject and redraw whenever the number of possibilities is not 2, 5 or 10 (when using single-digit random numbers), was not well understood and the majority of candidates failed to collect these 4 marks.

In contrast part (iii) produced quite good marks, the key being to explain the simulations ... random number ... rule ... outcome.
Again, explanations were needed in parts (iv) and (v)

6) This was a fairly straightforward CPA question. A dummy was required in part (i) so that E and F did not share "i" and "j" events. Normally the method marks for forward and backward passes in part (ii) are awarded for handling joins and bursts respectively. In this case there was no burst (the initial node does not count as a burst), and the M mark for the backward pass was given for correctly handling the late "i" time for a dummy. Thus candidates forfeited 3 marks in total if they failed to use a dummy.

Parts (iii) and (iv) were straightforward, but many candidates failed to collect the marks. For instance, in part (iv) a common wrong answer was 15.5 mins.

Jim's availability needed to be allowed for in the precedence diagram in part (v).

4772 Decision Mathematics 2

General Comments

Many candidates for this paper were able mathematicians. Their performances were good.

Nevertheless, there was much challenge in the paper, particularly in question 1.

Comments on Individual Questions

1) (a) Candidates did well with parts (i) and (ii), but part (iii) proved very difficult. Parts (i) and (ii) were concerned with what a teacher must do in two different circumstances. Part (iii) asked the candidates to explain/prove why at least one box must be ticked under **all** circumstances. Most candidates started their answers along the lines "If the teacher ...", and were therefore immediately sunk. Looking at specific circumstances did not gain marks. Candidates needed to show that the negations of the statements were contradictory. It needed an argument focusing on the statements, and not on externalities.

(b) Many candidates failed to define their propositions. Many failed to translate Angus's statement and Chloe's statement into compound propositions. Many that did so failed to test the equivalence of the two statements, or more specifically to compare truth values when it was not foggy, when the top lift was not working, and when lunch was taken in Italy.

(c) The key to this question was to write down the contrapositive of the given implication. There were several well-argued answers which did not explicitly use Boolean algebra. These could only earn partial credit. Truth table solutions earned no credit here.

2) This question was answered very well. The computations of the paybacks in parts (i) and (iii) caused difficulties – unsurprisingly given the inherent complexities. Pleasingly, the majority of candidates handled part (ii) well. The point here is that the square roots of the paybacks need to be taken, and not the square roots of probabilistically weighted means of those paybacks. This was very well understood.

3) Question 3 had many and varied points. It covered a lot of ground without raising any significant difficulties for the candidates.

4) Candidates were generally very happy with parts (ii) and (iv). Quite a few knew the post-optimal analysis in part (ii), which was pleasing.
In part (i)there were many candidates who busied themselves with explaining the mechanics of surplus variables et al, rather than with the modelling that was asked for in the question. Far too many candidates, if they remembered to define their variables, neglected that essential phrase "the **number** of ...".

4773 Decision Mathematics Computation

General

The number of candidates taking this exam continues to decrease. The majority of those candidates sitting the paper demonstrated a good knowledge of the subject content.

1) Most candidates gained high marks on this question. In (i) a number failed to label their diagram. Most candidates understood the processes required in (ii) and (iii) to achieve a maximal flow, and were able to identify the corresponding minimum cut in (iv). In (v) candidates were required to model appropriately the bidirectional nature of BD and CD and to give a clear interpretation of the individual and maximal flows.

2) This question was poorly understood by many candidates. The most significant difficulty was the use of indicator variables to model the opening of mines C and D, both in the constraints and the objective function.

3) Many candidates were able to construct the spreadsheets for (i), (ii), (v) and (vi), though some failed to give any indication of the formulae used. This was a particular problem in (v) where the correct solution cannot simply be implied from a set of correct values. Some candidates struggled in (iii) because they tried to start from the given equation, rather than deducing it. Only some candidates appeared familiar with the necessary theory to complete (iv).

4) Most candidates who completed this question achieved high marks on it. In (i) there were the usual errors of either not showing formulae, or of not adjusting the column widths when printing to make the full formula visible. Part (ii) was done well except for a few careless errors, whilst in (iii) a number of candidates did not appreciate that “a further 19” required a table of 20 results.

4776 Numerical Methods (Written Examination)

General Comments

The purely computational parts of this paper were found straightforward by most candidates. Theoretical parts were found more challenging, and interpreting results was difficult for all but the very best candidates.

The standard of presentation of work, and in particular the systematic setting out of numerical algorithms, seems to have improved somewhat. However some candidates frequently resort to scattering calculations on the page, making it difficult for examiners to detect and reward any correct work.

Comments on Individual Questions

1) **Lagrange's interpolation formula**
This question attracted many correct solutions. However marks were lost by those who confused the x and f(x) values, and by those who could not simplify the quadratic.

2) **Relative errors**
The algebra required in parts (i) proved very straightforward, but only a minority were able to use the binomial theorem correctly in part (ii). Part (iii) required the understanding of relative error but was not well answered.

3) **Solution of an equation, Newton-Raphson method**
This was a very straightforward question, with very many candidates scoring full marks.

4) **Numerical differentiation**
Parts (i) and (ii), finding the estimates and demonstrating that the forward difference method is first order, were done well by most candidates. Part (iii), giving the answer to the accuracy that is justified, proved tricky for quite a few. One surprisingly common error was to drop the negative sign.

5) **Errors in the representation and storage of numbers**
Almost all candidates were able to interpret the spreadsheet notation in part (i). The explanation expected for the 'dirty zero' result in cell A4 was that the spreadsheet does not store numbers such as 0.6 exactly; hence a calculation which would give exactly zero on paper may not give zero when carried out on a computer. The most common answer, however, was that the value entered in cell A1 is not 0.6. This is a possibility, of course, but it rather misses the point. Very few candidates were able to make the required inferences in part (ii). Adding 1 causes the significant figures shown in cell A4 to be hidden in cell B4. Subtracting 1 again to get a clean zero shows that these figures were lost altogether.

6) **Numerical integration**
The numerical work in first two parts was done well by the vast majority of candidates. It was pleasing to see so many correctly dealing with the orders of the trapezium rule and Simpson's rule. Part (iii) was found more difficult: in particular, very few could estimate the effect of the values of f(x) being approximate. If each f(x) may be in error by ±0.000 005, and the range of integration is of length 2, then a sensible estimate of the error in the integral is the product of these two numbers, i.e. ±0.000 01. (A few resolute candidates arrived at this conclusion by re-working all their calculations.)

7) **Solution of an equation, false position and secant methods**

Locating the roots in part (i) was well answered, but the modal score for each of the other three parts was zero. It seems that the false position and secant methods are not as well known as they should be – and indeed that they are frequently confused. (Of course the two methods use essentially the same formula to get from two estimates of the root to a third: the difference lies in what is done with the third estimate. It is an important feature of the false position method that, at every stage, we have two estimates which bracket the root; it is an important feature of the secant method that we pay no attention to whether the current two estimates do or do not bracket the root.)

4777 Numerical Computation

There were fewer than 10 candidates for this unit, so no report is published.

Coursework

Coursework report – June 2012

Moderators were pleased to receive the MS1 and the sample of work from the vast majority of centres in good time. Additionally, it was rare to find the Authentication Form, CCS160, missing; when it had to be requested the majority of centres responded helpfully and efficiently.

It is hoped that centres find useful these Reports to Centres and the individual report that each centre receives from the moderator (now sent electronically on Results Day), and use them to inform their marking in subsequent series. Many of the comments in this report have been made before, because we find that they continue to be the most frequently occurring issues

It should be stressed that the vast amount of work seen displays a high level of commitment by candidates and assessors with appropriate marks being awarded.

4753/02: Concepts in Pure Mathematics
There were a number of instances of incorrect work being given full credit. It is expected that obvious departures from the criteria will be penalised. The following serve to illustrate areas where adjustments are made to what is usually over-generous marking.

- Those candidates who relied too heavily on a graph-plotter (particularly in domain 2) often incurred a heavy external moderation adjustment. Assessors are reminded that the task is to demonstrate the ability to use the Newton-Raphson method and not just to demonstrate the ability to use a piece of software. The use of any software is to be encouraged so long as the report of the candidate indicates an understanding of the method. Usually this means that the formula for Newton-Raphson is derived and used on a calculator or spreadsheet for at least one of the roots. However, some candidates demonstrate that they do not understand how to use their graph-plotter. For instance, some are not able to produce roots to the required number of significant figures and most seem unable to deal with “overflow” messages. Such problems are rarely penalised by the assessor and so adjustments have to be made by the moderator.
- A significant minority of candidates were credited for the “hypothetical case” – i.e. saying what *would* have happened if they had tried to use (usually) Fixed Point Iteration.
- In many cases computer generated illustrations were not at all clear. (For example, in domain 2 a requirement is to show clearly at least two tangents which match the iterates; often these start off the graph).
- Error bounds for one of the roots found by the Newton-Raphson method were often stated rather than established.
- In domain 3, the main problem was the graph work. The discussion of the criterion for convergence in this domain was very often unclear. Often full credit was given for incomplete or incorrect arguments.
- In the comparison domain candidates often used different starting points to find the root (sometimes found to a different level of accuracy) and were then given credit for discussing speed of convergence.
- The comments on ease of use were seldom relevant – but were often unduly rewarded.

On a positive note, only a few candidates used quadratics for success or trivial equations for failure. Additionally it was pleasing to see rather more assessors penalising poor or incorrect terminology. It was rare this series to see comments from the assessor such as “all good” in this domain when candidates consistently described functions as equations and finding roots of graphs.

4776/02: Numerical Methods

Most candidates attempted suitable tasks, but in a small number of cases a heavy penalty was incurred by candidates doing lightweight tasks and only nominally meeting the assessment criteria. This was usually on solution of equations.
Not all candidates are able to give a correct formal statement of the problem. This is seldom penalised by assessors.

Many simply describe the methods, rather than justify their selection, for the second mark. This is particularly so in numerical integration where candidates engage in a book work description of how the methods work for which credit is usually awarded in domain 2. This is not the focus of the criteria which are usually not being met. It is expected that candidates will explain why they have chosen a particular strategy. Additionally some extra explanation is required to justify an assertion that "The mid-point rule underestimates and the Trapezium rule overestimates the area".
In this task "a substantial application" is deemed to be finding the value of the chosen method by using up to 64 strips. A small minority of candidates are still given full credit for only going as far as 16 strips.

Many do not deserve the second mark in the technology domain, yet it is frequently awarded. Often there is simply a description of what software was used.

Some candidates compare their values with known values – π or values obtained from the MATH function on a graphical calculator. Analysis of errors should be contained within the workings of the task and not by comparison to an outside, known, value.
A few use the theoretical values for *r* even when there is compelling evidence that this is inappropriate, and some candidates still extrapolate from (say) S_4, obtain a less accurate approximation and are given full credit.

Quite often over optimistic or very conservative, final answers are given full credit. Few candidates are able to argue coherently for a stated level of accuracy referring only to their iterates. Limitations were often simply ignored, but given full credit.

4758/02: Differential Equations

There were fewer large changes to centre marks or changes in general this season.
Centres are still submitting investigations into 'Aeroplane Landing' where the initial model (resistance proportional to velocity) is rejected on the basis of what is predicted for the first 9 seconds. Unless the whole motion is modelled, to include the phase where the brakes are applied, full marks cannot be obtained for many of the criteria in Domains 2 and 4.
Also, in 'Aeroplane Landing', the accuracy of the data is rarely considered. However, this would prove helpful when varying parameters and when comparing the predicted and collected data.
When investigating 'Cascades', in both the initial and revised models the focus should be on the flow through the second container - that is, the container which has fluid both entering and leaving it. The flow out of a single container can be used to calculate the parameters. When revising the initial model, if one assumes that the flow is proportional to h^n and then the value n found which gives the best fit to the experimental data, this is curve fitting and not modelling.
Finally, for most experimental/ modelling tasks care should be taken to avoid circular arguments. Using the experimental data to derive the parameters which are then used to produce the predicted values which are compared to the same original data is a circular argument. Where possible, it is better to use the results from one experimental trial to predict the outcomes from another experimental trial. This also helps avoid curve fitting.

Oral communication

It is a requirement of all three tasks that the assessor fulfils this criterion and writes a brief report on how it was done and the results. Assessors are reminded that it is not permissible to give credit for any of the other criteria as a result of this oral communication.

OCR (Oxford Cambridge and RSA Examinations)
1 Hills Road
Cambridge
CB1 2EU

OCR Customer Contact Centre

Education and Learning
Telephone: 01223 553998
Facsimile: 01223 552627
Email: general.qualifications@ocr.org.uk

www.ocr.org.uk

For staff training purposes and as part of our quality assurance programme your call may be recorded or monitored